Ground Water Hydrology
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Module No # 06
Lecture No # 27
Surface Investigation of Ground Water (Contd): Electrical Resistivity / Seismic Refraction / Gravity / Magnetic Methods

Welcome to this lecture 27.

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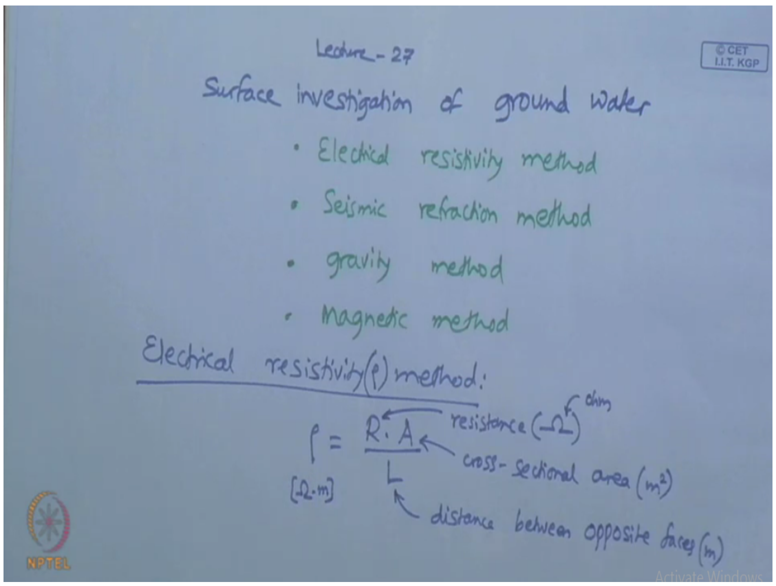

So in this lecture so we are continuing with the surface investigation of ground water and specifically we are continuing with electrical resistivity method. So then we will move on to seismic refraction method and followed by gravity method and lastly magnetic method. So coming to this electrical resistivity method which we started in the previous lecture the electrical resistivity so this is the electrical resistivity it is denoted by the letter Rho.

And this Rho is given by R into A / L so here this R is the resistance. So this is the resistance which is measured in ohm so this is the notation for ohm. And A is the area the cross sectional area so this is measured in square meters. And L is the distance so the distance between opposite faces so that is also measured in meters. So this electrical resistivity so it has a units of ohm meter and so this electrical resistivity it varies for different materials.

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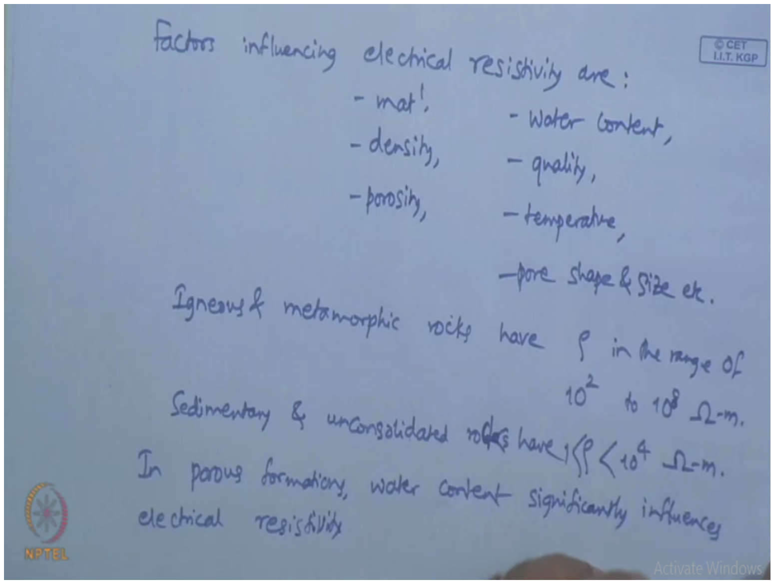

And so the factors influencing electrical resistivity are material, density, porosity, water content, quality, temperature, pore shape and size, etc. So this so the variation of generally this ignescent metamorphic rocks have so this Rho in the range of 10 to the power 2 to 10 to the power 8 it is ohm meter. On the other hand the sedimentary and unconsolidated rocks have rho which is varying between 10 to the power 0 and 10 to the power 4 that is 1 that is ohm meters.

And so the in porous formations so the water content influences significantly influences the electrical resistivity. So the American society of civil engineers has given the representative variations ranges of electrical resistivity.

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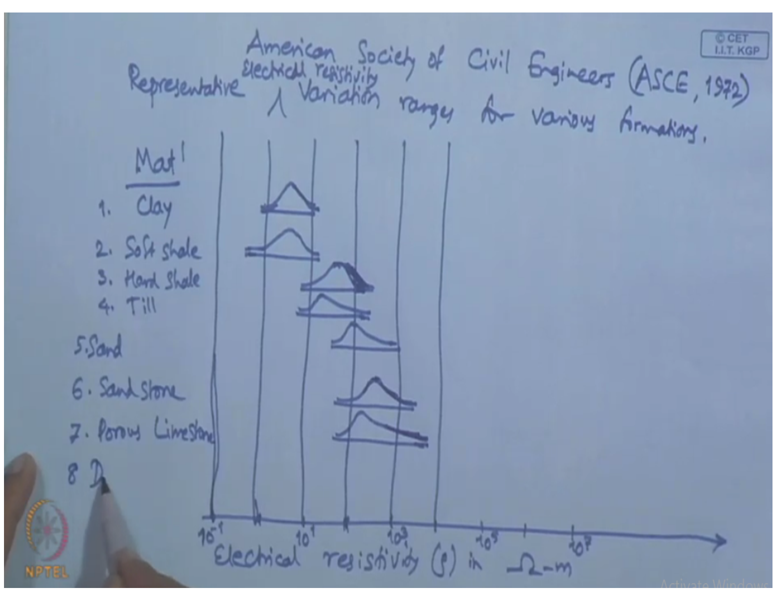

So in one of its document published in 1972 so this is representative electrical resistivity variation ranges for various formations. This case it is sees the material and the electrical resistivity range so this in ohm meter.

And here so this starts with the scale starts with 10 to the power -1 and moves on to 10 to the power 1, 10 to the power 3, 10 to the power 5 then 10 to the power 7. So in this case we have is clay whose electrical resistivity varies in the range of this its more or less symmetrical variation. So in the range of 10 to the power 0 to 10 to the power 1 so followed by this is soft shale which is also quite fine grained like this one.

And in this case also the variation is somewhat similar like clay only thing is here it may show a larger variation on the lower side. Then followed by hard shale this case it varies between 10 to the power of 1 and 10 to the power 2 and which shows skewness to the right. Then the fourth one is the till or the tilled earth which shows skewness to the left. Of course in case of hard clay so it will show this is to 10 to the power 2. And till it will show a variation which is skew to the left followed by sand.

And sand shows again is skew to the power that is skew which is skew to the left with the mode around 10 to the power 2 ohm meter. Then followed by the sand stone so this is the fifth one is sand sixth one is sand stone. Sand stone is even shows it is even higher electrical resistivity which is almost showing a symmetrical variation with the mode of the electrical resistivity lying between 10 to the power 2 and 10 to the power 3.

And followed by this porous lime stone so this porous lime stone also it has the mode value of the electrical resistivity only thing is it is skew to the left. Then lastly it is the dense lime stone this dense lime stone shows large variation in this case. So this variation it starts with say 10 to the power 3 and it continues even beyond 10 to the power 6.

So this how the variation of this electrical resistivity varies. And as we can see this clay will have very clay and soft shale will have very small value of very low value of electrical resistivity. Now let us go to the electrical resistivity.

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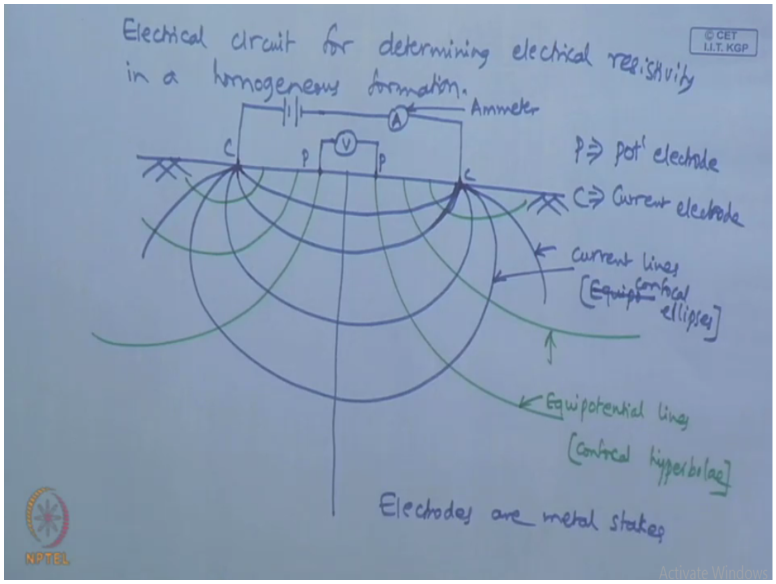

This case the electrical circuit for determining electrical field electrical resistivity in a homogenous formation so there are basically all the two current electrodes which are located faraway in the same line has the potential electrodes. So in this case this is the so these are the potential electrodes so this P implies the potential electrode and C implies the current electrode its symmetrical formation.

And this case so between the potential electrode so there is a volt meter and between the current electrodes. So there is a battery source and an ammeter and here this so this is a C is the current electrode and this case the current lines are ellipses and the equipotential lines. Let me show with different color and equipotential lines are confocal hyperbola which is orthogonal to recurrent lines. Like this these are the equipotential lines.

So these are in the form of confocal hyperbola and then these are the current lines so these are the equipotential lines and these are the current lines. So these are equipotential I am sorry this confocal ellipses so this is the arrangement and this case the so what is measure is the apparent resistivity. Then this so the electrodes no before going to that so and so the so the electrodes are metal stakes which are driven into the ground.

And are sometimes this saturated solution so potential electrodes are porous cups with saturated copper solution.

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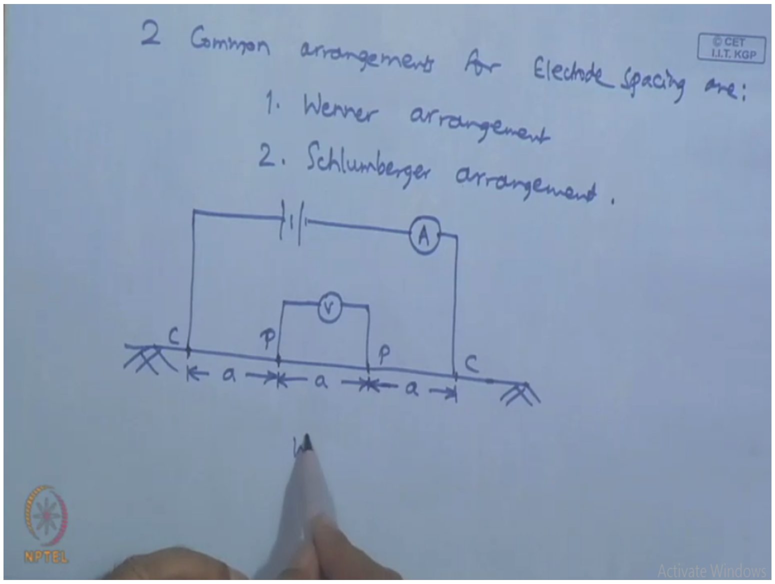

And here so this one there are actually two types of arrangement so the two say two common arrangements for electrical resistivity for electrode spacing are one the wenner arrangement the second one is the schlumberger arrangement. So in the wenner arrangement basically the potential electrodes are now let us discussed about this wenner arrangement in which the distance between the potential electrodes is one third the distance between the current electrodes.

So there is a voltmeter between the potential electrode and the distance is A and the same distance on either side on each of the potential along the same line. There are two current electrodes the left current electrode and the right current electrode. So there will be a battery source followed by ammeter to measure the current and this is the wenner arrangement for electrode spacing.

So the so let us now discuss the schlumberger arrangement so the schlumberger arrangement for electrode spacing for this electrical resistivity determination. So here the distance between the potential electrodes is somewhat less. That is say B if B is the distance between the potential electrodes.

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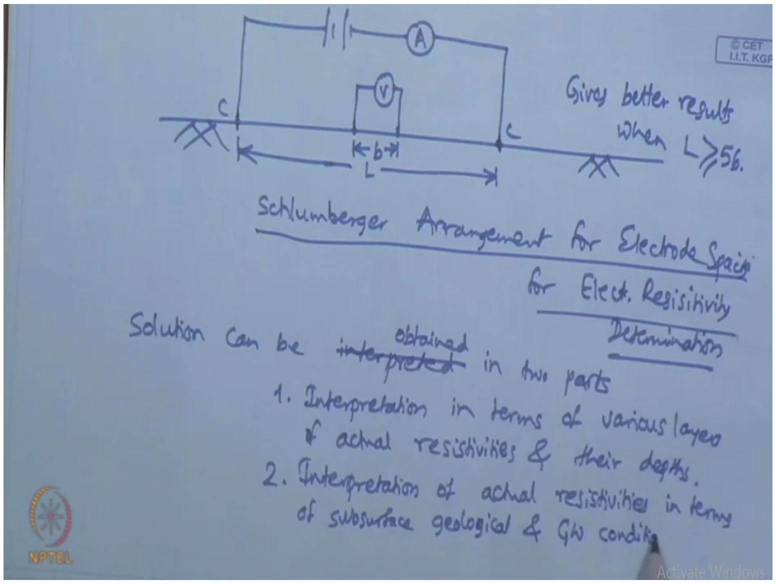

There will be a voltmeter which connects the potential electrodes and then so the current electrodes are far off. Of course it is again symmetrical arrangement so these are the current electrodes and there will be a battery source and followed by this ammeter to measure the current. And in this case the distance between the current electrodes is taken as L and it gives better results.

So it is said that so gives better results when L is greater than 5 B greater than or = 5 B. So this is the second common arrangement for the electrodes and now let us discuss about the interpretation of the results. So the solution can be interpreted in two parts or other the solution can be obtained in two parts.

So in the first part that is the interpretation in terms of of various layers of actual resistivities and their depths. And in the second part it is the interpretation of actual resistivities in terms of subsurface geological and ground water formations ground water conditions or formations.

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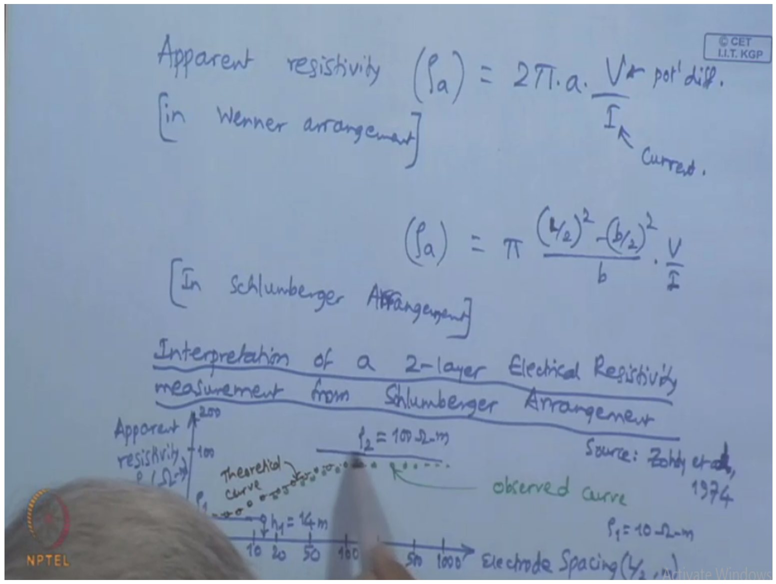

And here one thing I need to mention here so in case of the wenner arrangement this there is what is called the apparent resistivity apparent electrical resistivity. In wenner arrangement so is given by so this is Rho A. So this Rho is 2 Phi into A into V / I so V is the voltmeter reading or the potential difference and I is the current. So this is the potential difference and I is the current.

So the same apparent resistivity in schlumberger so this Rho A in schlumberger arrangement so this Rho A is given by phi into L / 2 square - B / 2 square / B into V / I. Where shown l is the distance between the current electrodes B is the distance between the potential electrodes so this is the expression for the apparent resistivity.

In case of schlumberger arrangement and now let us go for so the interpretation of a two layer electrical resistivity measurement from schlumberger arrangement. So this is taken from the source ZODDY ETAL in the year nineteen seventy four. In this the apparent resist electrical resistivity Rho A is indicated along vertical logarithmic scale.

So this is apparent resistivity so this is in ohm meter and it varies all the way from say 10 this is said 20 then this is let us say this is 100. Then let us say this is 200 and on the horizontal scale which is also logarithmic scale which is the electrode spacing. This is l / 2 in meters and it as per this Zoddy's results it varies all the way from 2 and here it is 5, 10, 20, 10 to 100 and hundred to 1000.

So here this is so this is 100 and then this is 1000 and here in between we have say 20 then 50. Similarly here we have say 200 then say 500 this case the so there are basically two curves that is the one is the theoretical curve and the observed curve. So this the theoretical curve so it has this points and the observed curve. So this case so this is the theoretical curve this is the observed curve and here so this is the asymptote.

So this indicates a Rho 1 and there is a higher level asymptote which is so this Rho 2 so this Rho 2 is 100 ohms meter. And this Rho 1 is 10 ohm meter and if you take the so here we have this H1 is 14 meter and basically so this H1 is the depth of so this depth of sandy aquifer. And this so basically this is and this is the asymptote and here in this case so we need to match the theoretical curve and the observed curve.

So that finally we get this one it shows a lower asymptote of say 10 ohm meter and higher asymptote of say 100 ohm meter.

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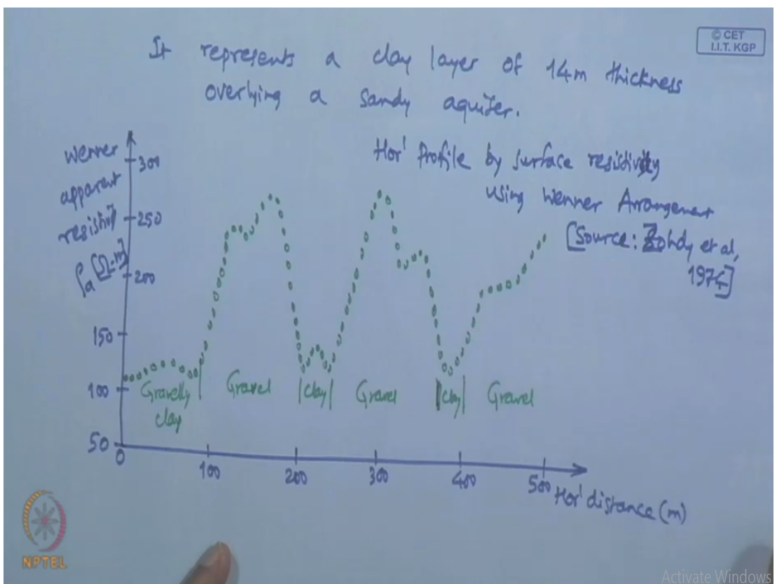

And so essentially this represents so it represents a clay layer of 14 meters that is thickness over which is overlying a sandy aquifer. So based on the electrical resistivity values so we can interpret that so this two layer formation having a clay layer in the top which is over sandy aquifer there is also another method of interpretation of the results. So in this case says using the wenner arrangement so here also so this is semi logarithmic plot and in this case the horizontal scale is in terms of distance.

So this is the horizontal distance which is in linear scale say 100 to 500 meters so this also taken from so this is the horizontal profile by surface resistivity So using wenner arrangement again the source is the same that is ZODDY ETAL 1974. And the vertical scale represents the wenner apparent resistivity. So this is Rho A in ohm meter and this is in this also in linear scale so 50, 100, 150, 200, 250 and 300.

This case so suppose based on the electrical resistivity values we can identify this data so suppose it is gravelly clay. In this case the resistivity will vary just in the range of 100 to 150 ohm meter and if it is gravel then the resistivity will be varying in the range of 200 to 250 and even slightly higher also. And again when it is clay, the resistivity again will drop back between the range of 100 and 150 then again when there is gravel the resistivity goes up again and there above 200.

In this case so again so based on the resistivity measurements we can interpret the formation. So in this case we can say that say up to this it is gravelly clay and here so this is indicating gravel and this is indicating clay again this is indicating gravel and here it is indicating clay and again follow the gravel.

So like this the apparent resistivity is plotted this horizontal distance between the electrodes in this wenner arrangement and so based on the variation of this apparent resistivity we can interpret the ground water the subsurface geological formations as well as the ground water permeability.

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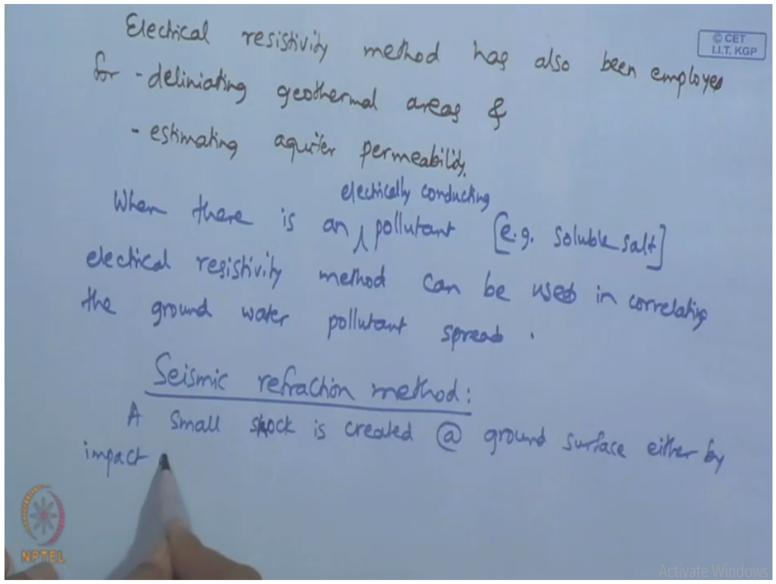

And so this electrical resistivity method has also been method has also been employed for delineating geological formations or geothermal areas and for estimating aquifer permeability. So when the so this electrical resistivity when there is a say pollutant when there is an electrical electrically conducting pollutant say for example that is the soluble salt. So the electrical resistivity method can be used in correlating the ground water pollutant spread.

So now we will move on to the seismic refraction method. So in this seismic refraction method a small shock created at ground surface either by impact of a heavy instrument or by an explosive charge and the travel time required for shock waves to travel known distances is recorded. So this is the seismic refraction method.

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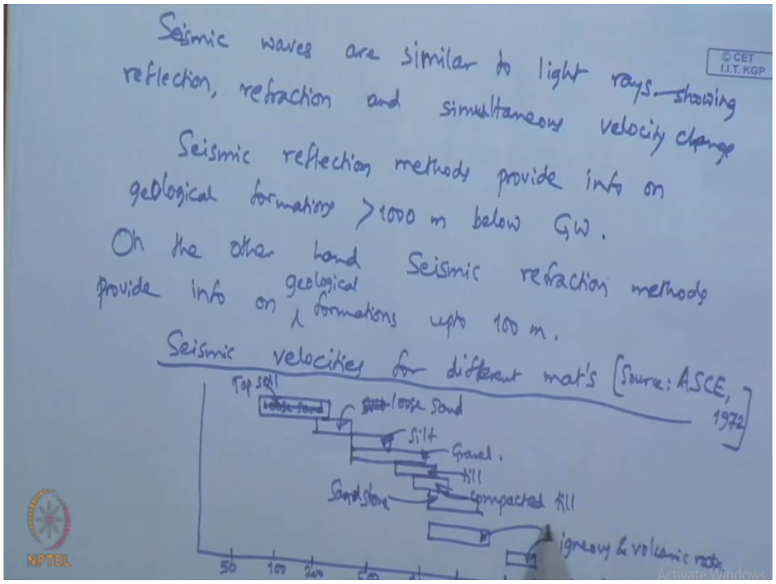

And here so the there is also this seismic waves are similar to light rays showing reflection coma refraction and simultaneous velocity change. And in this case so the seismic reflection so the seismic reflection methods provide info on geological formations which are thousands of meters greater than greater than thousands of meters below ground level.

On the other hand seismic refraction methods provide information on formations geological formations say up to hundred meters and the characteristic seismic velocities. So the seismic velocities for different material so this is taken from the source of American the document of American society of civil engineers nineteen seventy two. In this case so this is the velocity in meter per second so this is 50, 100, 200, 500, 1000, 2000, 5000.

And in this so here the loose sand will have seismic velocity in the range of 100 to 200 meters. So this is loose sand and so the silt will have velocity slightly higher. So this is silt and so this I am sorry this is top soil so this is the top soil and this is the loose sand and this is followed by silt. And so this is silt as well as gravel so gravel will have a higher. So this is gravel followed by till so this is till and then compacted till then sand stone and so on.

And this highest this one by the by seismic refraction velocity is for igneous and volcanic rocks so in between you have the sedimentary rocks. It show the almost the same this one this is the sedimentary rocks so we will stop here and will continue in the next lecture thank you.