Fluid Inclusion in Minerals: Principles, Methodology, Practice and Application
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Lecture – 24
Application of Fluid Inclusion to Ore Forming Environments (Contd.)

Welcome, to today's lecture. We will continue our discussion on the application of fluid inclusion microthermometric data to understand ore forming environment, the hydrothermal ore deposits in particular.

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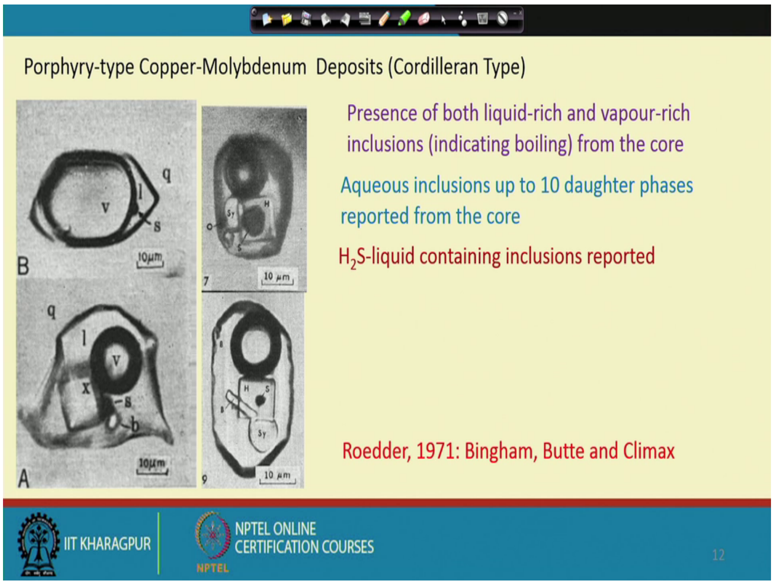

Today, we will discuss some other important about the types. And the possibly the most obvious one when we talk about the magmatic hydrothermal system are the porphyry copper deposit.

So, this particular in from this particular display diagram this picture and the information is retrieved from some old literature. This is from Roedder, 1971, where there was some comparison of the Bingham, Butte and the Climax porphyry this Bingham and butte are the porphyry copper deposit and Climax is the porphyry molybdenum deposit I will be restricting the discussion to only to porphyry copper system.

So, in the old literature only we will see that this documentation is the way that. So, here we could see the inclusions that are described from this porphyry system. So, we know that if we have to look at the porphyry copper deposits the typical ones occurring in the western American Cordillera or in the Chilean Andes are the ones which will give us the idea about the porphyry system. Even though it has said that there could always be some differences sometimes very significant across deposits which are categorized into similar or the same type which is a porphyry type.

One of the major one of the very interesting aspect of the porphyry type deposit is that since their magmatic hydrothermal fluid and the magmatic hydrothermal fluid is essentially the one which exalts from a crystallizing magmatic pluton and in the porphyry copper deposits in the cordilleran or the Chilean Andes region they are the ones where the plutons are shallow or emplaced in shallow conditions where the fluid could evolve by boiling. And this boiling of the fluid generally gives rise to the components which are vapour rich. and the aqueous component which becomes extremely briny or my concentrator or very extremely saline which is exemplified by occurrence of such kind of vapour rich inclusions is shown here.

And, inclusions which will sometimes be described is continuing about 10 daughter phases or so. And such inclusions when they are subjected to microthermometric experiment the heating experiments. Here in this particular inclusion a halide crystal, a sylvite crystal. And there is this dark one is a essentially interpreted to be a specular rate like a hematite crystals and sometimes that is these kind of inclusions also do have sulfide like a chalcopyrite gained as a daughter crystal.

And, during and then heating experiment it is observed that this halite and the sylvite or the chlorides are actually the one which dissolve, but the other ones like this any sulfide or any other sometimes even the anhydride kind of mineral the daughter crystals also do not dissolve when the inclusion is heated to very high temperature. But, the fact is that these inclusions will be moisturizing at a very high temperature almost greater than 600, 700 degree Celsius.

And so, they do represent. So, they actually give us a very definitive idea that these deposits actually have been originated or a one of the sub important contributor of the fluid is a magmatic fluid. So, the presence of both liquid and vapour-rich inclusions and the sometimes these inclusions also do have H 2 S. And in this old literature we see that these kind of interpretations were made from crossing stages where the gas could be observed under the microscope and then identified.

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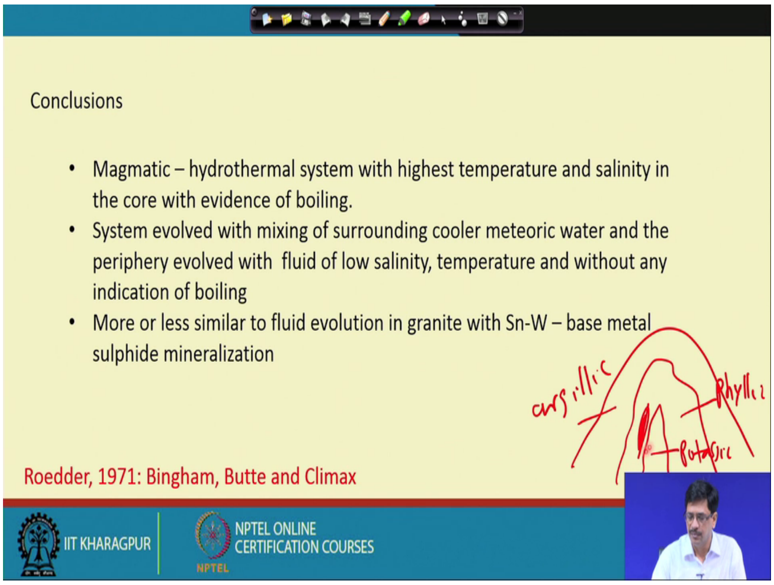

And so, such kind of this entire spectrum of the inclusions that will be studied in this will also have and they will always be arranged in a in a in space exactly the we see in a porphyry copper system as we know that in a porphyry copper system we get the they do have a zonal pattern of alteration we do have a kind of they are represented as the lateral or vertical zoning, we do have a potassic core. Potassic core which actually will be exemplified by presence of biotite or potash feldspar and this particular zone potassic core will be the direct, or here actually the magmatically derived fluid place their own.

And, then generally there will be a zone which will be a phyllic alteration zone which will be sericite quar serycite rich or typified by an assemblage of quartz and sericite and we get sometimes the ore cells. They also do contain the chalcopyrite bornite and pyrite and glycosine then it is surrounded by argillic this kind of alteration zones are observable in many of the typical porphyry copper deposits, then we do have a porphyritic alteration zone.

So, what is actually interpreted is that the core part is a result of the magmatic fluid which is so, that in this particular condition the fluid will be mostly be transporting the metal or the high solubility of the metal. So, it is not expected to be depositing these metals in a form of the ore minerals, but only when the fluid that is the warning stage of the fluid of this the contraction of the vapour and then temperature is decreased then only the solubility of the metals we drop down. And there are interpretations, that there later on after during the warning stage of this hydrothermal activity, when the vapour phase is condensed into low saline fluid then the meteoric fluid mixes with the originally did magnetically derived fluid. And we get the zonal pattern of alteration and the mineralization in conformity with this alteration zones.

So, a porphyry copper deposit fluid inclusions should always be studied with respect to where the sample is been taken from which alteration zone. So, normally the potassic alteration zone will be exemplified by occurrence of this kind of very high temperature fluid and very high saline going to 70, 80 weight percent initial equivalent and temperature even in excess of 700 – 750 degree Celsius. And then the stops work in the vein systems. In the later alteration zones will actually be reflected by the warning stage of the hydrothermal activity and deposition of the ore minerals and specific locales.

So, the so, as so, that is what exactly the scenario which were interpreted in this kind of porphyry copper deposits where the data of this salinity will always range from very high saline to very low saline, and as well as the temperature. So, the involvement of meteoric fluid becomes very obvious. And so, the magmatic hydro thermal system with the highest temperature and salinity of the core the system evolves by mixing with the surrounding cooler meteoric water. And, the situation is kind of a comparable to what we saw in this in tin tungsten deposit for example, the mole granite scenario that we that we considered.

That there also the initially magmatically derived fluid was in a two phase condition boiling and then gradually the system with decreasing temperature pressure condition it warned. And then there was code for incursion of the less evolved low temperature low saline low salinity fluid to mix and then bring about the mineralization what we saw in case of mole granites similar. More or less similar situations are also visualized in these porphyry systems although the geological setting and the host rock types are little different and the alteration zones are very characteristic of the porphyry copper deposits.

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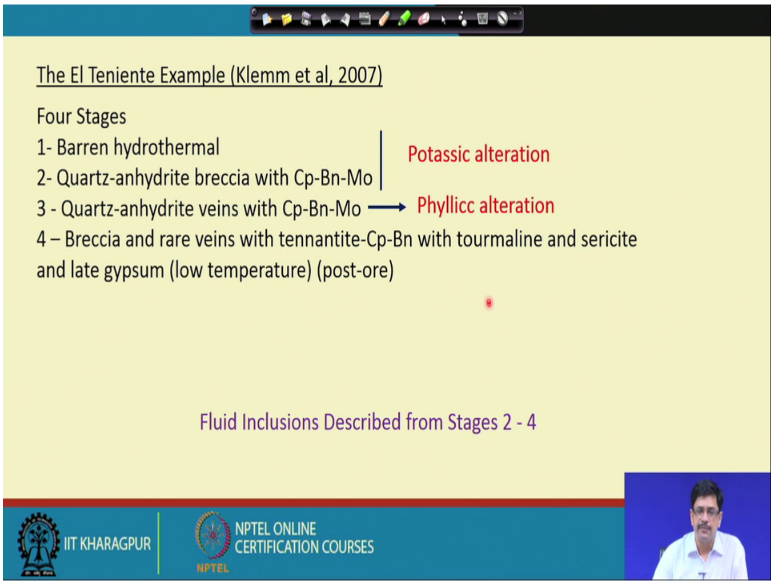

So, looking at some of the recent literature and taking the example of this el teniente deposit porphyry copper deposit in chili. So, here it is also the mineralization is visualized to have a four stages out of which the first one is barren hydrothermal exactly the same way that the originally high temperature magmatically derived fluid was responsible. And then a quartz anhydride breccia with chalcopyrite bornite and molybdenite. This is coincident with the potassic alteration zone and then it gave rise to a quartz anhydrate vein with chalcopyrite bornite and magnate molybdenite is coincide with the phyllicc alteration.

And, then the stage four was a breccia and the rare veins with tennantite chalcopyrite and bornite with tourmaline and sericite and late gypsum sometimes in typically in a porphyry system tourmaline is a alteration or there is a product is sometimes not very common, but this deposit is. So, the fluid inclusions were in this particular deposit as has been given the reference here were described from the stage – 2 to stage – 4.

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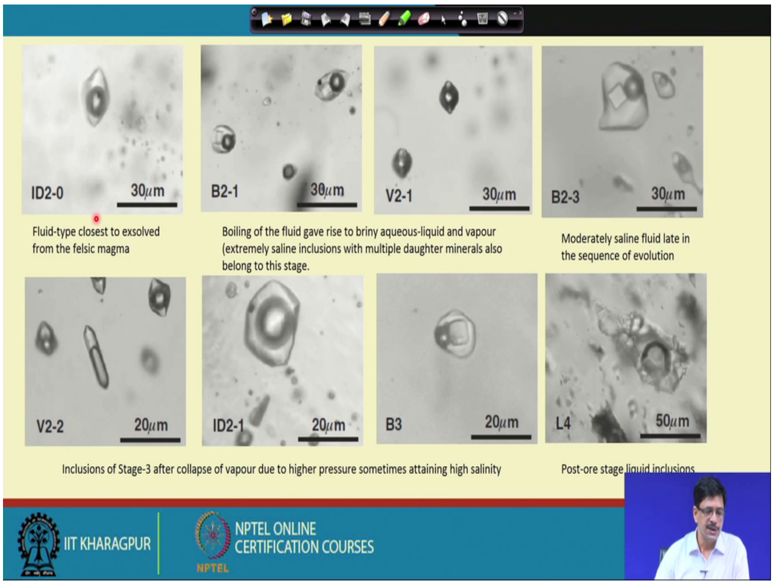

And, we could see the similar situation here that this particular inclusion which is a moderate salinity inclusion this is fluid is ferric it is closest to the exsolved from the felsic magma and the inclusions which are represented by this halite as well as the opaque daughter mineral daughter crystal occurring here.

They are supposed to be there and these ones along with the ones which are dominated by vapour are supposedly the result of the boiling and such kind of boiling even which is not shown in this diagram even result in inclusions with multiple daughter phases and that supposedly a very very high salinity and temperature as well and these are the moderately saline fluid these are late in the sequence of evolution it is sometimes it is ambitious that with the or with the decrease in the pressure temperature condition with the condensation of the vapour and mixing with other fluid sometimes a later stage that even this kind of the boiling and the condensation process also takes place in a very con committed manner.

And, also in the later stage some high saline fluids are also generated which are entrapped is halide bearing daughter crystals, but they are not as high saline as the ones which are produced from the initial phases of boiling you could see here is a one halide bearing daughter crystal. And, these are the inclusions which are the representative of the stage – 3 after the collapse of the vapour bubble and to a higher pressure sometimes attaining the high salinity.

And, these are the ones which are the stage – 4 the almost the barron stage in which the a liquid rich aqueous inclusions were trapped. And so, this, do also conform to the temperature salinity distribution as we as is generally observed in case of the porphyry copper deposits.

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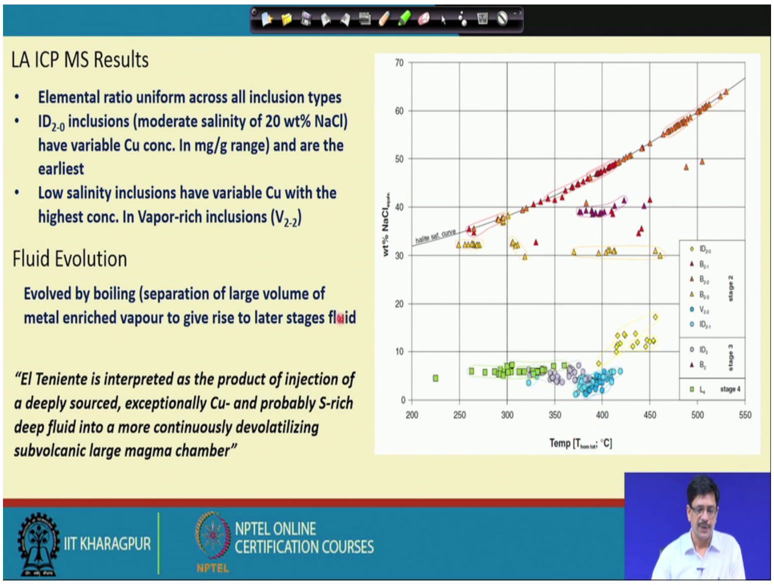

Interestingly the now, since this these are taken from the recent literature, where in most of these kinds of deposits when they are studied that the inclusions are also analyzed by the available analytical technique like ICP LA ICP MS where the inclusion cavity contents were analyzed by an ICP MS; the method which will be discussing later part of this lecture series.

So, the a LA ICP MS results they indicate that these the inclusions which were represented as this one which is almost like would be considered as the first stage of the fluid or the exactly the magmatically derived fluid or moderate salinity they do have variable concentration of copper in terms of milligram per gram. And whereas, the ones where we see this vapour rich inclusions and this stage – 3, as well as stage – 2, these are the ones which contain copper concentration in there in the range of almost like a few milligram per gram to sometimes be in weight percentage ranges.

And, the low salinity inclusions a variable copper this kind of inclusions which are described here, coming from the stage – 3 and this is the plot of the temperature salinity weight percent salinity where we could see that these represent the inclusions which are almost the stage – 2 and stage – 3 mineralizing mineralization duration during that process where there were many stages of fluid boiling and condensation of the vapor.

And, then these are the ones which are the L 4 aqueous inclusions which are very low saline, lower temperature and where one could always invoke a situation where there could be mixing of late meteoric fluid. So, what is ambitious here is the fluid evolved by boiling separation of large volume of metal and this vapour to give rise to later stages of fluid. So, to code the author; so this is interpreted is the product of injection of a deeply sourced exceptionally copper and probably sulfur rich deep fluid into a more continuously devolatilizing subvolcanic large magma chamber.

So, I would also definitely refer that the original work be referred to for a detailed discussion of this, but here we could always make a correlation between what inclusion types one sees and the data one. So, in the older literature when we did not have much of or the concentration of different elemental species measured from the individual inclusions in the absence of that the interpretations were mostly based on what the temperature salinity distribution that we get and from that we try to interpret our data.

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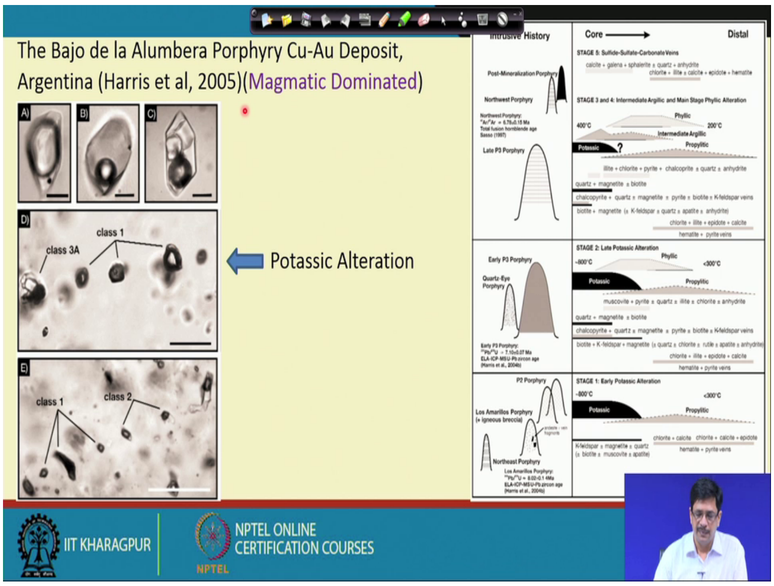

This is also another example of a porphyry copper deposit from the Bajo de la Alumbera porphyry copper deposit in Argentina, where the only difference compared to the previous one is that if the authors here they visualize that this multiple this stages the main stages of mineralization and alteration is actually was caused by only the magmatic fluid without so, without involvement of much of meteoric fluid.

So, the as I said that when we look at the or attempt to do our fluid inclusion study, it is always essential to have a good idea about the demineralization the constitution of the mineral, the ore body in terms of the mineralogy, the different types of alterations and the stages of this alteration. And we says they do because we have some idea that in a porphyry copper system we get the potassic alteration which is the earliest stage. And represent in the highest temperature condition and as the temperature goes down they go to porphyritic kind of alteration when pyrote and chlorite kind of assemblies and this is the stage – 2, the late potassic stage – 3.

So, these this kind of situation could be interpreted by a proper examination of the different types of veins, their alteration hallows and the mineralogy of the ore body. So, these authors as sited here they interpreted the sequence to have developed in 4 or 5 stages. And the inclusions that they observe, where the or the as before in as is observed in many of the porphyry copper deposits the liquid rich inclusion, and the vapour rich inclusions, and also the very high saline multiple daughter phase bearing inclusions.

And, here we could see they classified their inclusions is class 1, class 2 and class 3. So, the class 1 are the aqueous inclusions of variable ratio of the vapour by vapour plus liquid, and the ones which are very high saline including containing multiple daughter phases.

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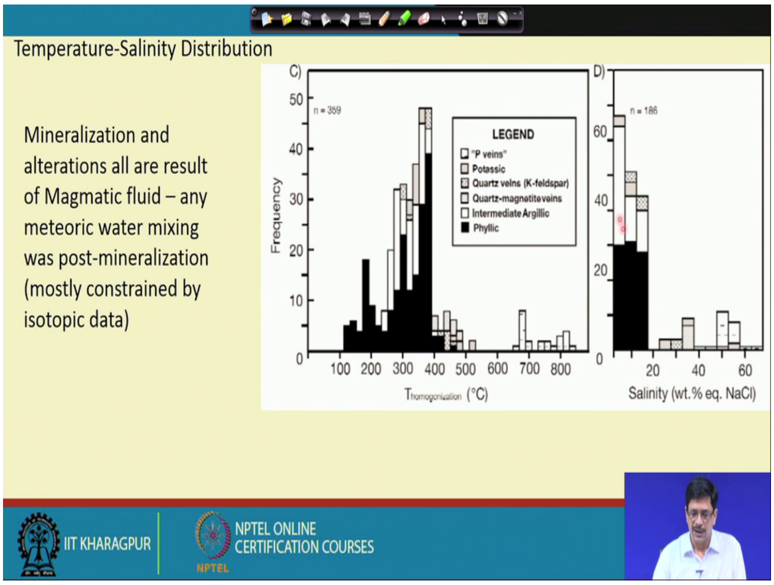

And, here the data are in plotted here you could see that the temperature of homogenization of the inclusions; mostly the veins during the earlier phases the p veins which is like here do have the record the highest temperature almost between excess of 800 degrees Celsius which we know that even we cannot determine with the kind of fluid inclusion stage where we have a temperature range of 600 to minus 196.

So, they do require the thermo metric operators which they where the temperature of range of operation could be still higher and similarly the polyphase inclusions giving salinity is within excess of 60 weight percent and we could see the distribution. And here very interestingly the phyllicc alteration is generally of a much of a lower temperature corresponding the fantastic can be a early potassic and the a late potassic alteration zones. And so, it more or less conforms to the picture that we generally acquainted with about the porphyry copper deposit.

So, here in these the explanation for this evolution of the fluid is interpreted to be a magmatic fluid which evolved up to this kind of a low salinity and low temperature stages and without and where it is interpreted that the meteoric fluid is actually essentially posed to and did not have much of role to play here. So, in this context I would also like to mention that the fluid characteristics generally when we talk about in terms of salinity a temperature by getting a temp fluid which is moderately low and low saline and the temperature of the order of 200 – 300 degree Celsius or sometimes even a little less.

There could be interpreted also because there are new ideas coming up as to how a magmatic fluid actually evolves. Sometimes it is observed that most of the alteration characteristics and the fluid evolution can be explained by or without involving any extraneous meteoric fluid. And this generally would be a matter of conjectural and this is definitely I think which is to be looked into very carefully, but the possibility always is there and one would have one has to interpret the fluid inclusion data accordingly.

So, here whether so, most of the arguments in favor of a magmatic fluid. So, for example, if we take this particular the Bajo de la Alumbera case here the data or the idea that led to noninvolvement of a meteoric fluid during these most of the stages of a mineralization and alteration actually has come from the stable isotope data. So, fluid inclusion data cannot individually settle the issue the whether a meteoric fluid was actually involved or not involved.

So, in this case the most of the oxygen isotope data that were that was done on the alteration minerals in the potassic phylic and the argillic alteration zones the authors believe that it is they all show the signatures of a magnetic fluid which we cannot describe or cannot discuss in this particular context of discussion. But this original work can be consulted and see of those of because of the oxygen and hydrogen isotope ratios they do also indicate the fluid ancestry in terms of a meteoric fluid magmatic fluid or a connate fluid ok.

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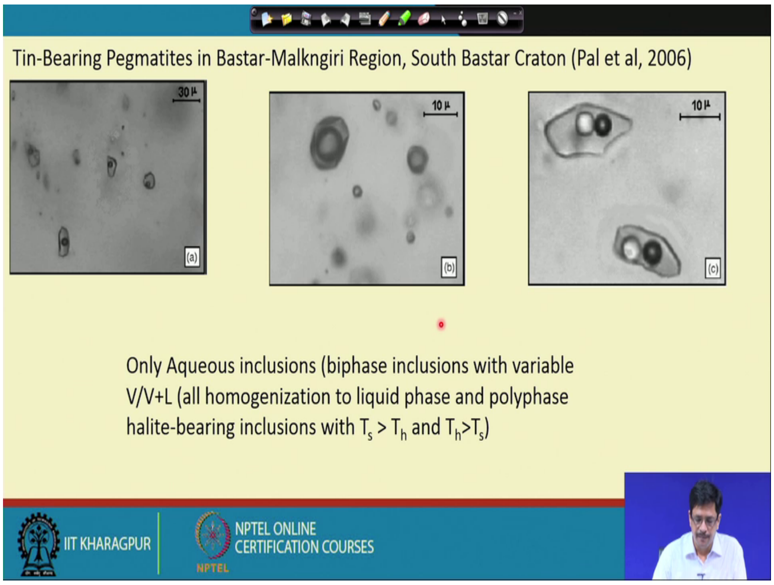

So, now I will like to discuss something about the about another Indian deposit which is a tin bearing granite pegmatics pegmatite system, because as I said that typically the skarn type of mineralization which give the majority of that in terms of the sources like many parts many other parts of the world. In the Indian shield, we do not have well established or well documented such kind of skarn deposits maybe some occurrences are there in the transferability region.

But, these are the ones which we got an opportunity to study and here it is essentially is a tin bearing pegmatite kyanite pegmatite system in the Baster Craton amongst emits the better sedimentaries belonging to the super series. And here the tin mineralization is in the pegmatites the pegmatites actually traverse the host meta sediments like quartzite or these hystographs are also the meta basics, which are the pre-existing rock types there and the pegmatites are present in these lithologys as well as in the barite.

And, the pegmatites which are observed in mythology like quartzite or in the meta basics they display a typical zone zoned nature of their occurrence. And also have a different or interpreted to have given rise to the mineralization in different stages of a cassiterite different generations of cassiterite and along with some culmer tantalite mineralization.

So, there have been a one of even though not a very major resources, but they are being exploited for the tin transform tin and molybdenum tantalum resources. So, here the inclusions were studied from quartz in the pegmatite from all the different types. The staniferous as well as non staniferous sometimes there are pegmatites which are also barren. So, when we the sample the tin bearing the staniferous pegmatite or the non staniferous pegmatite we will see that the fluid inclusion characteristics are more or less uniform in a sense that we get the aqueous biphase inclusions with low by the proportion of vapour as well as high proportion of vapour.

Although there is no record of any vapour phase homogenization of these aqueous inclusions, and we also see polyphase inclusions with containing single halide daughter crystal, where the homogenization of the dissolution of the daughter crystal is sometimes either less than the liquid vapour homogenization or more than the liquid vapour homogenization.

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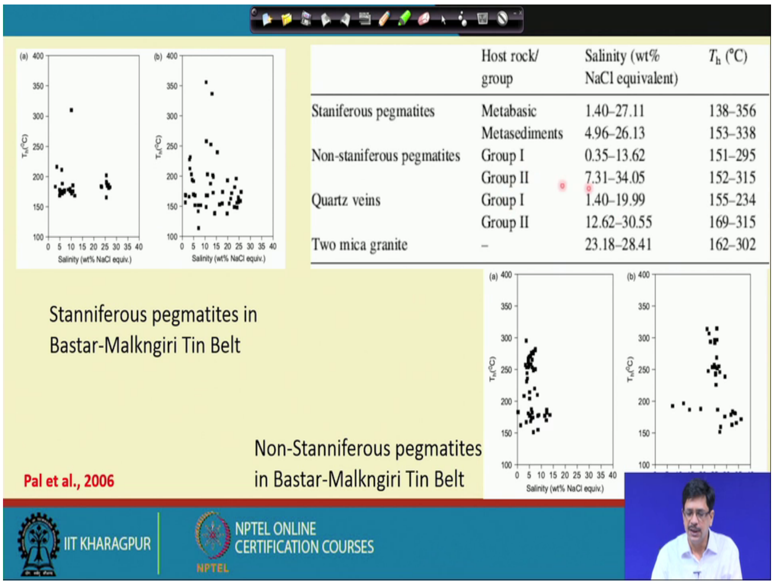

And, look at the ranges this staniferous pegmantite or the non staniferous pegmatite or the quartz veins and also for a comparison the host two mica granite also was studied for the fluid inclusions in the matrix quartz.

So, you could see what we get here is the salinity and temperature ranges are more or less very overlapping, but if when we see and just take an example of this staniferrous pegmatites over here, and the non staniferrous pegmatites, we could only we could only interpret in terms of presence of fluids of two different salinities. And one could always visualize that the mineralization definitely was brought about by or is likely to have been brought about the mixing of two fluids.

And, when it is a case of metal like tin one would expect that the fluid which is represented by a low salinity characteristics which should be which is more likely to be a meteoric fluid which will be more oxidizing and the other fluid which is more saline and is likely to be reducing in nature. So, that it could transport the tin in form of plus 2 the stanus ions in term in form of chloride the chloride complex the essential two type of chloride complex. And these two fluid must have is likely to have mixed and brought about the deposition of the tin in form of the cassiterite mineralization which kind of a confirms to the picture when we take from the staniferrous pegmatite either in the meta sediments or in the meta basics.

As you as against that when you look at the ones which are non staniferous we miss either of the two components either a low saline component or the high saline component. And, then we make our interpretation that what actually could have happened in this kind of situations. So, this is one example. So, this is a pegmatite from an Indian occurrence which I thought would be worth sharing and also the way that the argument or the logic was put forth and the fluid inclusion data could be interpreted in conformity with where you what you observe in the mineralization.

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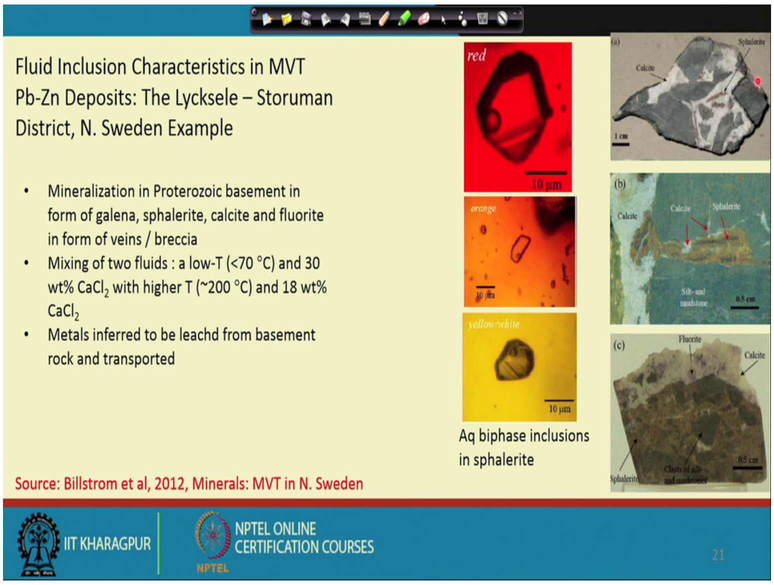

Well, the Mississippi volatile deposits are one of the very interesting deposits and are important deposit in terms of contribution of lead and zinc for the world. We know them occurring in the in the united states in the pry states in the state of in the Viburnum trend the state of Tennessee and so many such deposits. And such type of deposits in other parts of the world are also reported one of the interesting thing about these deposits is that since they are they do have sphalerite in the abundant sphalerite in them. And, sphalerite as a mineral also which can be studied and it is translucent or rather transparent in ordinary visible light and we can see fluid inclusions in this sphalerite.

So, here we do have a better idea or which a lot of more definitive about the characteristic of the ore fluid when we study such kind of a deposit although we do not get a very good such occurrence in the Indian context or a good documentation. So, it is a what taking up this example or looking at this example this has been taken from the Lycksele Storuman district in Sweden. This is one of the Swedish example where we could see this ore specimen where there are calcite and this calcite cement within brecciated kind of ore. This is present in the. So, generally they are suppose related to be epigenetic in nature and in the kind of cemented calcite and the sphalerite which is shown here and, they do also have fluorite.

So, in these kind of deposits the fluid inclusions could be studied in sphalarite and fluorite as well as calcite and give us a better control on the understanding the fluid characteristics. So, the mineralization is in proterozoic basement and the almost of the late proterozoic kind of time and in the form of galena sphalarite and calcite. So, here when the fluid inclusions were studied and the temperature in salinity values were determined. It was could be interpreted in terms of the fluid inclusion temperature homogenization temperature was observed as low as even less than 70 degree almost possibly 48 degrees is the homogenization temperature for the lowest inclusion and maximum going up to 200 degree Celsius. And the fluid in terms of it is salinity variation from as low as 18 weight percent, CaCl 2 to 28 percent ca CaCl 2 calcium chloride what we determined and, the metals to be inferred to have been leached from the basement rock and transported with this fluid.

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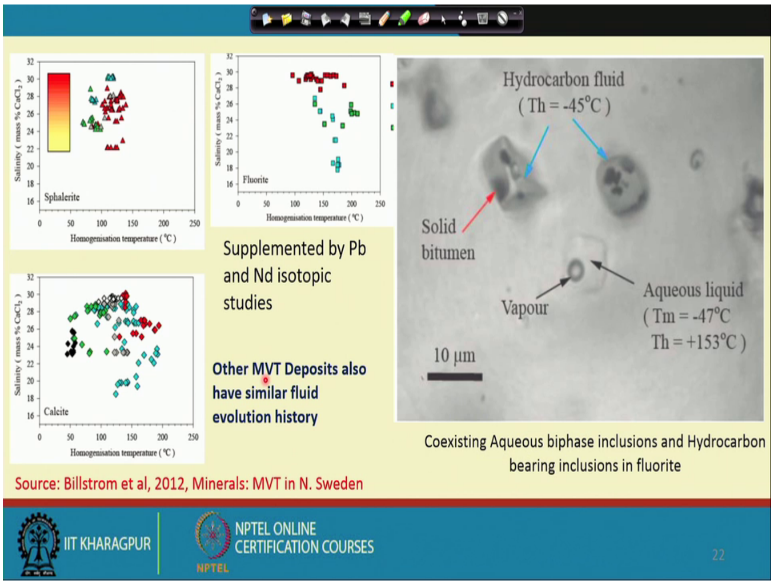

One thing we know about this particular mississippi valley type deposit they are interesting in the sense that this fluid. Most of the cases they are interpreted to be decimal fluid derived from the sedimentary rocks pores spaces of the sedimentary rocks and in this case they are the Cambrian sediments. And the here some of the examples of fluid inclusions from fluoride which you could see that here is an aqueous biphase inclusion which is core which co-exists with inclusions where there are hydrocarbon there are some this black things which are occurring inside the inclusion are essentially a bitumen and even there this liquid part also contains substantial amount of methane.

So, this fluid is very characteristic and characteristic in it is content of hydrocarbon and then the salinity and the temperature data for the sphalerite, and fluorite, and the calcite when they are plotted on temperature salinity kind of fluid evolution diagram the situation becomes very clear that they do represent fluids of different salinities. And it is inferred that the mineralization was brought about by a fluid mixing which even the in the composite diagram which we saw before. We also presented one, we also saw one typical Mississippi valley type deposit where in most other situations a Mississippi valley type deposit a fluid mixing trend is generally observed or interpreted, ok.

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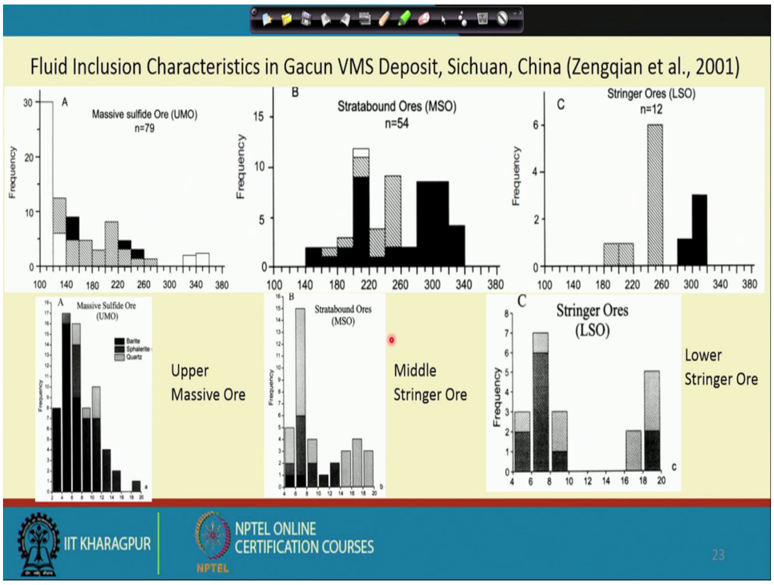

So, the as we know that the volcanogenic massive sulfide deposits do constitute a very important class of hydrothermal deposits and essentially results of seafloor hydrothermal activity, whether it is a cypress type VMS deposit occurring an extensional tectonic setting or a core coated deposit which is occurring in a convergent type of tectonic sitting is in the Japanese island. So, this is one example of a of the Gacun VMS deposit in Sichuan china which are essentially mesozoic inhales you have got ones compared to the ones which occur in the Canadian or in the in the BTB province in Canada.

So, in this particular VMS deposit these are this mineralized mineral mineralization sub is basically can be divided into the massive sulfide ore, the upper massive ore and the middle stranger ore. This as we as we know the typical geometry of a volcanogenic massive sulfide deposit where we get the massive sulfide lenses the massive sulfide lenses is immediately below is a footwall volcanics and which we get the stranger.

And, in this particular situation it is the designated is the middle stranger ore and the lowest stranger ore which is also a stock work type of zone generally where we see a quadratic type of alteration. And the fluid inclusion characteristics in terms of the salinity and temperature shown here where you could see the temperature going to in the upper massive upper massive ore going to 300 80. Or so, in both in this case also more than 300 in all these cases and the salinity value also going to 20 weight percent equivalent.

So, when we see this we know that they actually do not quite exactly correspond to what could have been a characteristic of a seawater which we know as one of the major contributing in a volcanogenic massive sulfide deposit.

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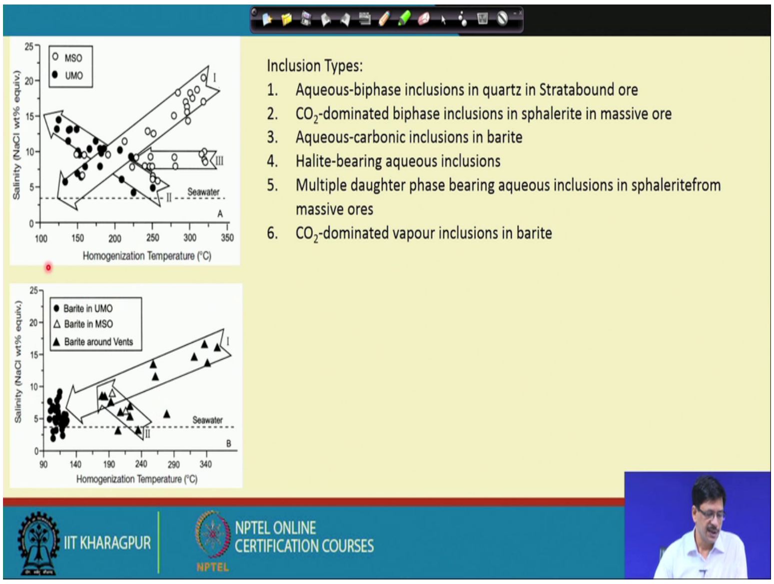

So, if we look at this data of the temperature and salinity here the people the authors who studied this particular deposit they interpreted their data in terms of mixing train in which the inclusion types that they saw was there is aqueous biphase inclusions. Carbon dioxide dominated biphase inclusions, aqueous-carbonic inclusions, halite-bearing inclusions, multiple daughter phase aqueous inclusions and carbon dioxide dominated vapour inclusions.

So, here as one of the important one of the characteristic feature of this particular occurrence of VMS which is that the fluid has carbon dioxide in it and the mixing. So, this is the generally the characteristic of this. This boundary represent sea water which is about 3.5 weight percent, and when we see a temp the water char the fluid characteristic which is way above a salinity and temperature compared to the sea water we could always interpret in terms of a fluid coming from different sources. And, when we see a typical model for the volcanogenic massive sulfide deposit we see there is a sub volcanic sub or a or rather we could be calling as a sub plutonic felsic magmatic body which gives rise to the fluid and then there is a impervious cap which keeps the fluid and the with it is metal content and then there is just two-two stage kind of convection cell in the upper part.

And, then with regeneration of this kind of the mixing of these two fluids take place after in response to kind of little deformation faulting of the impervious layer and this 2D, two kind of fluids that mix together mix. And then give rise to the mineralization. So, there is always a possibility of fluids very close to seawater salinity and temperature to mix with fluids of higher salinity and temperature have been derived by some other magmatic source or sometimes also it is speculated that this seawater also could have undergone a boiling this by give. And then it gives rise to components which are differ in salinity higher and lower salinity vapour and a higher salinity liquid. But, in this particular case the author they visualize this kind of mixing trend.

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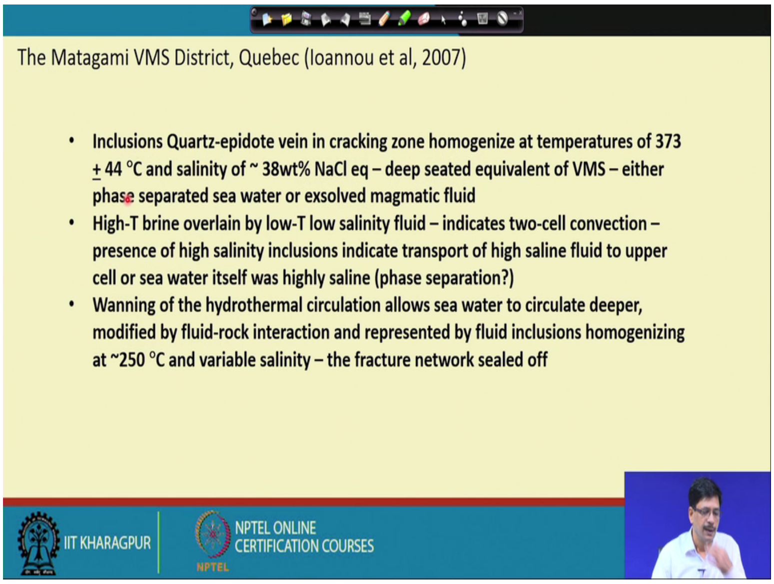

If we compare so, it will be worth looking at typically old Archean and VMS district in Quebec this is the Matagami VMS district in Quebec. So, it is as compared to the one which we just saw this, in this particular deposit where it is also being subdivided the mineralization into a into a cracking zone which is essentially the stock work zone where the fluid is supposed to be of a higher temperature.

And so, this you have the inclusions in quartz epidote vein in the cracking zone which homogenize temperature up to 373 degrees Celsius or and also have salinity weight percent up to 38 weight percent NaCl VMS; the high-T high temperature brine overlain by low temperature salinity fluid. They indicates to the exactly the what we are discussing now this convection. And it typically typical volcanogienic massive sulfide deposit is can be divided in space into a lower circulating cell which is dominantly contributed by a high temperature high saline fluid a possible magmatic derivation and a lower temperature, and variable salinity fluid which would be a sea water which percolates through the fracture spaces and, the mixing takes place.

So, here in this particular world and which is deposit is over is in the Matagami VMS district in Quebec which is in the BTB province in Canada, where this high-T brine that is overlain by a low temperature lower salinity fluid. It indicates that there is a two-cell convection and the presence of high salinity inclusions indicate the transport of the high saline fluid to upper.

So, whenever we say we find fluid inclusions of moderately high salinity then there is a always a possibility that that is created when the low there is a mixing between the low and the high circulating cells. And the volume of the hydrothermal circulation it allows the seawater to circulate deeper modified by fluid rock interaction. And then, they are represented by fluid inclusions which homogenizing through somewhat intermediate values of temperature of 250 degree Celsius.

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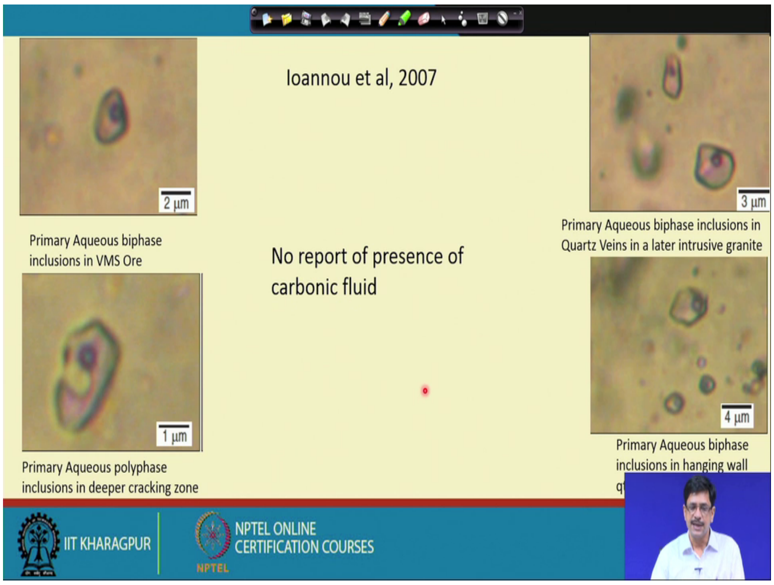

So, here are the examples the fluid inclusions which are these are the primary aqueous biphase inclusion from the VMS zone this kind of polyphase inclusions are coming from the cracking zone which are the lower zone which is dominated by magmatic magmatically derived high saline high temperature fluid. And, the one here this is also a situation which is after towards the volume of the after the mixing of the low the lower in the upper cell. And the fluids of moderate salinity and this inclusion type were also compared with the with the team inclusions taken from the veins in a nearby organic pluton which is later in the mineralization, just for comparison.

Now, the difference or the characteristic feature of this particular the fluid system that is there in the Matagami VMS district is we do not see any carbon dioxide in the fluid.

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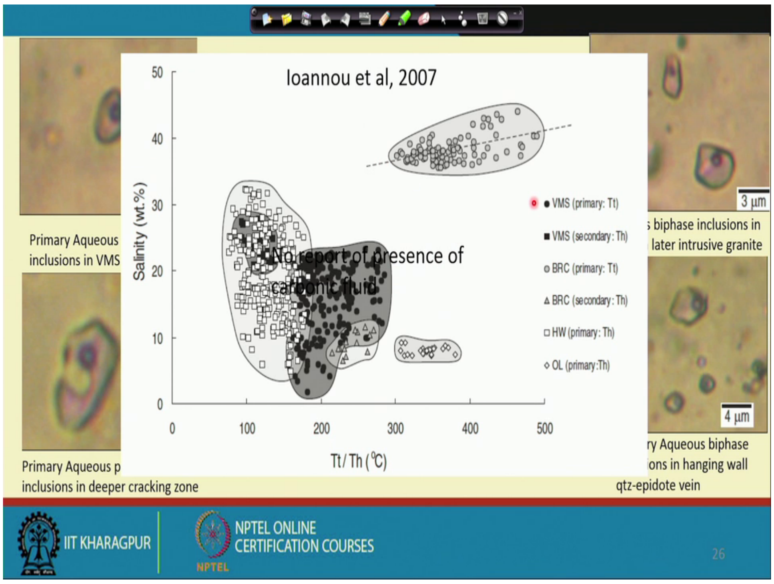

So, here the authors interpreted this; is this fluid to have evolved in this kind of a manner. This represent the this situation corresponding to the cracking zone where the it is a actually the stock work quartz epidote veins and the originally the magmatically derived fluid was confined to that part. And then, these black circle represent the VMS the main VMS zone. And this is the hanging wall sulfide region where we still the temp the fluid is evolved to a lower temperature with the mixing and this part is the fluid it is sampled from the quartz vein in the later geomantic phase.

But, the fluid as you as you is exemplified has been they seen from the fluid inclusion pipes and the distribution in different special zones, could be interpreted in terms of the mixing of these fluids and giving rise to the volcanogenic massive this sulfide massive sulfide lens. And, sometimes this with the later incursion of the fluid we also do get later veins quartz epidote veins. So, here this is a one of the good example of characteristic of the VMS deposit even though we do not have many such deposits in the Indian subcontinent. The only one possibly of a the one which is the from the lower cation the deposit which is reported as the normal deposit, but the there is no such fluid characteristic document as it available.

So, that brings us to the end of these today's lecture. And we will see another one or two examples of our application of fluid inclusion microthermometric data to ore forming environment and we will continue in the next class.

Thank you.