

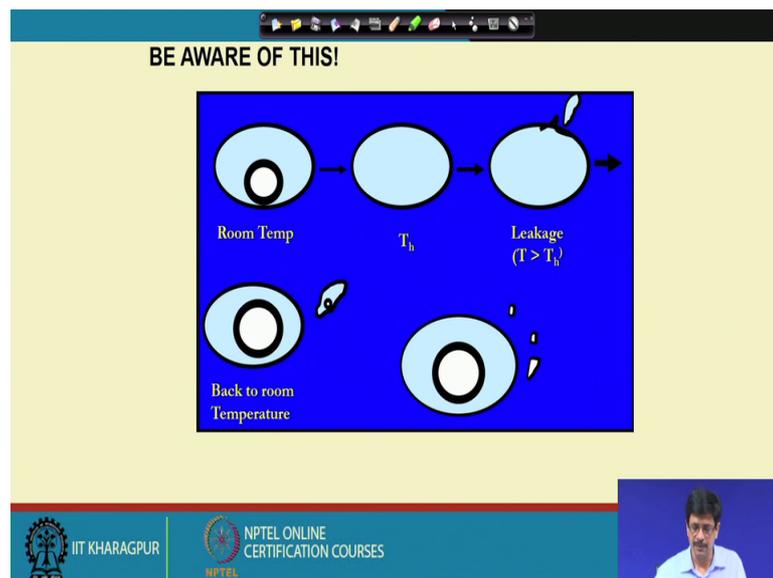
**Fluid Inclusion in Minerals: Principles, Methodology, Practice and Application**  
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**Lecture - 14**  
**Aqueous Fluid Inclusions (Contd.)**

Welcome to today's lecture. We will continue our discussion exactly from where we left in the last class. We will be, we were discussing about the some of the practical tips, some of the clues to do micro thermometric experiments on our judgement of choosing the inclusions, and not introducing much of mistakes in the choice of the inclusion. And in such kind of heating experiments we are generally fought with this, we generally face this problem that, sometimes inclusions are overheated and if those inclusions overheated beyond the temperature of that homogenisation; that means, the point at which they attain the homogenous state.

And we know that any further heating would actually make the inclusion move on the isochore, and if the inclusion is dense or dense higher weight percent NaCl equivalent it will follow a stripper isochore and that would be lots of higher internal pressure generated on the wall of the inclusion on the host crystal, and the inclusion leaks.

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So, if you see this what we have been discussing, we were just trying to understand that if an inclusion which is overheated beyond this temperature homogenization. If you are

observing it and we are going beyond the temperature of homogenisation and while observing the inclusion the leakage takes place, then will be able to very easily detect the chain during the micro thermometric experiment. So, we know that this particular inclusion has leaked during micro thermometric.

But there are chances that the inclusion might have leaked because of some earlier episodes some thermal perturbation, even it during the process of its evolution or there are chances that during a micro thermometric experiments, on an inclusion which we are not observing, but a nearby inclusion in the same sample, which is a has a little different kind of a composition or the trapped at different temperature pressure condition. It might so happened or the inclusion is larger either of this possibilities, the inclusion would have leaked.

So, if the inclusion leaks then there is the content of this so, it is exactly the process the as an when inclusion leaks, a part of the content gets out of the main bulk of the inclusion and gets immediately sealed. So, actually the process is exactly similar to a ceiling process. So, to entrapment or encapsulation process, that takes place primarily in the mineral that is growing from the fluid. So that means, if this inclusion is leaked and then again has its almost like as if press a silliness in for press entrapment actually is taken place at a higher temperature; and that will explain why the vapor bubble will be larger compared to what was there in the original inclusion. And we know that we did not see or we did not measure we did not have an idea about what exactly it was.

If it happens to be an inclusion, which we have taken the freezing done initially, and we did we noted down their parents or even taken a sketch or a photograph, and then we are by in the course of changing to a heating experiment, then we are heating this particular one. And we find that the vapor bubble seems to have sort of grown larger than you what it was before or we could clearly see some satellite inclusions like this, in this case or this case around that inclusion that we know that this inclusion has been leaked.

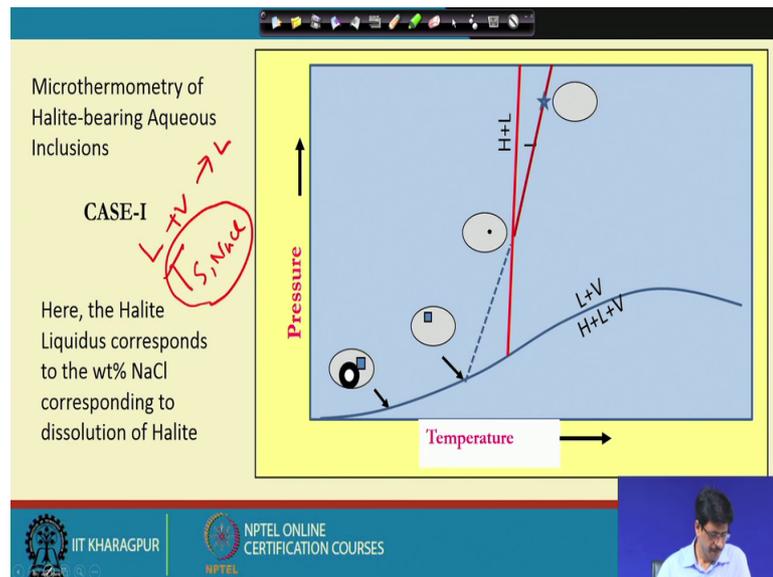
So, the suggestion is that it is not it is better not to take the run of this particular inclusion normally. And also in this I would also like to mention that the heating freezing experiments is done in such a way that, we put the chip inside the equipment inside the heating freezing system, the photograph the image which we have shown the each of these heating freezing system will have a simple chamber, where a particular chip which

is broken from the fluid inclusion section is put inside that sample holder. And when we do a freezing study, we first do the freezing study on all the aqueous biphasic inclusions that that there that we plan to take the freezing runs.

It is not that we alternately heat even though in a stage Linkam Thm s g 600 kind of a stage, it is possible that in that the same inclusion could possibly be frozen and then again heated. But, I would suggest that a freezing study a freezing done should be first completed on all the inclusions that you plan to take. And then this gives us the it become sometimes the practical problem is here, that would relocate back those same inclusions on which freezing runs have been taken. Because, as we will see that our data on this inclusions have to be paired data on their homogenization temperature and salinity in terms of weight percent NaCl equivalent.

So, it is mandatory that freezing and heating run be taken on the same inclusion. So, if you have taken the freezing run on say 10 number of inclusions that are present in a chip and we decide that will be freezing these 10 inclusions aqueous by freezing inclusions then sequential again we have to relocate them one by one. So, now, that so, in that process if any particular inclusion would have been would have been overheated, then it should be very well documented and the data of that particular inclusion should be discarded. There could be many more such kind of practical aspects of fluid inclusion studies and as in we may discuss some of them as then when they come even through case studies.

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So, we will now from the aqueous biphasic inclusions we will. So, discuss on the other important type of inclusions that we mostly encounter, are the inclusions which are the aqueous polyphase inclusion. And the poly aqueous polyphase inclusions just to give a little bit of an idea that considering only the ones where we get a single crystal that is the sodium chloride. And we have also discuss that there is a possibility that the crystal that we observing, a crystal of sodium chloride is that it is precipitated from the liquid as the temperature pressure conditions decreased. There is an another possibility that this particular salt crystal is not a result of precipitation from the liquid on attainment of saturation, but it is actually a case of heterogeneous entrapment or caught up as a solid phase when the inclusion was trapped.

Now, since with this stage we are only considering homogenous entrapment. So, we will not consider those cases now. And in such cases where so, the only way to so, when we are doing experiments on such kind of polyphase inclusion, it is good to actually keep it in mind, that when we see aqueous polyphase inclusions containing halite daughter crystal, it is very possible that we should get a group of such inclusions polyphase inclusions in a sample; rather than just a stray case of only one alone inclusion containing a halite daughter crystal and no other such polyphase inclusion, then observed in the sample. Then it gives us our suspicion that it possibly could be a daughter phase, it could be a captive phase captive in the crystal which is caught up as a process of heterogeneous entrapment.

So, we go by the assumption that the entrapment was homogenous, and the daughter crystal which is observed in the inclusion cavity is a result of precipitation as a post entrapment phase change; precipitation from the liquid on attainment of saturation with respect to the particular solid crystal. And in this case it is sodium chloride. And we and also we discussed that such inclusions the, they the freezing study of such inclusions is not going to give us any idea on the salinity of such kind of inclusions. So, the basic idea is that we want to get the salinity of this inclusion to calculate density.

So, now we will talk about the microthermometry of the halite bearing aqueous inclusions and let us take the case 1. So, the case 1 it indicates that this star corresponding to some pressure temperature value let us say  $P_1 T_1$ ; here the one phase liquid homogenous liquid was entrapped. And since, it is homogenous one phase liquid so, it is it will also as per our own assumption it will follow isochoric path. But, it will follow an isochoric path till the point where this halite will attain saturation means there will be appearance of one small I mean nuclei of a halite crystal here

Now, since such this particular the appearance and halite crystal actually would correspond to what is been plotted here as the liquids halite liquids, where it to be halite plus liquid on this side and one phase liquid on the other side. So, such liquids so, this liquids actually correspond to a very fixed weight percent of sodium chloride as you will be seeing them at a what could be the value. So, suppose this is  $P_2 T_2$  temperature pressure corresponding to the point at which the halite crystal is appeared. So, now, it will be following a path in the halite plus liquid line halite plus liquid coexistence, it would be a not exactly line would be curve because a density is going to change is not going to straight line, but it is going to be a curve.

So, it will keep on evolving with the size of the halite crystal gradually growing and it will finally, intersect the curve which actually is the halite plus liquid plus vapor and liquid plus vapor curve. As we saw before in a phase diagram where, a water plus NaCl a system was depicted, with the continuous critical curve then the halite plus liquid plus vapor curve. So, it actually will be present some intersect that halite liquid vapor coexistence curve here. And from that point here the vapor phase will nucleate as and when it comes to the point here, there will be a vapor phase and the vapor phase nucleates and the vapor phase goes on increasing in a size.

So, this we see at the room temperature, biphasic, a sorry aqueous, polyphase containing vapor plus a sodium chloride crystal. So, this is a situation corresponding to case 1. Now what is the exactly the same situation, what we did before that we reverse try to reverse this phenomena, and record the change the phase change then what kind of phase changes will be expecting here. So, if we reverse this. So, when we increase the temperature at some point, the vapor phase is going to disappear a liquid vapour homogenous will be take place and then from that, we will only have a liquid plus halite which is which will exist and it will follow the curve again and we will go on up to the point, the point at which the halite will disappear.

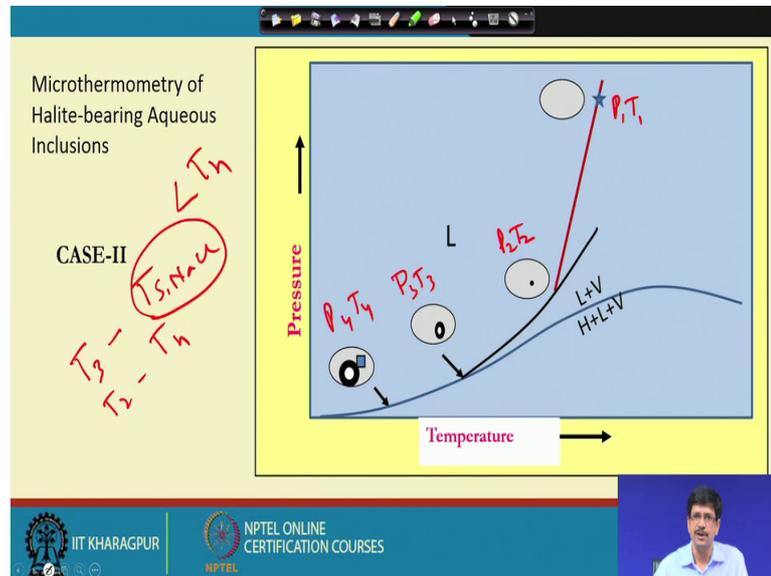
So, we will be in we will be in fact, be noting down these parameters this is of course, a temperature of homogenization, we can say that we will get a value corresponding to a L plus V to L, but that temperature will be not of much help to us here because we have not attend a homogenous state of the of the conclusion fluid. We will be attaining the homogenous state of the inclusion fluid only at temperature pressure corresponding to this  $P_2 T_2$  where the salt crystal disappears. Exactly the same mechanism the point at which a salt crystal nucleated, and when we are during the process of heating when we are reaching at this particular temperature pressure condition the salt crystal will disappear.

So, that will be the temperature of dissolution of NaCl. So, here we will represent it in the in form as  $T_s \text{ NaCl}$ . To be most specific we can write  $T_s \text{ NaCl}$  or you can write  $T_s$  and so, this temperature  $T_s \text{ NaCl}$  is the one which is near important parameter for us as far as this particular situation is concerned. And here we attain the homogenous condition and we know that from this point onwards the fluid will follow an isochore and the logic is exactly same we discuss before, we will not be able to reach at the point corresponding the trapping temperature, we can only go up to a up to a situation where the salt crystal disappears. It is possible to reach at a point of  $P_2$  and  $T_2$  beyond the temperature at which liquid plus vapor homogenization took place.

So, this is a first possibility and here we are this is the case 1, where the halite bearing inclusions are entrapped and evolve and the post entrapment phase change takes place and heating response which is exactly done to reverse the process, in which we can note down the temperature of liquid vapor homogenisation, which will which occur first at a temperature lower temperature and then further heating, it follows the halite plus liquid

coexistence curve till the point at which the halite liquids mix and beyond which it is a single phase liquid field and the inclusion has attained homogeneous state and it will follow an isochore.

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The second case as can be depicted is roughly that it might have so happened that, the inclusion fluid was much less a line the weight percent NaCl equivalent was less compared to the first case here the inclusion is trapped as a single phase liquid, and then on the way of its evolution in the following the isochore, it will intersect the liquid plus vapor liquid. So, essentially boiling curve of the corresponding to that particular liquid particular water NaCl system so, it to further decrease of the temperature the vapor bubble goes in size, and attains a larger size particular this point and then again during this process what happens that the, halite attains saturation and it comes to existence and we see a halite crystal.

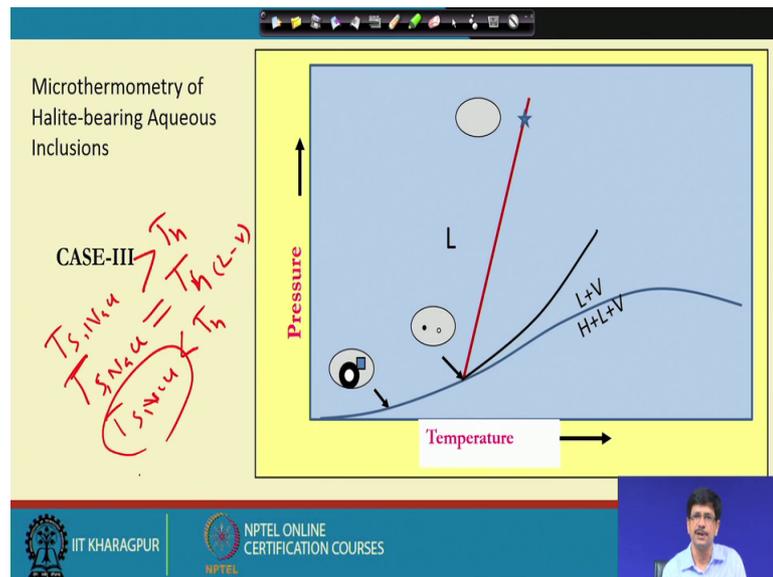
So, if we reverse this process what we expect here that, the temperature of dissolution or halite can be observed between suppose this is our  $u$ ; this is the  $P_1 T_1$ , this is  $P_2 T_2$ , this is  $P_3 T_3$  and this is  $P_4 T_4$ . So, what happens is that this halite which was present in the room temperature will disappear at a temperature corresponding to temperature pressure correspond, temperature let us say temperature corresponding to  $T_3$ . So, further heating from  $T_3$  to  $T_2$  it actually follows a liquid vapor equilibrium curve at which  $T_2$  the vapor bubble disappears.

So, here in fact, the temperature  $T_3$  is also useful to us, because  $t_3$  will essentially correspond to the  $T_s$  NaCl. So, here  $T_3$  is nothing, but our  $T_s$  NaCl here and  $T_2$  will be the temperature of homogenisation at which the fluid will attain homogenous condition, and then  $T_1$  is the temperature of trapping as we know before. So, here the why I say that the  $T_3$  is important for us, because  $T_3$  is  $T_s$  NaCl and the salinity of this particular inclusion fluid is calculated based on this  $T_s$  NaCl as before. So, previously the liquid vapor homogenization was not an important parameter to us.

But here the temperature  $T_3$ , which is less than so, here actually  $T_s$  NaCl is less than the  $T_h$ . So, the previous case the  $T_h$  NaCl was greater than  $T_h$ . So, the homogenous state was obtained only at  $T_s$  NaCl and here the homogenous state is obtained and liquid vapor homogenization. So, in both these cases, we calculate the density only at which the temp the fluid becomes homogenous the temp the stay it attains the homogenous state, and then we calculate the isochore exactly based on the questions we should discuss before. If there equations were formulated which will be applicable to a much wider range of temperature and pressure and also the weight percent of salinity of the weight percent NaCl equivalent.

So, the equation which we described in terms of the  $d\rho$  by  $dt$  being fitted as a function of temperature and salinity, and it has a very wide range of applicability and most isochores can be constructed. And in case you are dealing with a fluid which is far more saline than of the contains the weight percent NaCl content is higher than the range of applicability of the previous set of equations we can always look for which set of equations should be applicable to construct the isochore in that case and the third possibility is the one pair the halite.

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So, here the similarly the situation is that the inclusion is entrapped at corresponding conditions of  $P_1 T_1$  here and so on is the star here follows the isochore, and it meets at a point which is exactly kind of an intersection of this liquid plus vapor and the halite plus liquid plus vapor. So, here what will happen that are halite and the vapor will simultaneously nucleate as the temperature and pressure decreasing. And on further decrease of the temperature and pressure, both the halite and the vapor bubble (Refer Time: 20:43) in size and we see them in this kind of state at room temperature.

So, heating this inclusion will characteristically show that the liquid that the solid halite crystal and the vapor are disappearing at the same time. And then this becomes homogenous and. So, here the situation is that  $T_{s NaCl}$  is equal to  $T_h$  say you put put L v liquid vapor homogenization. So, there are 3 situations where  $T_{s NaCl}$  greater than  $T_h$  in that case the density is calculated based on the temperature of  $T_{s NaCl}$ , the  $T_{s NaCl}$  is equal to  $T_h$  there also the density is calculate because their the fluid is becoming homogenous. So, both salinity the salinity salinity is calculated on the base of the  $T_{s NaCl}$ , and here  $T_{s NaCl}$  is less than  $T_h$ . So, here  $T_{s NaCl}$  is also important for us, because the salinity will be calculated based on  $T_{s NaCl}$ , but density will be calculated on the basis of the temperature at which the fluid has become homogenous.

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**Homogenization by dissolution of daughter crystal**

**ARE ALL SOLIDS DAUGHTER CRYSTALS?**  
**DO ALL DAUGHTER CRYSTALS DISSOLVE?**

$$W_{\text{NaCl}} = a + b T_d + c T_d^2$$

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So this is the, these are the 3 situation which are depicted here the case 1; there is a the some little bit for practical practicality involved that what exactly happens. So, if this is a room temperature condition in which the halite is observed with a very well developed phases and the edges. So, with slight increase in temperature from room temperature to say about 100 degree or so, the halite actually dissolves by first rounding off of the edges and becomes circular in its outline, and gradually decreases in size and becomes almost like a black dot and disappears.

So, as compared to a liquid vapor homogenization, here we do not see the halite executing any Pseudo Brownian movement because it is a solid crystal, and chances that the similar kind of situation that if the inclusion geometry is not very proper and there are some clarity problem, then one may always miss the point of dissolution of the NaCl by a few degrees. But, then in that case one has to adopt the same strategy that go on doing this repetitive measurement of the dissolution of the crystal, and a point here exactly same thing happens. If that if one has obtained the temperature of dissolution of halite say corresponding to  $T_s$  NaCl, then decreasing the temperature by a few degrees from  $T_s$  NaCl the halite will possibly will not nucleate instantaneously.

But we will come into existence temperature much lower than the  $T_s$  NaCl. So, if the  $T_s$  NaCl this a sodium chloride crystal is not fully disappeared a full not full melted or dissolved, then by immediately decreasing the temperature from temperature of the

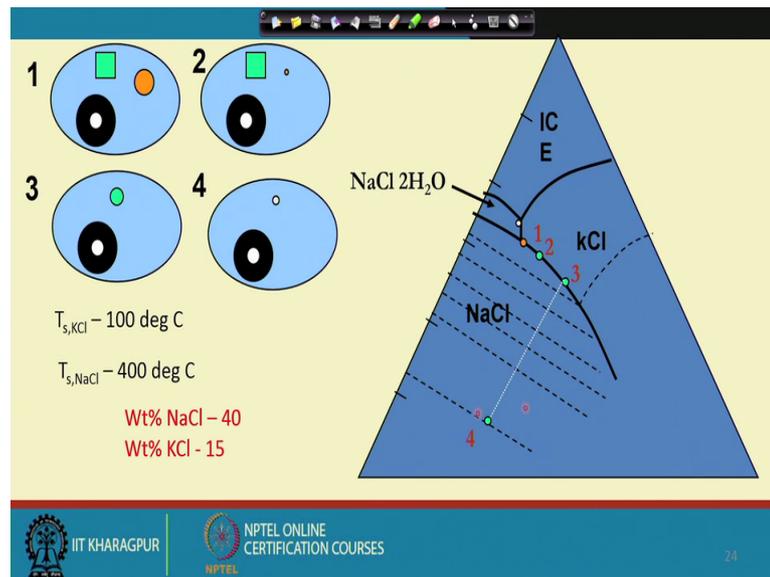
temperature which was erroneously, measured as a temperature of a dissolution of a halite a halite crystal will start doing from that particular point. So, these are the practical situations in which by repetitive measurement and some of the inclusion the clarity could be very good and here also we talk about the producibility of the order of plus minus one degree celsius.

So, these are the 3 situations which are discussed. So, in this is a  $T_s \text{ NaCl}$  is less than that of  $T_h$  here  $T_s \text{ NaCl}$  is more than  $T_h$  and here is  $T_s \text{ NaCl}$  is equal to  $T_h$ . So, we have discuss the issue of are all solids daughter crystal. So, if not their coptic crystals and their dissolution will not a dissolution temperature is not going to tell much about the fluid characteristics. And, a question that do all daughter crystals dissolve because we discussed that there are polyphase inclusions in many situations where the content daughter crystals more than 1, sometimes there is gypsum daughter crystal or a calcite daughter crystal sometimes there are even sulphide, mineral their present is a daughter crystal.

And in situations like in porphyry copper deposits there are inclusions with multiple daughter crystal which have reported. We find that the chlorides mostly the 2 chloride for the dominant daughter crystals sodium chloride and potassium chloride that there is a halite and sylvite, there we find that we are able to obtain the dissolution of the daughter crystal in a heating experiment. But we find sometimes that the kinetic of dissolution in other. So, daughter crystal like calcite or gypsum an hydrate sometime is very slow, and people report of an obtaining such kind of dissolution by doing prolonged heating experiment, skipping the temperature starting at a very long for a very long time to take care of certain issues, but those are the things which we are not discussing in this particular lecture series.

Conferring ourselves to very commonly encounter situation simple situations and which we can use micro thermometry for characterization of the fluid and understanding the fluid evolution. Corresponding to temperature of dissolution of the daughter crystal which is halite in this case, it also can be fitted into a non-linear equation in  $T_d$  for calculation the weight percent of NaCl. Since, we know that the room temperature solubility is a round 26.3 so, this parameter a mostly will be that and for the increase in solubility of sodium chloride that is halite with temperature can be fitted is a function second degree polynomial in  $T_d$ .

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And just as we were discussing we can just quickly have a look on a situation where it is a complex or ternary, sodium chloride potassium chloride and water system, where there is possibility that we get a situation there are 2 daughter crystal present; one represented as this green square is a halite and the one with orange circular outline is sylvite that is potassium chloride. And this is what most of the cases it happens, the halite and sylvite when their present together this is the way we see them optically they can be distinguished one having a very sharp phases and edges one is rounded is potassium chloride.

So, the heating behaviour of such inclusions can be understood with the help of this ternary this is an H<sub>2</sub>O NaCl and KCl ternary part of it. Around 60 percent of NaCl this side 60 percent of potassium chloride this side, and we can go we know that we go from here this is the pure KCl corner. Now, in on this if you try to use this particular diagram to understand the freezing to the micro thermometric behaviour, then here this is a binary this is the ternary eutectic; the ternary eutectic value is something around minus 23 to minus 24 h L NaCl KCl minus 24.9 near about approximately 25 degree Celsius and this is the NaCl H<sub>2</sub>O NaCl 2 H<sub>2</sub>O hydro halite field, and these are the temperatures

So, this is the temperature contours 100 150 200 250 300 400 like that and let us say that we have a aqueous by aqueous polyphase inclusion containing halite and sylvite as daughter crystals. If you heat them and also let us presume that these existence of this

halite and sylvite have come into being being there in the inclusion cavity after the liquid vapor separation. So, the homogenous fluid and the first thing to occur here was a vapor phase separation and with both this halite and sylvite attaining the saturation at temperatures which are then the lower than the  $T_h$ .

So, here what we see that we suppose the bulk composition of the inclusion was somewhere here which we did not know exactly what it is. We are seeing as halite and sylvite and say like for example, we start heating it when we start heating it this orange circle corresponds to a room temperature where you have the curve, which is corresponding to KCl NaCl coexistence. So, both this both NaCl and KCl are present here. If we increase the temperature because of greater solubility of potassium chloride this sylvite crystal will first start decreasing in its size if this and it will decrease in size and by that there will be a little bit of an apparent increased in size of the sodium chloride crystal instantaneously but it is not going to continue for long.

And point corresponding 2 is where is shown that the halite and sylvite are both existing, at a little higher temperature about 80 degree 60 degree the so. And then temperature at the point 3 about near about 70 80 degree centigrade or so, this sylvite crystal is disappearing a sylvite is completely dissolved. And now, it has gone into the region of NaCl plus water stability field, and it will continue to move to the higher temperature in this region with gradual decrease in the size of the sodium chloride crystal and as it as it happens before this it will be rounding off of the sodium chloride crystal, and the gradual decrease in size finally, it will just disappear at a point corresponding to 4.

At this point we can by using of the couple the values here on the ternary as we as we generally read from a ternary diagram, this is 40 percent NaCl and 115 percent KCl which is essentially by the way by the sequences of the changes the phase changes we observed in an aqueous poly phase inclusion containing a halite and sylvite daughter crystal both. There so, we are not going on to discuss many other ternaries here of the freezing this micro thermometric response ok.

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The slide is titled "Presentation of Microthermometric Data". It lists "Sources of Error" as Calibration, Replicate measurements, and Metastability. It also states "Similar Histograms for Salinity / Density Data also". Handwritten notes in red ink include: ① Failure of vapor bubble nucleation response, ② No gas in vapor bubble, ③ Failure of vapor bubble to nucleate, ④ Non-reproducibility. There are two histograms: the top one shows "No. of Inclusions" vs "Temperature Interval" with a multi-colored bar chart; the bottom one shows "No. of Inclusions" vs "Temperature Interval" with a black and white bar chart and labels 'L' and 'V'.

So, we will now go on to discuss so, to we have reached the stage for examples let us say we have selected our sample, got our fluid inclusion sections, have done routine petrography and we have classified inclusions and we have started our work with our aqueous inclusions. There are other inclusions as well there maybe carbonic inclusions and all of the types of the inclusions; we have taken the data on them what the micro thermometric response for the carbonic fluid will be the discussion for later lectures. And suppose we have generated the data, we have acquired the data on as many number of aqueous inclusions that we have planned initially to take.

So, before going on to discuss that to how we present the data, we could possibly quickly discuss some of the issues that might have been there during the course of micro thermometric. Generally, it is a voice to talk about what are the different sources of error that could be there in our data. The first thing is that calibration which would have a initially during our description of the micro thermometric principles as well as the equipment that is used for micro thermometric studies, we know that those equipment have to be periodically calibrated for the stability of the equipment there electronic equipment. And if we have not been careful enough or there is been some instrumental error, where the calibration could possibly shifted very quickly or very arbitrarily, then that could be a situation in which that is could be a source of error

So, this source of error we can say that it is within to control of our the fluid inclusions is at is instrumentation, and to get the instrument calibrated if you there are some instrumental errors to rectify those errors, to see to it that the calibration does not shift. And in a system like a like Linkam T h g m g is 600 this is a 3 point calibration that we generally do their, temperature at a much lower value as corresponding to even minus 200 or minus we can go up to minus 196, when we know that we can make liquid nitrogen to pass on the stage. The and one point at about 0 and the another point could be any higher temperatures mostly 500 600.

So, that gives us a calibration line, which will be and then we can go on to take some standards is as unknowns. For example, any melt any metal whose melting point is known and use them as unknowns that can see whether the values reproducible or not. So, getting a getting an instrument with no calibration problem is a first and foremost requirement for a for micro thermometric measurements and to make the data meaningful. If the replicate measurements are not done, then the as we know that the variation in even point 1.2 0.3 a 0.5 degree Celsius in the temperature of depression of freezing point, would result in difference of 0.3.5 weight percent NaCl and which will also cause a difference in the density of the fluid that is not that is not acceptable that is also not advisable. It is always better to take data which reliable accurate and reproducible.

The third important aspect of fluid inclusion micro thermometry, which needs to be known very well, but little to be little could be done with it is the metastability. Now what we understand by metastability is, in the context of occurrence of monophasic inclusions monophasic aqueous inclusion with it mention a little bit about the vapor bubble not actually is being the absence of a vapor bubble in a aqueous inclusion, one of the causes being metastability means, the vapor bubble could not nucleate in the inclusion cavity. That is that can happened and sometimes the metastability degree of metastability could be feeble to very serious. Sometimes what happens?

So, this is one number 1 that sometimes we get this as the failure of vapor bubble to nucleate it one, the other is that many a times it leads to pretty much conjunction of time as well as unsuccessful micro thermometric experiments with which sometimes so happen is the a lack of response no response on freezing. There is a aqueous biphasic you could see there is an aqueous biphasic inclusion, your subject you need to the freezing

experiment. You see that there is absolutely no change even if you go on decreasing the temperature to minus 1 and 6 sometime it is observed. These kind of a testability sometimes explain that when the what you basically wanted to achieve here is that the inclusion to freeze become solidified, that has not happen that is a metastability.

Sometimes say it is explained that if there is lack of any kind of seed crystal or some particular something that helps in getting the liquid frozen, when absence of that it may not, but that could not be ascribed as a reason in case of fluid inclusion. Because, when we say that a majority of the cases we get the responses we expect, in some we do not get any kind any response no shrinkage of vapor bubble no solidification of the liquid, and it its can be only recalled that the inclusion is metastable. Even the, such kind of exact causes of such metastability is also not very well a settled.

Then sometimes it is observed that the vapor bubble after temperature and homogenization is obtained a vapor bubble does not come back or fail of reappearance exactly we can say the same as little bit of a variation of the point number 1 the failure of the vapor bubble 2 nucleate. This is a also a meatstability, sometimes these kind of metastability or we can say that failure of vapor bubble to nucleate or reappear after homogenization. This sometimes can be circumvented by again going on decreasing the temperature to even for lower value corresponding to again freezing and sometimes as I said that this metastability, the degree of metastability is variable.

Sometimes the metastability is feeble which can be circumvented overcome by doing repetitive cycles of such heating freezing experiments, but then the fact remains that only those values which are reproducible should be accepted or else those values should not be accepted at all. The other one with what we see is the failure in reproducing or non reproducibility you can say that, means in a particular single phasing run we determine a temperature of melting of the ice let us say minus 5.0 degree Celsius. When we are doing repetitive or to replicate measurement, we get values which are completely different and then completely different value on any subsequent stages of any subsequent freezing run, this also is described as a manifestos and (Refer Time: 41:39).

So, these are these some of the points can be discussed as the sources of error and it is advisable that inclusions which are showing any such problems of metastability, they data should not be included that data should not be accepted only those inclusions, where

the be inclusions respond the way exactly as per the our basic knowledge of the phase, changes the phase behaviour and when you get the temperature of homogenization or the temperature of melting of the ice well reproducible, then only we will accept those data otherwise not.

And sometimes it is suggested that the degree of metastability is also related to the size of the inclusion. The inclusion which are generally less than 5 micron size some sometimes even such inclusions display for greater degree of metastability, compared to the inclusion which are of moderately acceptable size range of between 10 to 14 microns or so.

But then sometimes it so happens that the by simple, that could be scarcity of good workable inclusion and then one has to take measurements on such smaller inclusions, but then a fact is that if those inclusions display such a high degree of metastability, then their data cannot be used. So, we will continue our discussion in the next class and complete a discussion on the aqueous inclusions, and then move to other topics. So, continue in the next class.

Thank you.