Ground Water Hydrology
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Module No # 06
Lecture No # 28
Sub Surface Investigation of Ground Water (contd.) Geographical / Resistivity / Spontaneous Potential / Radiation Methods of Logging

Welcome to this lecture 29 of ground water hydrology.

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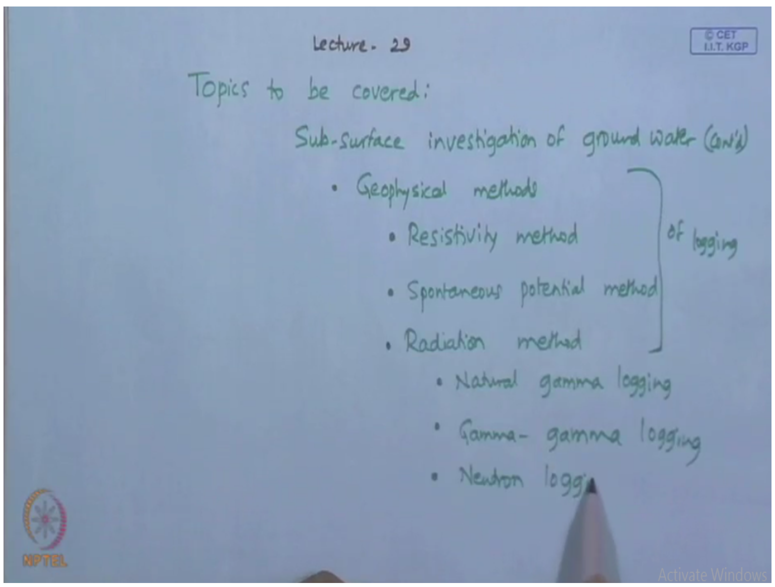

The topics to be covered in this lecture are subsurface investigations of ground water. So this is this is continued and within this so here geophysical methods and under this geophysical methods the resistivity method then followed by spontaneous potential method followed by radiation method.

So these are all the methods of logging. And under the radiation method this natural gamma logging, then gamma logging then neutron logging. So these are the topics which will be covering in today's lecture. And so we will go to we will continue with this geophysical method which we were discussing in the previous lecture.

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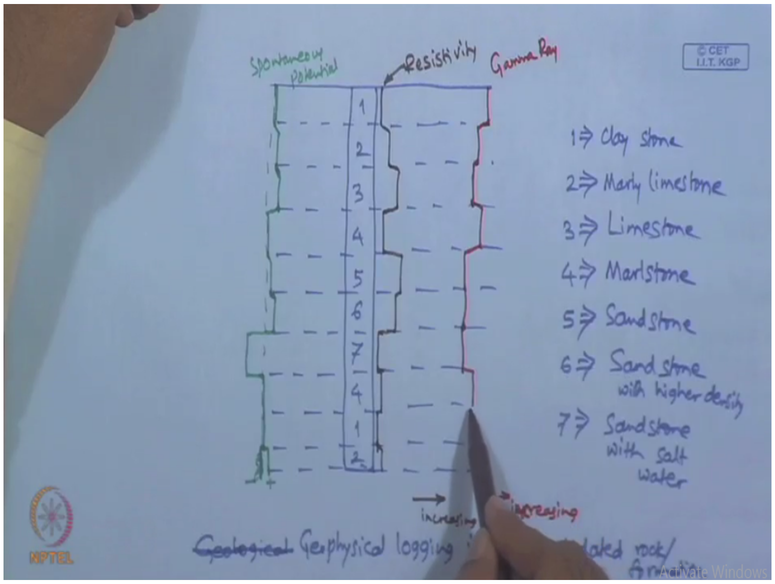

So here that is the geophysical log geo geophysical log in a consolidated rock consolidated rock or formation. So in the previous lecture we discussed the geophysical logging in an unconsolidated rock or formation. And in this lecture we will consider the geophysical logging in a consolidated rock or formation and here we have a consolidated rock or formation with various sun and various formations at different depths.

Let us say number these formations as 1, 2, 3, 4 then maybe so 5, 6 then 7, 4, 1 may be 2. And so here this 1 represents clay stone number 2 formation number 2 represents say marly limestone formation number 3 let us say it represents limestone formation number 4 rock formation consolidated rock formation number 4 represent marl stone. Consolidated rock formation rock or formation number 5 represents sand stone.

The consolidated rock or formation number six represents sand stone with salt water with let us say this is higher density or say dense sand stone and seven to say this is sandstone with salt water. So let us say these are the rock the seven formations in the consolidated rock. And let us say this spontaneous potential is indicated in this green color.

So this is the spontaneous potential and here this is positive on the left side and negative on the positive on the right side and negative on the left side. And in this consolidated this one say it could this clay will have a very small positive words one or almost 0. Then it is followed by so this marly limestone will be slightly higher. Then followed by limestone it will be even higher then followed by again marl stone so that will also have almost negligible spontaneous potential.

Then the fifth one is sand stone so the sand stone will have some spontaneous potential then the sixth one is dense sand stone. It will even have higher spontaneous potential and the seventh one is this one with salt water. So it will have a negative spontaneous potential then followed by 4 that is marl stone which is negligible spontaneous potential. Then followed by it is clay stone which also has negligible potential then lastly it is sand stone but with salt water.

So again so that also has slightly negative but negligible now this second is the Marly limestone it will have slightly this one. So this is the variation this is the geophysical logging in terms of the spontaneous potential and similarly the geophysical logging in terms of the resistivity. So this is so here this case this is the increasing direction of so this is increasing direction and the resistivity for the this one that is clay a lime stone is quiet less.

Then for Marly limestone it is higher. Then it is the lime stone it is even higher. Then the marl stone it is less than the fifth one is sand stone so this sand stone is higher resistivity and the sixth one is dense sand stone that will slightly lower resistivity. And seventh one is sand stone with salt water and that will have much less resistivity. Then the fourth one is marl stone that will slightly more resistivity than sand stone with salt water.

Then again this is clay stone with low resistivity then again this is marl stone. So like this so this is the resistivity log and then the third one let us say the same thing if we represent the gamma ray. So in this case and again this gamma ray so it is this is the increasing direction. So in the first that is clay stone it has some gamma ray potential then for the Marly line stone the gamma ray potential is less. Then this lime stone it is even less then this marl stone it is slightly more.

Then the fifth one is this is sand stone so it is less. Then the sixth one is also less. Then the seventh one so is this seventh one is it’s even less slightly less. Then four it will be slight this one and again so this one and then two. So this is the gamma ray logging so this is the geophysical logging in a consolidated rock or formation.

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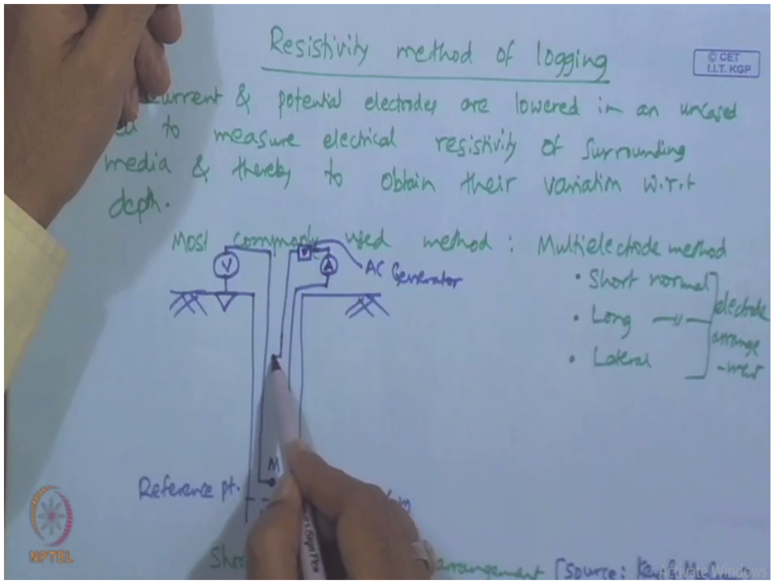

So now we will specifically go to the resistivity method of logging. And in this so basically so here this current and potential electrodes are lowered in an uncased well and to measure electrical resistivity of surrounding media and thereby to obtain to obtain their variation their variation with respect to depth. And here so the multi electrode method is most the most commonly used method is the multi electrode method.

And in this so there are basically short normal long normal. And so within this the short normal that is electrode arrangement then the long normal electrode arrangement and then the lateral so these are the electrode arrangement. So let us briefly discuss the short normal electrode arrangement. So in which so this is the short normal electrode arrangement so in this so this is in uncased well. And here one side is so this is the voltmeter and here so this is the point M.

And so this is the reference point and so this is the A. The distance between A and M the vertical distance between A and M is very small. So and of course this is this is taken from the source that is KEYS and MCCREERY in nineteen seventy one. And they have so the short normal so they have they adopted a distance of AM which is symmetrical with respect to this reference point as say .4 meter.

So that is M is .2 meter above this above reference this midpoint. And A is .2 meter below this. And from the other electrode is the current electrode is going. And here it is the current that is the ammeter and there is AC generator. So this SI ac generator and from the ac generator say there is another current electrode which is going point B. And the distance between the vertical distance between B and M they around 15 meters.

So this is the short normal electrode arrangement. And now we will go on to another the second type of arrangement for this resistivity method of logging.

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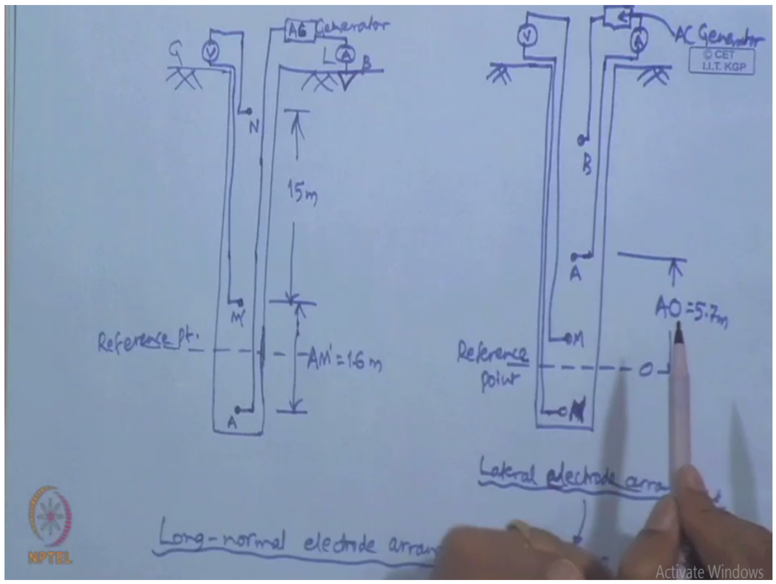

That is the long normal electrode arrangement. So in this the so this is the uncased well. This is the ground level here the reference point. So this is the reference point and this the electrode is a current electrode. And this case the earthing or the earthing is with the current electrode in the earlier case that thing was with the potential electrode. And in this case the earthing is with the current electrode and here there is an AC generator.

So this is the ac generator and from the ac generator there is an arrangement to measure the current. And there is this grounding this is the point B. And here this potential electrode so that is this is N and so here there is an arrangement to measure the voltage and this one so the other electrode that is on the top side of this reference line. So this is the or there this is the reference point and so this is M and the distance this is M or M dash.

So this distance adopted is about this AM dash is 1.6 meters which is symmetrical with respect to this reference point. And again this M dash N this is again 15 meters. So this is also taken from the same source that is KEYS and MCCREERY 1971.

So the only difference between this and the short normal arrangement electrode is the distances between the grounded current electrode which is below the reference point and the ungrounded potential electrode which is above the reference point at the same distance so the distance is much higher it is of the order of say 1.6 meters.

While in the previous case it was just .4 meters. Now let us come to the lateral arrangement so this is the long normal electrode arrangement and now let us consider the lateral electrode arrangement. Again this is from the same source that is KEYS and the MCCREERY. And in this lateral arrangement so this the distance AO so this uncased well.

And so here this is the reference point and that is denoted by the letter O and the electrode the potential electrode is M and N on either side of this reference point. And there is a voltmeter and so this is M I am sorry this is M is above this one and N is below the reference point. And the distance is much less. And this cases the current electrode A so this is below or other above the potential electrode M and there is an arrangement to measure current.

And there is an ac generator so this is the AC generator and the other this current electrode is the top most that is at point B. So this distance AO so here remember NA of the current electrode pierce of the potential electrode pierce of the grounded. So that is distance AO is of the order of say 5.7 meters and again the distance between A and B is of the order of say 15 meters.

So this is the lateral electrode arrangement so basically with each of this arrangement so it can measure the resistivity. So this resistivity is in this case the resistivity log.

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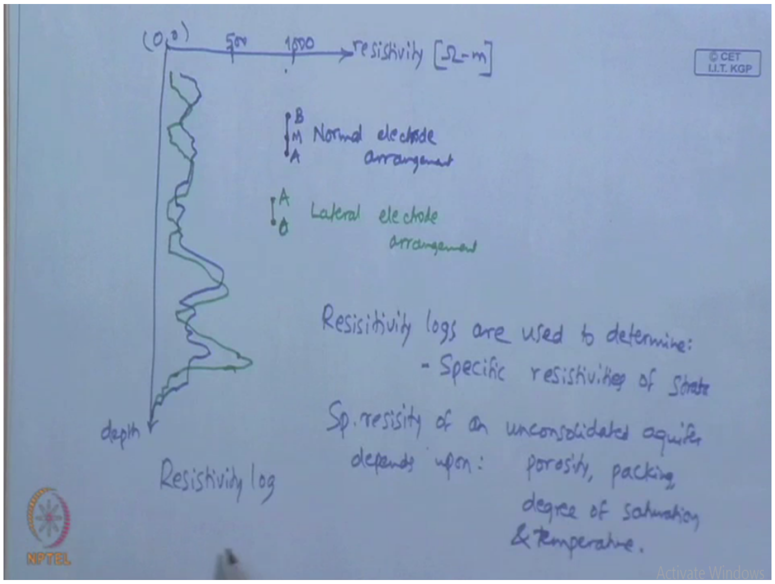

So that is so this is the depth and here this is the resistivity so this is in ohm meter and let us say this is 0. And this is say 500 and then this is 1000 ohm meter. And let us consider the normal so in this case let us see this is the normal the resistivity it may vary. So this is the N and then B so this is the normal resistivity that is normal electrode arrangement.

On other hand the lateral electrode arrangement so this is A and this is I am sorry this is O and A so this is the lateral electrode arrangement for this. The resistivity may show a different slightly the staggered this one slightly the one with this time lag. So this is the lateral electrode arrangement shown in green color. So here actually so this resistivity so this resistivity logs are used.

So this is a resistivity log to determine specific resistivities of strata. And so this is the specific resistivity the specific resistivity of an unconfined aquifer. Unconsolidated aquifer so it depends upon porosity packing degree of saturation and temperature. So the fresh water we have the fresh water sand has moderate to high values. And this one the shale, clay, salt water have a low electrical resistivity fresh water sand has moderate to high values of electrical resistivity.

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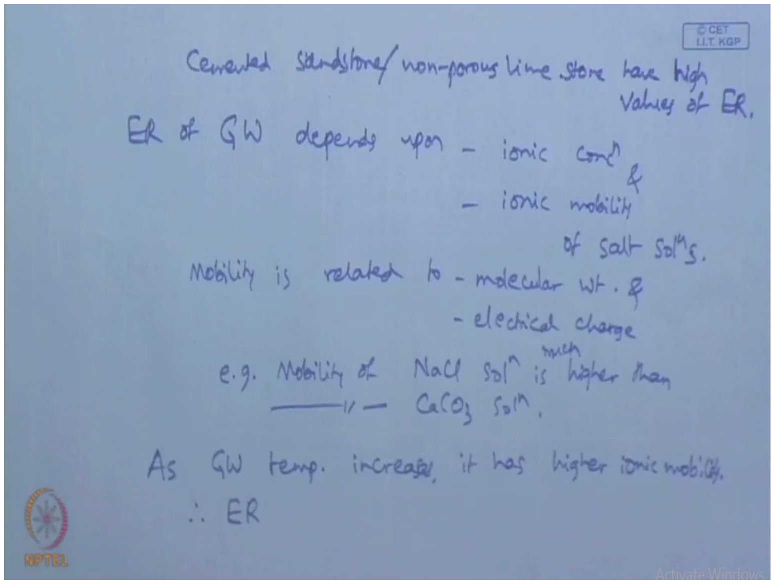

And this cemented sand stone and so non porous lime stone have very high values of or high values of electrical resistivity. So this the electrical resistivity of ground water so depends upon ionic concentration and ionic mobility and ionic mobility of salt solutions. So this mobility is related to the molecular the electrical molecular weight and electrical charge.

Electric charge so here so this mobility of for example mobility of this sodium chloride solution is much higher mobility of this calcium carbonate solution. And so as also as ground water temperature increases it has higher ionic mobility. So therefore these electrical resistivities are electrical resistivity values are multiplied by correction factor to obtain the electrical resistivity at standard temperature of 20 degree Celsius.

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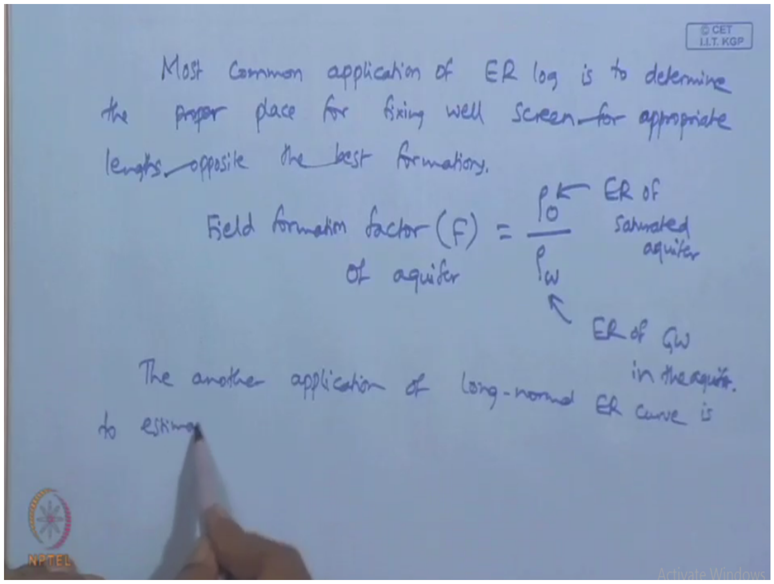

So the most common application of electrical resistivity method electrical resistivity log is to obtain or to determine the proper place for fixing well screen for appropriate lengths or say optimum lengths. And in this case so the there is what is called field formation factor for appropriate lengths that is opposite the best formations. So there is what is called the field formation factor so it is denoted by F of an aquifer.

So this F is determined as the ratio of rho O / Rho W where this rho o is the electrical resistivity of a saturated aquifer whereas Rho W is the (()) (40:38) the electrical resistivity of ground water in the aquifer. And so this is another application of long normal the electrical resistivity curve is to estimate permeability.

So in this case so depending upon the as previously mention the electrical resistivity very much depends upon the whether it is a fresh water or salt water. So therefore we can so determine the based on the electrical resistivity charge we can determine where the fresh water and is existing and where the salt water exists.

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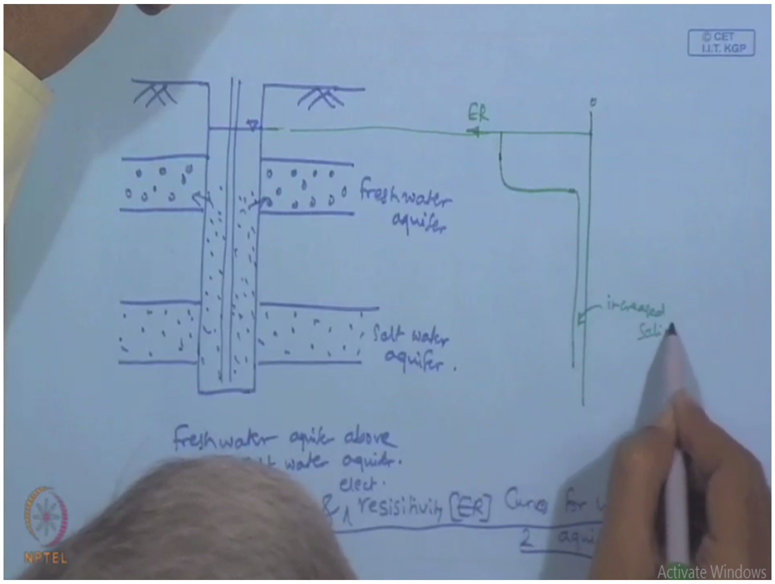

So in this case say for example that is the let us say the hydrologic conditions and this resistivity curves. Electrical resistivity that is ER curves for wells penetrating to aquifers. So in this case so let us say there is an aquifer there is a well which penetrates a salt water aquifer below the fresh water aquifer. So in this case so this is this is the well so this is a fresh water aquifer above salt water aquifer. See let us say this is the salt water aquifer so this is the salt water aquifer and this is the fresh water aquifer.

In this case so suppose this is the water level and so corresponding to this so this supposes this is the electrical resistivity. And this is it respect to the water level and this case say the fresh water aquifer will have a higher. And let us say so because of this pumping well is this one so let us say the so there is so because of the pumping salt water has come almost very close to the fresh water aquifer.

So in this case so we will see that the electrical resistivity in the fresh water aquifer is much higher. And so the so here this is this electrical resistivity access with 0. So this is saline water increased salinity and decreased electrical resistivity or as in this case this is this is this indicates fresh water. So like that we can determine the based on the electrical resistivity log we can determine whether it is the ground water is fresh water or salt water. So now we will go to the spontaneous method.

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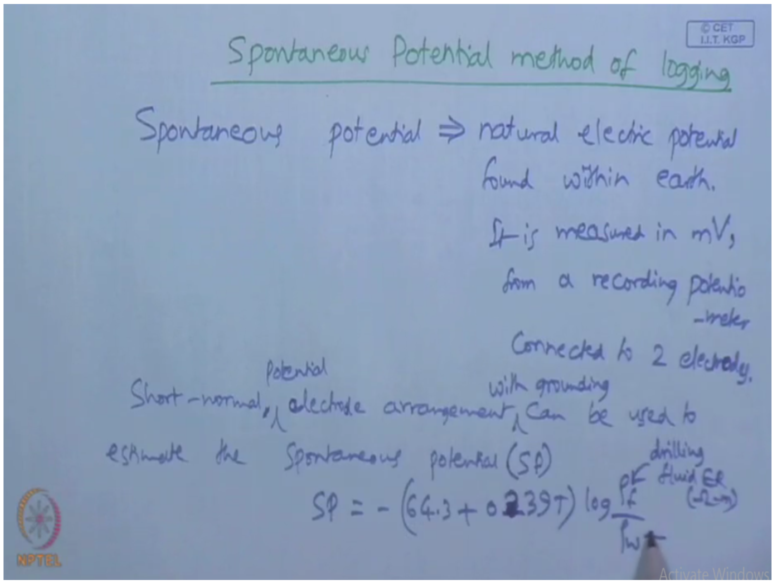

The spontaneous potential method so this is the method of logging so in this spontaneous method spontaneous potential method. So this spontaneous potential this is the natural electric potential found within earth that is known as the spontaneous potential. So it is measured in milli volts. And so milli volts form a potentiometer form a recording potentiometer connected to two electrodes.

And here so again the same arrangement which used for the short normal long normal arrangement can also be used to estimate that is so the short normal and long normal short normal electrode arrangement potential electrode arrangement can be used to estimate this spontaneous potential. So the short normal potential electrode arrangement says with grounding so it can be used to estimate the spontaneous potential.

And this spontaneous potential is there is an equation for the spontaneous potential so suppose if you denote this spontaneous potential as SP and the equation is so SP is = -64.3 + .0 .239. I am sorry it is + .239T into log of Rho F / Rho W. So this Rho F is the drilling fluid resistivity electrical resistivity in ohm meter and this rho W is the ground water resistivity ground water electrical resistivity.

So that is also measured in ohm meter and T is the bore hole temperature so this is the bore hole temperature in degree Celsius. If you know these three parameters T Rho F and Rho W the spontaneous potential can be estimated. So we will continue this in the next lecture we will move on to the radioactive logging as well as other methods of subsurface ground water investigation so geophysical logging thank you.