Laboratory Practices in Earth Sciences: Landscape Mapping

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Welcome back. So, today we are going to discuss the dating part as I have mentioned in the previous lectures also that dating is again one of the most important aspects. If we are trying to understand the time frame of the evolution of the landscape and also the events like climatic events if we want to bracket or the tectonic events also. So, these are the best techniques and one of the best techniques which is available is the optical stimulatory illumination because this gives more precise age as compared to the order dating techniques. I do not say that this is the only best, but I would say that it is one of the best techniques which is available. So, we have been using EMS also. That is accelerator mass spectroscopy that is based on the air you are using carbon or like charcoal or you use the buried roots or any old stuff which comprises carbon that can be dated with what we call the C 14 dating actually.

Now, coming to this part let us have a brief discussion and as I have also emphasized in the previous lecture that this will be followed by a lab. So, we will be having the lab visit. So, let us see what exactly is the optically stimulated illumination and short form that we call this as an OSL dating. So, the development of illumination if we go back then initially it was like thermal illumination dating technique. A TL was first developed by Asking in 1964 and initially it was applied to the archaeological sites and mainly to obtain the firing age of the ceramic material or you can say the potteries.

But later it was thought that why cannot this technique be applied to other fields of geology and earth sciences. So, then David Hutton and his colleagues found that the TL dating technique could also be applied to sediments and since quartz and feldspar could be set to 0 , I will come to what exactly we are talking about. But they found that the quartz and feldspar are the most abundant minerals which are available in the sediments and can be used as a part of measuring the illuminations stored within it. And so, actually zeroing I will briefly tell this is also termed as bleaching actually ok. So, when the sediments are exposed to sunlight then whatever the energy was stored when they were buried will set to 0.

So, all illumination has been completely wiped off and that is what we call bleaching. So, whenever so, this sediment can be like I would say that can be used again and again and it can be used as a clock ok. So, when it gets buried it will keep acquiring the energy and that energy is being stored in the form of the illuminations ok. So, quartz and potters feldspar that are both silicate minerals comprise typical lattice ok. And this is what we call the charge defects.

So, this lattice depends again on the crystal form ok. And they are that this lattice is usually formed during the crystallization process when we talk about the eruption of magma or the lava flow and all that just to cooling effect that is what the process of crystallization is ok. So, these two minerals of silicate family they have good lattice which can store the energy and when they are artificially like what we call stimulated they will release the energy stored in form of light ok. So, this led to development of optically stimulated illumination dating technique in 1985. So, this is not a very old technique which we are talking about right now, ok.

Now of course, it started way back like in more than 50 years 60 years back like in 64, but now the OSL is not very old one ok. So, illumination dating basically what we talk about is that amount of light that is your illumination emitted from mineral grain like quartz and feldspar when stimulated by a beam of light is used to determine the elapsed time since the sediments were buried after deposition. So, this will give you the time of burial and that is what we call the time of deposition age. So, after the deposition how it will keep acquiring the charges ok. So, or the energy so quartz and feldspar they act as a dosimetry ok.

Recording the amount of radiation to which they are exposed during burial. So, here the exposure does not mean that they are exposed to the environment they are buried in, but they are exposed to the radiation because the earth material is radioactive ok. So, from that surrounding material they will keep acquiring the radiation ok. So, when they are exposed to those materials they will keep acquiring them. So, once the sediments are eroded, transported and deposited, that is by whatever the action you take wind water or ice and subsequently buried ok.

So, once this is the process like you have eroded, transported , deposited and finally, buried ok. So, buried they are away from the light and this is basically we are talking about the sunlight ok or any artificial light also, but they are away from that they are and, but they are exposed to low level of natural radiation which has been like in form of alpha beta and gamma from the surrounding sediments. So, this is exactly why being exposed to radiation is ok. So, they are not acquiring the energy from the natural light, but they are acquiring the energy which is what we call the low level of radiation from the surrounding sediments. This is what we are having the radioactive material. So, radiation comes from the decay of radioactive elements and these are the elements like uranium, thorium, potassium and rubidium ok.

So, these are the main minerals, sorry the radioactive elements which enrich the energy or they allow the sediments to store the energy. So, this is what the energy is mainly coming from the radioactive elements. So, now, when these crystals are irradiated again by the radioactive material ok, part of the radiation is released and the rest will be trapped ok. So, basically what we are looking at is the trapped charges in the lattice. So, when such crystals are heated, even if this is again we are bringing into the laboratory and artificially heating them the stored energy will be released and that will be released in the form of light and the process what we call is thermal illumination effect.

So, luminescence dating is basically categorized into two, one is thermal illumination dating and another is optically stimulated illumination ok. So, these are the two categories we have and then on OSL in particular in OSL is a measurement of trapped charges concentrated in mineral grains and determination of the environmental dose from the surrounding grains. So, this is what we call that is what we try to get the D e that is dose and then another is the dose rate ok. So, these are the two parameters we will be coming to this for and that is how we are going to get these two parts ok. So, now further information about this is that when we calculate the age we also try to take into consideration the cosmic ray energy which is also affecting the overall energy stored ok.

And that is one of the reasons why we need to know the precise location of the sample from where the sample has been taken. So, apart from the alpha, beta and gamma what we are talking about the radiation source ok. The minor extent is also seen from the cosmic rays from outer space ok. So, this is what we see that there is some contribution of the cosmic rays also when the sediment is buried within that. So, surrounding us we will see that alpha, beta and gamma it will keep on radioactive material will keep enriching the lattice in form of the charges, but the cosmic rays also will have some sort of an input in that ok.

So, radiation energy trapped in crystal defect is stimulated in laboratory through TL or OSL method that we will see how what what are the this this OSL method what we are OSL dating provides an estimate of the time elapsed burial this is what we have discussed and basically it it gives you the depositional age of the sediment. So, again it has been explained in a simpler way that once your sediment is buried. So, it will keep acquiring the energy that that is what we call ionizing energy is stored in the crystal lattice and built up over the time following the burial ok. So, after burial it will keep acquiring and the sources coming from alpha are potassium rubidium and thorium ok. And that is in the form of the alpha, beta and gamma and also what we were talking about the cosmic rays ok.

So, over the time the this is what we usually try to get is the equivalent dose that is DE and then the dose rate is been calculated from the the the sediments the same sediments, but through different method that is what we call the gamma spectrometry and we are measuring the concentration of this radioactive element. How much was the concentration of this in terms of the radiation provided to that. So, basically, we try to measure the uranium thorium and potassium. So, we we and that has been taken as a dose rate ok and this is equivalent dose ok. So, once you know the equivalent dose and dose rate you can calculate the H e k and how we are using this.

So, the equivalent dose DE is then divided by the environmental dose. That is, the dose rate that I am talking about is your environmental dose ok. So, that you usually use the part of the sediments to determine the percentage of uranium thorium and potassium and that will give you the. So, how do we obtain basically the DE ok. So, DE is obtained by the using the the grains mainly if you you want to use the quartz you you have to use a particular method, but and if you are using feldspar then there is a different and this is what you are having the dose rate is your environmental dose rate what we I was talking about the DO or maybe you can say and if you divide by then that will give you the age in gray actually. So, OSL technique first proposed by Hatney who used the light sensitivity electron trapped in commonly available minerals of on the earth crust that is mainly the quartz and feldspar.

So, this is the overall process of what we learn. It follows the three stages ok. So, one is what we have learned in the school time and all that the valence band and the. So, how the electrons are this and valence band and conduction band and all that ok and whether the electrons are in stable state or not that also gain are important here ok. So, the first process here is your radiation then storage and then eviction ok. So, these are the three stages which have been followed.

So, this is the valence band and then up and you have the conduction band ok. So, the electrons when they are irradiated move up ok, they go in are getting into the conduction band, but in between they had been trapped in this trapped energy is been measured through your artificially stimulated illumination ok. So, irradiation basically when the sediment is buried is the ionization radiation from the radioactive elements that is what we were talking about the alpha, beta and gamma and the elements which we are talking about is your potassium iridium thorium potassium ok. And the cosmic radiation ionizes the crystal ok, this process is known as irradiation. So, this is the initial process that we are talking about and during ionization ionization the electrons in the valence band out here may gain sufficient energy to rise to the conduction band.

So, they will start moving up and once they gain sufficient energy. So, second is the storage. So, they stay in the conduction band for some time until this electron is illuminated and release the energy in the form of single photon light that is your illumination ok. And then the third one is the eviction, that is the trapped electrons can be released due to sunlight or you can say laboratory induced illuminations ok. And the signal initially decreases rapidly and then at a slower rate.

So, basically this is the process that we are measuring ok in lab eviction. So, and the bleaching part which we were talking about is that once. So, once it is buried it will acquire the illumination energy and once it is exposed it will bleach and then it will be again like resetting will be done and again it will keep growing ok. So, this is what we are talking about. So, sediment exposed from burial bleaching due to the erosion transportation and deposition signal rapidly builds up in the buried cranes mainly from the natural radioactive elements uranium thorium potassium as well as cosmic rays sediment samples is collected this we will talk about that these are collected without exposing the sample to the sunlight ok.

Because sunlight is having higher energy and it will zero out. So, that is what we were talking about when the resetting was taking place. So, when it is exposed it will zero out all the energy which has been stored ok. So, the signal emitted from the mineral cranes in the samples when exposed to a beam of light is measured by a photomultiplier tube that we will talk about very quickly ok. Now the resetting one ok let me just talk about.

So, this is what we were talking about the age and how we will calculate ok. So, we will get the D that is your equivalent dose and the dose rate ok and both you will see that this has been mentioned in gray, but finally, if this has been done then then the age which you will obtain will be in years ok. But usually the D and D dose rate will be in gray per year ok. Now the OSL technique is usually what we do at once when the sample has been collected. How the sample is collected will be in a few seconds in the next coming slides ok. But one most important part which we have to take care of is that the sediment should not be exposed to the sunlight.

So, mostly we collect that in with the aluminum pipe or maybe the GI pipe ok. So, this is the same thing which we have discussed in the previous slides talking about the D and D 0 here ok. So, that will give you the age ok. So, an equivalent dose can be obtained by averaging the natural and the test dose information ok. So, D is measured in gray where one gray is 100 100 rads ok.

So, now, the environmental environment in which the optical stimulated illumination can be applied on a time scale. If we take then it ranges from 1 year to almost 200,000 years. It has a very wide range. This is one advantage of optically stimulated illumination dating technique. Whereas carbon is having limitations it will become like the ages will be having more uncertainty if we go more than 50,000 years or so ok more than that. So, the and then application here is extremely wide ok. So, you can talk about the exposure age. Nowadays people are talking about this ok.

The exhumation age shows when the hills or maybe the rocky portion or the rocks were uplifted here ok. And many other applications which have been given here in different environments are ok. This is mainly the coastal environment in the fluval environment. Also you can use this ok. And even the glacial deposits you can use you can use for the dissolution activity areas where you are having the caves ok. Slope deposits mainly the landslides and all that ok.

Alluvial fans, active tectonics, sand dunes you can talk about. And even as I said that we people have started using it initially with the archaeological site ok. And then this is all the marine environment you are having. And the desertic environment also you can use and lake strain also lake deposits ok. So, you can use it at multiple and very wide applications of the OSL ages.

Now, the sample collection mostly we do is that if we collect mainly in the pipes ok or if the sediments are not like if the coarse sand is there massive coarse sand is there then there is no issue or fine sand. So, then you can collect in pipes, but if you are having gravels and gravels it will be difficult to collect the material in pipes then we use the black tarpaulin to cover ourselves underneath to this and then collect the matrix ok. But that initial surface has to be removed while collecting because it is exposed to the sunlight ok. So, mostly we avoid this . This is what the pipe looks like. So, we hammer this into the exposed wall from here and then get it covered ok.

And mostly what we do is that since we understand that this portion might have seen the light because this was the portion over here ok of the wall exposed wall. So, this is the portion which is exposed and this was the last portion while covering this will also partly get exposed ok. So, this part we usually do not use, but the middle part has been used for normal processing ok. So, for OSL dating mostly we use the central portion of the pipe ok. Then there are different processes that we do that are chemical analysis and then magnetic separator that I will quickly come to.

Before we come up with a pure quartz extracted from the sediment. So, the wavelength is basically why this is important for us because for quartz mostly we are using the ultraviolet light and in the visible light with the wavelength of around 460 to 500 nanoseconds. This is for the ultraviolet light wavelength of that. For feldspar we are using infrared light ok and the wave which is the wavelength from 900 nanosecond meter to 0.

1 centimeter. So, the wavelength is pretty high here ok. Now, red light usually is what is coming in here because the sediments as we are talking should not be exposed to sunlight ok, but can be exposed to red light. The reason is that the wavelength is of course, 700 nanometers, but the energy is very low ok, but sunlight will have high energy. So, energy will be higher. So, this will zero out or we can say that this will bleach the sediments very fast or the energy which has been stored will be completely removed, but energy will not get affected the trapped energy will not get affected if you are exposing that in the red light.

So, all the processing we do is done in a dark room that we call ok and mainly this dark room is under a red light. So, the full sequencing we do is under the dark room and that dark room is not completely dark room, but this is your red light under the red light ok. So, chemical treatment initially removal of carbonates we do one normal HCL and then wash the sample by distilled water then we also use H 2 O 2 to remove the organic matters this was for carbonate and then wash the sample oven dry sieve sample and magnetic separation mainly we do because we want to remove the magnetic minerals ok. And then we also do HF when we we want it we want to use only quartz and if we are sure enough that we have enough quartz then we do HF hydrofluoric acid is one then that removes your feldspar oven dry H check for the feldspar use I R S I R S L. So, even though if you do HF there will be some left over of feldspar that can like affect your measurements ok.

So, the best way is that you again check I R S L and if you find that some content of feldspar is still remaining you probably do again HF ok. So, this is what we do as now in order to have the quartz basically we try to have this heave of 90 and this is on microns 125 and all that and 90 to 125 and mostly we what we do is that we take this range of this ribbon sample available for the dating and further separations ok why would say that ok. So, 90 to 125 size is used for optical simulations and further the magnetic and we use we pass through this this material when we we obtain ok through the magnetic separation and that will allow us a non-magnetic portion is extracted and then we usually this is the amperes which have been given for that the during the separation and vibrations what we do ok. Further after the magnetic separation again we go for hydrofluoric acid and removal of the feldspar the HF is washed in the remaining quartz is again treated and concentrated HCl to remove the byproducts and the reactions ok. After washing away the acid quartz it is then put into the oven for drying.

After drying quartz is again sieved using the 90-micron sieve and the greater than 90-micron portion is collected separately in a small plastic tube. So, that is being used and then for preparation of the eliquoids ok. So, this is your magnetic separation. So, during the lab we will show you all this instrument and finally, then when we are talking about when the quartz is separated which is greater than 90 microns and all that ok. We follow a typical cycle and these are done in the lab ok.

So, first we have not given any sort of an artificial dose. This is what we are doing because when we talk about the dose which has been given artificially then we are talking in terms of the radioactive dose ok. So, here we allow this sample to go through like or or decay in terms of after putting the like, preheating the sample and then the measurements are done here and then after that. So, this is what basically we took all the decay curves. This is the zeroing out completely of all the samples the energy is. Then when we put after the heat we are putting the we are measuring through the photomultiplier tube ok. But when we apply the test dose then again, we follow this ok. So, if the test dose has been applied then it will gain the energy and then again we have preheated and measured ok.

So, this is what we call this is this this is the sequence we run that is measuring of measuring natural and regenerative illumination this is measuring lumination sensitivity and finally, we are calculating when we are getting that is the we we use the L x by T x ok and then here you are using the grays what we have given that is 5 gray, 10 gray and 30 gray so on ok. So, that will give you the exponential curve and then this is what L x by L T x. Similarly, you are using the illumination and the test dose and then you are obtaining these three points. So, with this you will be able to generate a curve and that curve will help because this we know that at what was the first natural illumination we obtained ok where we did not apply any of such dose ok and that will help you by using this curve that was your equivalent dose ok. So, these are the steps which have been given and you will learn when we are talking about this.

So, this is what we are talking about. This is mainly the way you will get this point ok. So, this will be obtained if you are having the so this is known, but this curve helps you in obtaining the D. So, this is like in single aliquot regenerative cycle that is what we call SAR and so we we go for preheat then OSL then test dose and then preheat. So, this is the test dose part which we are talking about and this is the natural portion of that and this is what we call the L 1 and this is D 1 or you can say L x by your D x ok. So, you have multiple test runs like this that is what we call cycle ok and then that will help you in having the curve of different points ok and that helps.

So, if you are having the natural you can see that and that will give you the D. So, further if we look at so this is the part which we are talking about the the L i or maybe you can say L x or T x and then about the reader where we are using mostly the the two type of lights that is you for this is for quads mostly and this one is for feldspar. So, this is so you we need to when we are using feldspar then we need to change the filter and that helps measuring the feldspar part and mostly the feldspar is been done in the fine grain following the fine graining method that we will explain you how we are extracting the feldspar from the following the fine graining methodology. And this is what we call the cross all then this is the area where we put the disk ok. So, the small small disk has been prepared where the sediments have been allowed to stick using the silicon and similarly several disks have been prepared and that have been placed and then as I was showing you the cycle we keep running those cycles and to have the generation of the curves ok.

So, this is the measurements usually what would do and different cycles, cycle 1, cycle 2, cycle 3. So, this is natural and then we are applying the artificial dose from here. This is the test dose here, but this we are using as in for the regenerative dose ok. So, we use 10 gray, 30 gray then 50 gray and then again come back to the 10-gray ok. So, that gives us the curves and that is what we call the shine curves mainly. I will come to the conclusion that the decay curves also are there, but these are the final curves which we are using now which we get ok and these are the different points which we have measured giving the different dose ok. So, we are measuring the illumination here and then finally, with the help of the natural what you are having and then this curve helps you in getting the intersection here will give you the D e.

So, this is what we call the decay curve. So, in terms of the quartz mostly if this is quartz versus feldspar and mostly the quartz curves will decay like this ok. So, initially, but it will slow down and then finally, it will become like this ok this plateau type, but the quartz will decay very fast here and if you are having the young material then the curve will be something like this ok. And if you are having feldspar inclusion then you will have and that is what we call the impurity and this is not good for measuring the illuminations ok. So, we also take care of the moisture content and this is also used in the like moisture content is been used for in the calculation of the age. So, this we have to do and then the dose rate measurements either we are taking the dose rate sample in the boxes and keep for for 21 year days to to to stabilize the the radiation and then we use either the detector that is the HPGE and this is gamma spectrometer and for measuring the uranium thorium potassium content ok mainly and this will be used along with the cosmic dose will be used to measure the dose rate.

So, this is how the processes have been done in the lab here. This is a chemical process which we do and one has to be very careful because we are using HF also other than the other HCL and H2O2. So, and these are what we call the peaches in boxes we have. So, different samples collected from different areas are been kept in this separately labeled everything and then for oven drive we have like for drying the samples we have the oven here and then we also use the sieves sieving for that and as I told that this is always this area remains in under the red light that is what we call the dark room this is the sieve shaker we are using and this one is your magnetic separator. So, this is all placed in one single roof. So, first the chemical analysis then separation of then sieving then again we we put it in the magnetic separator then again we sieve if required and then etching is been done once through HF once we we feel that still the quartz is there that can be done and finally, we start preparing the once the quartz is been extracted we start preparing the the aliquots ok.

And this is how we use this silicon spray. So, the grains get stuck on that. So, we put a very few grains on this and then try to prepare the disk and then the disk goes into this actually ok. So, this whole system gets lifted and opens up. This is what we are having the radioactive source. So, this radioactive source is a photomultiplier tube and this is your high purity germanium HPGE gamma spectrometer which we use for obtaining the dose rate that is the measurement of the content of your uranium thorium potassium here. So, dose rate is generally measured in gray for anemia in order to get the precise dose rate and less uncertainty it is always necessary to avoid sampling within 0.

3 meters ok. So, this is usually when we are collecting the samples in the field we need to be careful about that ok. So, dose rate is measured by a high rate gamma spectroscopy the energy of the gamma radiation emitted from a sample is the process of isotope undergoing decay ok. So, this has been kept again at very low temperature using liquid nitrogen and the temperature goes because the electronics will then not work ok. So, this is one of the points which we usually try to maintain that HPGE is kept at a low temperature that is minus 96 degrees centigrade. So, further like grain size and the minerals as we have already discussed about this, the potash feldspar usually has a high OSL and high RSL sensitivity there and they get bleached very rapidly as I was showing the shine curves also or the decay curves.

So, the feldspar will decay very fast, the quartz will take time and then it will decay ok. So, again feldspar composition display and effect are termed as aluminous fading. So, this will have this effect of what we were talking about here ok and mostly if we are not we are having contamination then we may end up having under estimation of the age actually. So, most if we are using quartz then we try that the quartz the feldspar has been removed ok as far as possible. So, hence quartz is preferred over the because it is having like this is the reason and that you have fading and then it has been observed that the signal decreases very fast as the samples are stored in the laboratory in the dose.

So, and thus so in an anomalous manner because of the physical parameters of the traps suggest that it should be stable leading the age of under so, it is basically under estimation of the age will be there. But if you are using purely feldspar then we change the filter and then as I was talking about that we use IR and then we separate out the feldspar using the fine grain method ok. So, this also I have discussed about the grain size. So, I will just go ahead and IRSL part also infrared simulation signal is emitted when the mineral is exposed to infrared radiation typically and then used for dating mainly the feldspar. For OSL light emanated LEDs with the peak emanation this is again what we have already discussed in the earlier ok, but you can go through when you are getting the slides ok.

Now, this is important, which I initially mentioned about optical illumination, why it is better than the C 14 ages. So, optical dating can be done for mainly geological sediments, sometimes fire pot trees, bricks etcetera. Difference between radiocarbon dating and OSL dating is that the former is used to date organic material ok, while the later is used to date minerals. So, we are using the OSL to date the minerals and this is for your 14 C ok. By analyzing coastal dune using OSL dating it is now able to provide a better terminology for the past 300 years than the radiocarbon dating.

For such fluctuations 14 C production causes large uncertainty when ages are calibrated ok. So, one of the reasons is that this is having the half-life of your 5730 years ok. Hence reliable date can be obtained for the 14 C up to 50000 years, but if you see the OSL it can go up to almost like 200000 years ok. This is one of the disadvantages of the C 14 ok.

And again C 14 is mostly seen as detrimental to human life. So, it is transported not the in situ one ok. So, this is one of the and as I said that it can go up more than that actually T L can go up to like more than 5 lakh years ok. So, with this we will end up here and then as I told that we will come up with a lab. You will have the lab visit through like we will be showing the lab through recording and also, we will be doing a one lab on this ok. So, where you will have a hand on practice is how we are calculating the age of any particular sediment.

So, thank you so much and I hope you enjoyed this course and whatever queries you have you can please contact us we will try to sort out. Thank you so much. Thank you.