Ground Water Hydrology
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Module No # 06
Lecture No # 28
Seismic Refraction / Gravity / Magnetic Methods (contd.); Sub-Surface Investigation of Ground Water: Geographical / Resistivity Methods

Welcome to this lectures 28 of ground water hydrology so in this lecture we will continue the incomplete part in the previous lecture.

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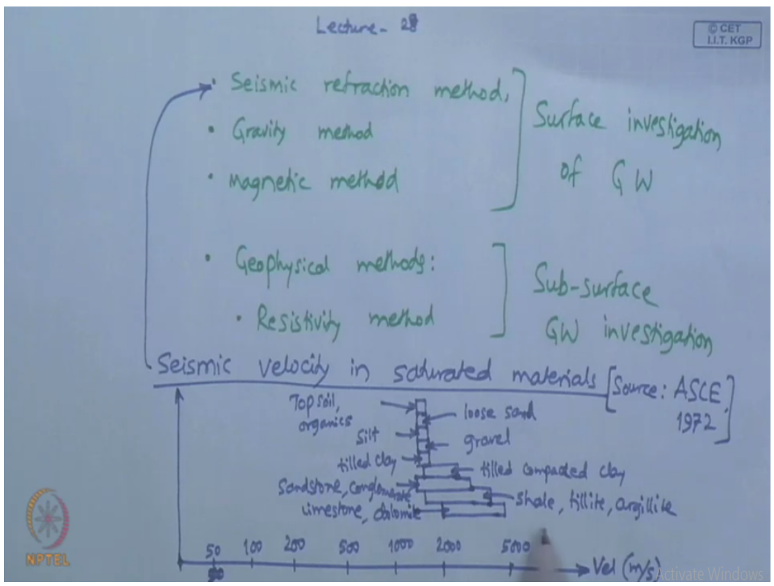

That is on seismic refraction method followed by gravity method and magnetic method. So these three methods come under surface investigation of ground water. So then we will move on to subsurface investigation of ground water and in that we will start with geophysical methods and within this the resistivity method.

So these come under subsurface ground water investigation so in the previous lecture we saw the seismic velocity in unsaturated materials. And in this lecture we will continue with so the seismic velocity in saturated materials. So this is so this is under the seismic refraction method and this is taken from the same source that is the American society of civil engineers from 1972.

So here the seismic velocity that is in meters per second on a linear scale I am sorry it's on a logarithmic scale 50, 100, 200, 500 followed by 1000, 2000, then 5000. And this is the horizontal scale and on the vertical scale we represent the different saturated material. And in case of saturated material the seismic velocity is more than 1000 meters per second.

And here so this is for top soil and organic materials then followed by loose sand. So this also will have the same range of seismic velocities greater than 100 and less than 2000. Then silt also the same range followed by gravel. So we are talking of saturated materials so this is gravel and followed by tilled clay.

So this compacted till compacted tilled clay it will have a slightly higher so this is tilled compact compacted clay and the higher range it exceeds 2000. Then followed by sand stone it will have the low range of velocity. In the same this one and it will have the low the higher range which is even higher than that for tilled compacted clay. So this is for sand stone and conglomerate.

So next you shale, telite and argellite it will have a higher this one. So this is shale, telite and argellite so next is limestone and dolomite for this the lower range of velocity is around 2000 meters and per second. So this is limestone, dolomite and higher range is slightly less than 5000 and next is weathered fractured so this is weathered or fractured rocks. So in this case the low range as well as high range will be much less than this lime stone and dolomite.

Now we will move on to the seismic velocity its variation of course which have shown already and also seen in the previous this one that seismic reflection is used for greater depths up to 1000 meters. And refraction used for smaller depths up to just hundred meters also.

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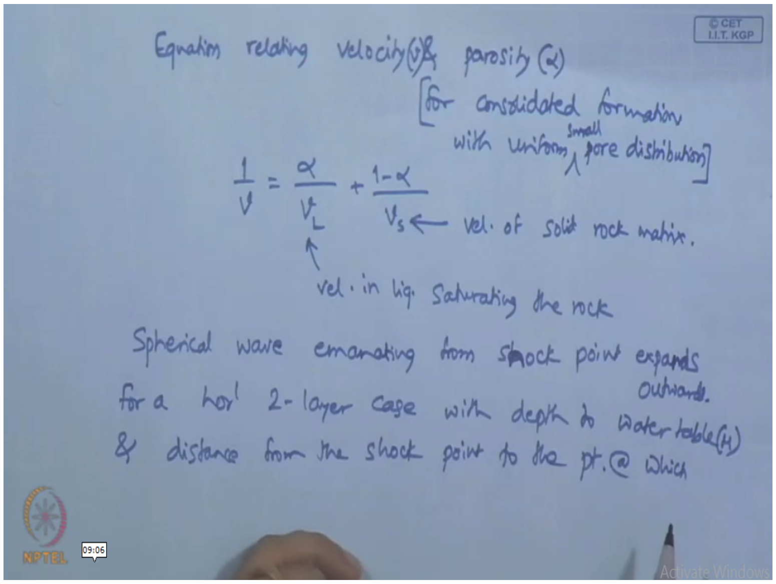

So now so there is an equation for equation relating velocity and porosity. So this velocity is denoted by the letter V and porosity is denoted by the letter alpha for consolidated formations with uniform pore distribution. That is these pores are small pores so in this case the there is an equation which relates the velocity with porosity.

That is 1 / V is given by alpha / VL + 1 - alpha / VS. So this VL is the velocity in liquid saturating the rock. And these VS are the velocity of solid rock matrix. So this is the relationship and here so this spherical wave which emanates from the shock point. From shock point so expands outwards.

And here say for example for a horizontal two layer case with depth to water table of H and distance from the shock point to the point on at which direct and reflected wave arrive simultaneously. So this distance S which is the distance from the point shock point to the point at which direct and reflected waves arrive at the same time or simultaneously.

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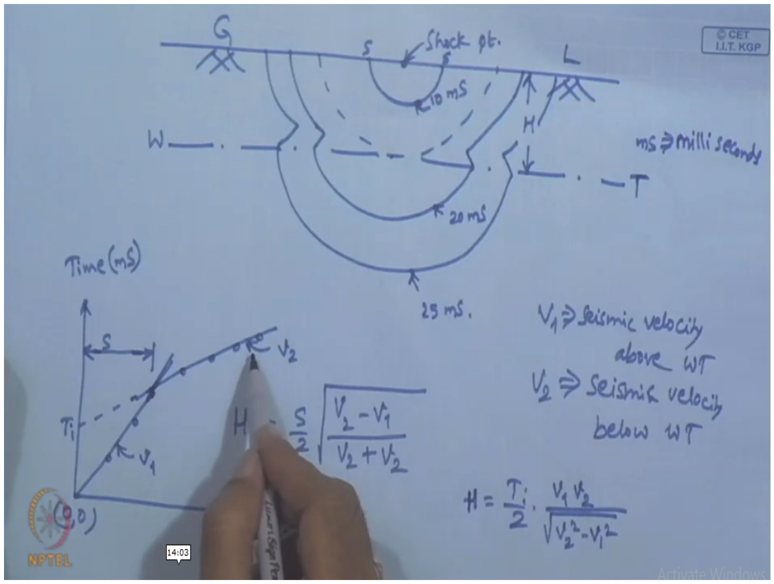

So in this case first let us draw the figure and so this is the ground surface. And here you have the shock point and the waves expand outward from the shock point. So this is the shock point and so here this is the water table so this is at distance of H below the ground. And here so this is the time is in 10 milli seconds.

So this is so this is the time in milli seconds so this is milli seconds that is MS this is MS indicates milli seconds. And next it is so this is at distance of 5 and here so this is this represents 10 milli seconds. So this curve represents 20 milli seconds and likewise so this represents may be say 25 milli seconds.

So in this case so if the V1 is the velocity of the seismic wave and the above water table and V2 is the velocity of seismic wave below the water table. So V1 is seismic velocity above water table V2 is seismic velocity below water table. So that case the depth to water table H is related by the equation S / 2 into under square root V2 – V1 / V2 + V1.

And obviously this V2 the seismic velocity below water table will be higher than the seismic velocity above water table. And here this case if you plot the distance time graph so this is the distance in meters and then this is the travel time in milli seconds. So in this case it will show two distinct velocities one above the water table so this is the velocity V1 and this is the velocity V2.

And this V1and V2 so this both this velocity lines they intersect at this distance S and here so if the intercept of this V2 velocity curve with this if the with vertical axis. So that is TI that case we can also write one more relationship that is H is = TI / 2 into the V1 V2 / under square root V2 square – V1 square.

So this is another relationship so where this TI is the intercept on the vertical axis for the higher velocity line hat is the V2 line which is represents seismic velocity below the water table. So and now we will consider that is this is so this is a horizontal two layered case one above water table which is at depth of H the other one below water table.

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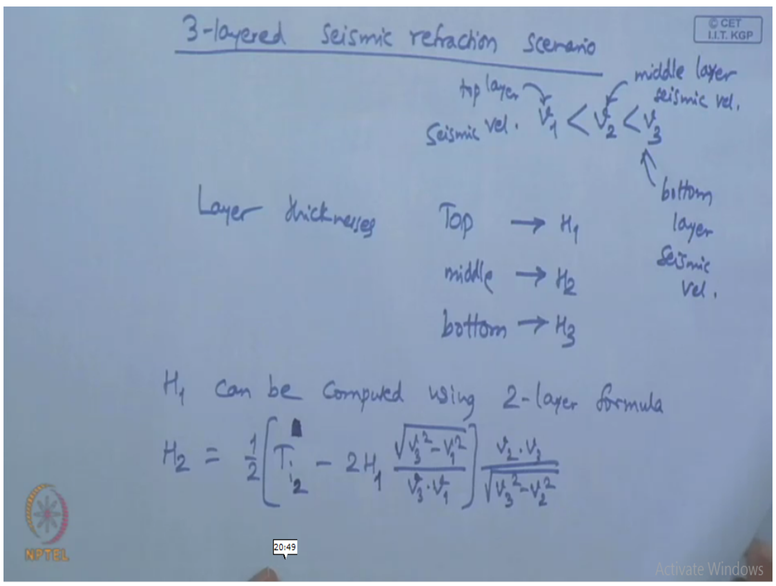

Now we will consider a three layered seismic reflection case scenario. So in which such that this the velocity through the top layer as well as a second layer as well as a third layer so there the velocity is through these layers are gradually increasing. And the thickness the layer thickness is so this is the top layer velocity seismic velocity this is the middle layer seismic velocity and this is the bottom layer seismic velocity.

And so this each of these layers so this thickness is are H1, H2 and H3. So the layer thicknesses are so this is top middle bottom. So this is H1, H2 and then H3 so in this case so the so this H1 can be computed using the two layer formula which was discussed few minutes back. And this so this H2 so this can be computed as half of TI square. And TI I am sorry this is TI2 that is the intercept in the vertical axis.

The time intercept in the vertical axis – 2H1 into under square root V3 Square - V1 square divided by V3 into V1 multiplied by V2 V3 / under square root V3 square – V2 square. So this is the expression for determining the thickness of the middle layer H2 in terms of the velocities V1, V2 and V3 as well as the thickness of the top layer as well as the time intercept in this of this V2 line I am sorry the V3 line so this TI2 is the time intercept of V3 line.

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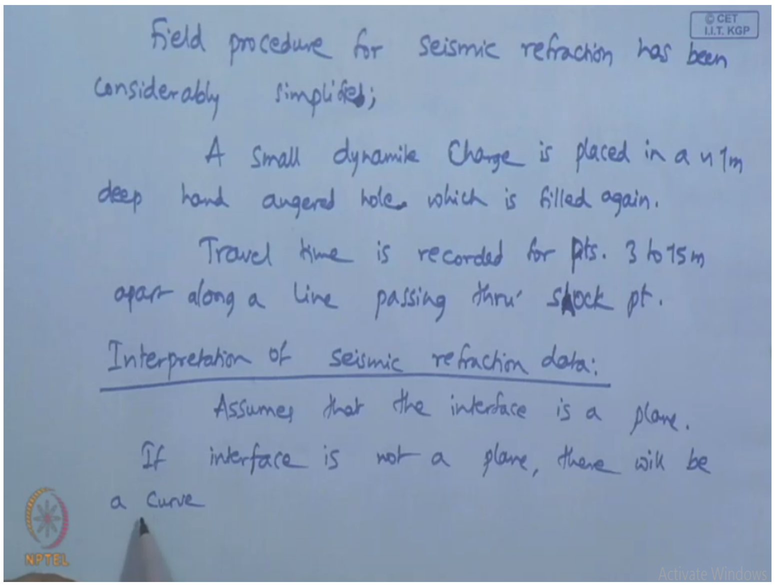

So now so this the field procedure for seismic refraction has been considerably simplified. And so here and this small charge a small dynamite charge is placed in an approximately one meter deep hand augered hole which is back filled which is filled again. So the time of travel as well as the travel time is recorded for points 3 to 15 meters.

Apart along the along a line from the shock point along a line passing through shock point and here so the so now let us discuss about the interpretation of the data. So this interpretation of the data assumes that the interface is a plane. If interface is not a plane then there will be a curve a small curve joining the two velocity lines instead of a point.

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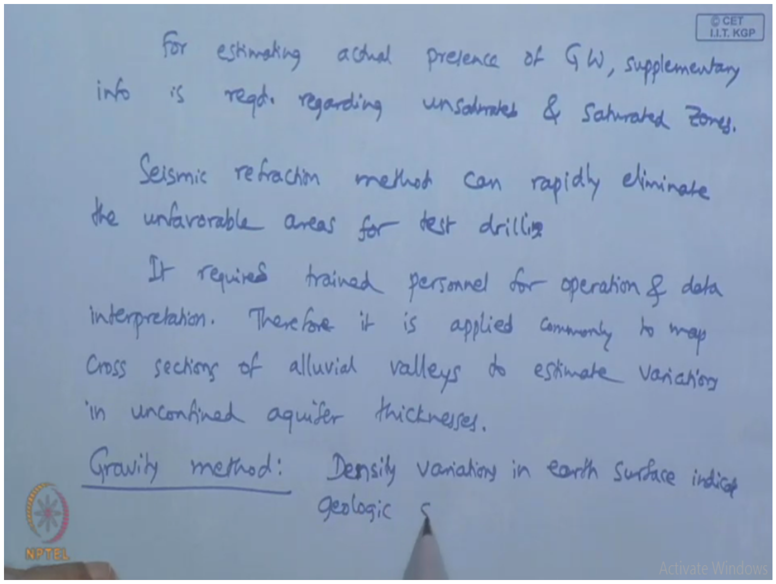

So here the actual presence of the estimating actual presence of ground water supplementary information is required. And so using this supplementary information regarding unsaturated and saturated zones so then we can be we can estimate the presence of ground water. So this seismic refraction method when applied can rapidly eliminate the unfavorable areas for test drilling.

So here so this it requires trained personnel for operation and interpretation and data interpretation. Therefore it is applied commonly to map cross sections of alluvial valleys to estimate variations in unconfined aquifer thicknesses. So now let us go to the gravity method so in this gravity method the density variations in earth surface indicate geologic structure. So this is the principle on which the gravity method is based.

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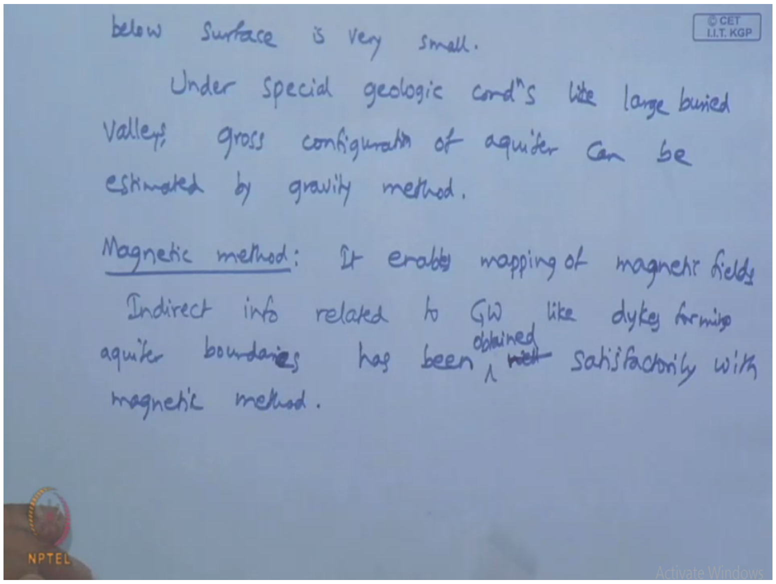

And this gravity method is it is very expensive since difference in water content so below the ground below surface is very small. Therefore these gravity methods are under special geologic conditions so like large buried valleys. The gross configuration of aquifer can be estimated by gravity methods.

So lastly we will go to the last method in this surface ground water investigation that is the magnetic method. So this magnetic method so it enables magnetic fields that is a mapping of magnetic fields. So indirect info related to ground water like dykes forming aquifer boundaries has been well has been obtained satisfactorily with magnetic method.

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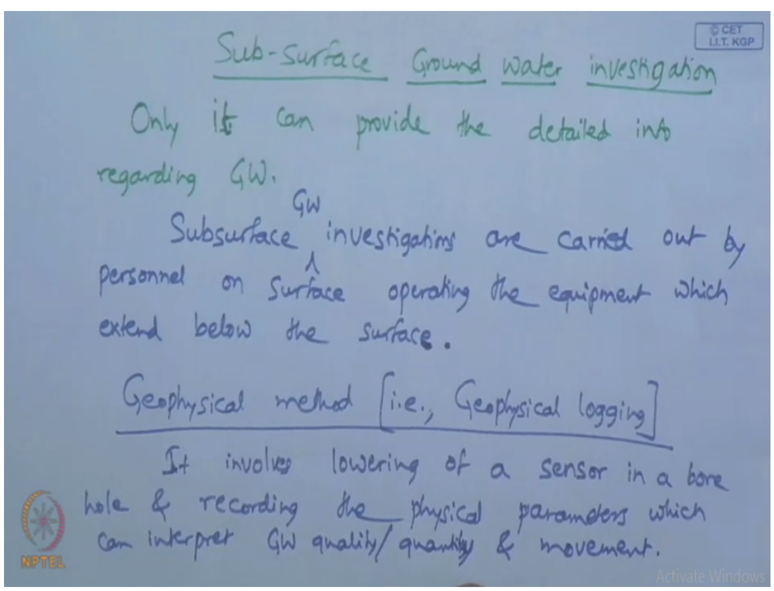

So this completes a surface investigation of ground water and now we will move on to the subsurface ground water investigation. And we all know that this subsurface ground water investigation is the only it can provide it means the subsurface ground water investigation. It can provide the detailed information regarding ground water. And here so the subsurface so the subsurface ground water investigations are carried out by technical personnel.

On surface operating the equipment which extends below the ground below the surface the equipment as well as its field of application is below the ground. And here so we will go to the geophysical method which is also known as geophysical logging. So in this geophysical method it involves lowering of a sensor or the sensing device in a bore hole and recording the physical parameters which can interpret this ground water quality quantity and movement quantity and movement.

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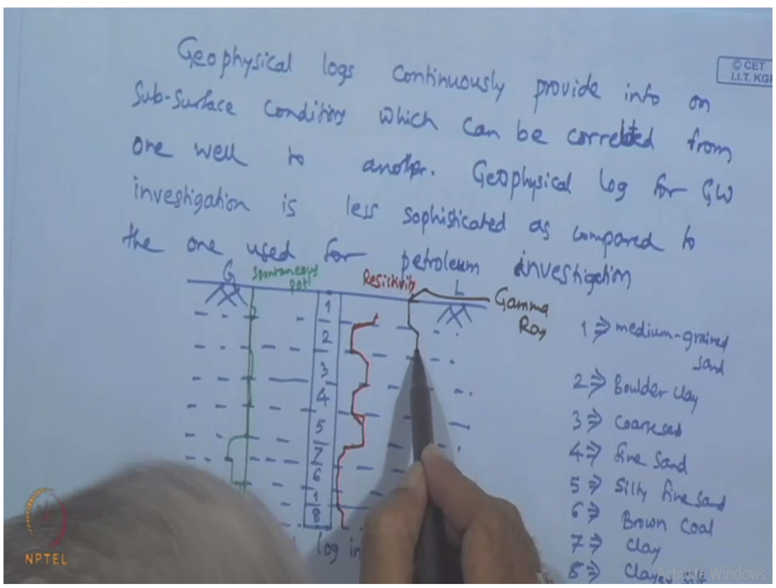

So we will move on to so this geophysical logs continuously provide info on subsurface conditions which can be correlated from one well to another. And here so this geophysical log for ground water investigation is less sophisticated as compared to the one used for petroleum exploration or oil exploration or investigation.

Now let us consider the geophysical log in unconsolidated rocks and geophysical log in consolidated rocks. Geophysical log in unconsolidated rocks in this case so this is the ground level and this is the bore hole and here there are various depth ranges. So in this the let us say these of the say 1 be 2, 3, 4, 5, 7, 6, 1, 8.

So here this one indicates medium grained sand two indicates boulder clay three indicates let us say three indicates a coarse sand and the fourth one indicates fine sand the fifth one indicates silt fine sand the sixth one indicates let us say it indicates brown coal the seventh one that is the it indicates clay and the eighth one let us say it indicates the clayey silt.

And this case say this geophysical logs can be used for getting the variation of this one say suppose here for your plotting the this spontaneous potential. And this case this is let us say the positive potential is shown on the right side of this vertical line and negative potential is shown on the left side of the vertical line.

And in this case the variation of this the potential suppose this is the variation of the spontaneous potential and then similarly let us say take the resistivity the electrical resistivity. And if these electrical resistivity's suppose it shows a variation like this so this is the variation of electrical resistivity.

And then let us say this is the variation of this gamma ray so this is gamma ray and suppose this is the in this case the values increase in this direction there it is electrical resistivity or the this one. And then the same thing can also be done for this caliper. We will discuss each of this separately.

And this geophysical log consists of this continuous information from this one. So based on this different this property is we can interpret the formations as well as the ground water availability in each of this. So we will continue in the next lecture on this geophysical investigation as well as we will specifically move on to the resistivity investigation or spontaneous potential investigations on thank you.