Ground Water Hydrology
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Module No # 06
Lecture No # 30
Radiation Method of Logging (contd.); Temperature / Caliper / Fluid Conductivity / Fluid Viscosity / Miscellaneous Logging Method

Welcome to the lecture 30 of ground water hydrology.

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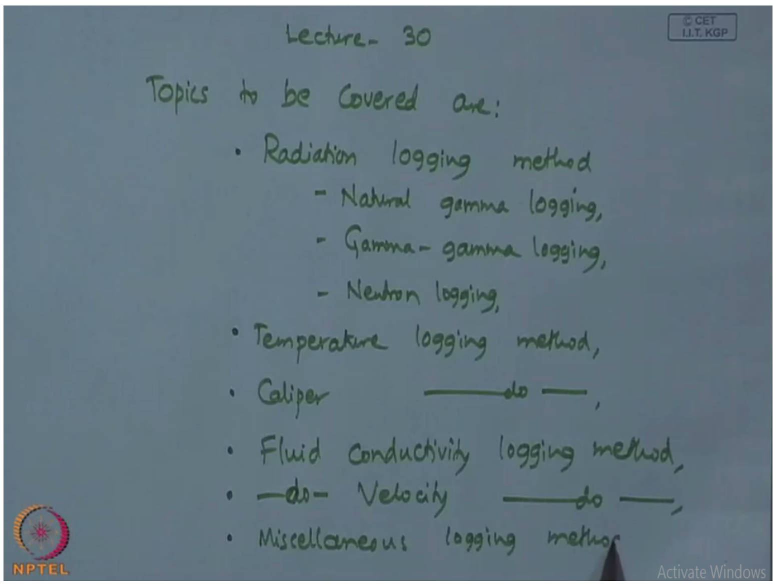

So in this lecture the topics to be covered radiation logging method. So within this radiation logging method natural gamma logging followed by gamma gamma logging followed by neutron logging and then we will move on to temperature logging temperature logging method followed by caliper logging method followed by fluid conductivity logging method followed by fluid velocity logging method and then lastly miscellaneous logging methods.

So these are the topics which are proposed in this lecture and first we will start with the radiation logging. So in this radiation logging so within this we start with the natural gamma logging and in this so this is based on the principle of principle is the emittance of natural gamma rays by all rock soil formation. So that is the principle on which this logging is based on and here so this radiation originates from unstable isotopes of a potassium, uranium and thorium.

And so the natural gamma activity gamma ray activity of clay is much higher much higher than sands and carbonate rocks. So the application of this of natural gamma logging applications are one in lithol one major application is lithology identification and of course there are other this one also the identification of other fine grind formations like clay, shale etc.

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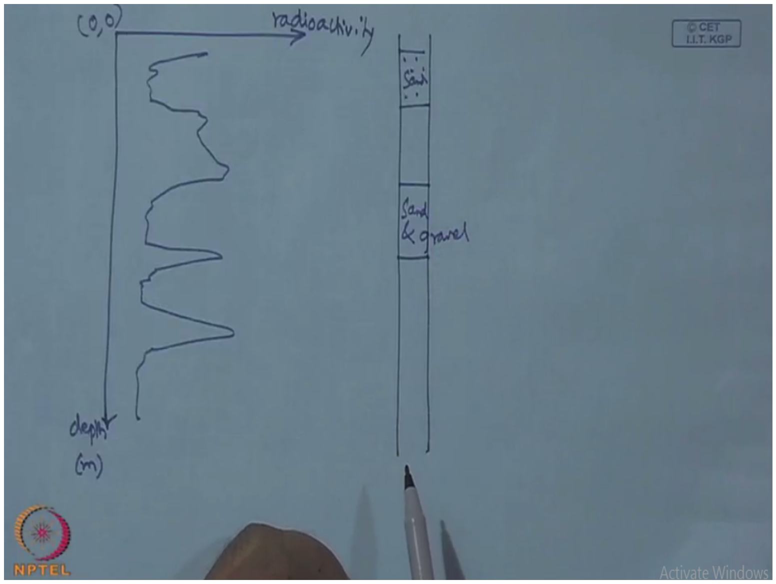

So these are the application and in this a typical natural gamma ray log will has a depth along the vertical axis. And then the radioactivity along the horizontal axis an here so in this case so this will constitute something like this. And here so this is 0, 0 and this corresponds to so in the geological log so may be this corresponds to sand.

Again so here it is sand and gravel and this is till. So here this is clay then sandy clay then again here this is sand and gravel and then again this is till and again so this could be gravel so like this so we can identify the this formation of the rock using this natural gamma logging.

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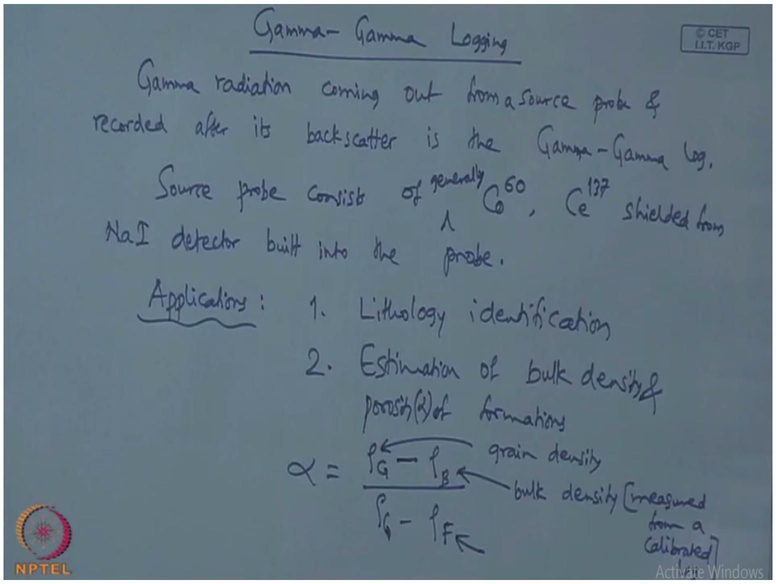

Next we will go to that is gamma gamma logging so here gamma ray radiation originating from assay coming out from a source probe and recorded after its backscatter is the gamma log. And so this source probe consists of cobalt 60, cesium 137 so this is generally so these isotopes of cobalt and cesium so this is shielded from sodium iodide detector built inside the into the probe. So this again the application of this so 1 is lithology identification.

Then estimation of bulk density and porosity of formations say if this porosity is denoted as alpha then this alpha can be written as Gamma G - Gamma B I am sorry Rho G - Rho B / Rho G - Rho F. So here this Rho G is the grain density. And Rho B is the bulk density so this bulk density so this is measured from a calibrated log and then this Rho F so this is the fluid density so if so this 3 parameters are known so then we can estimate the porosity of a formation using this gamma ray logging.

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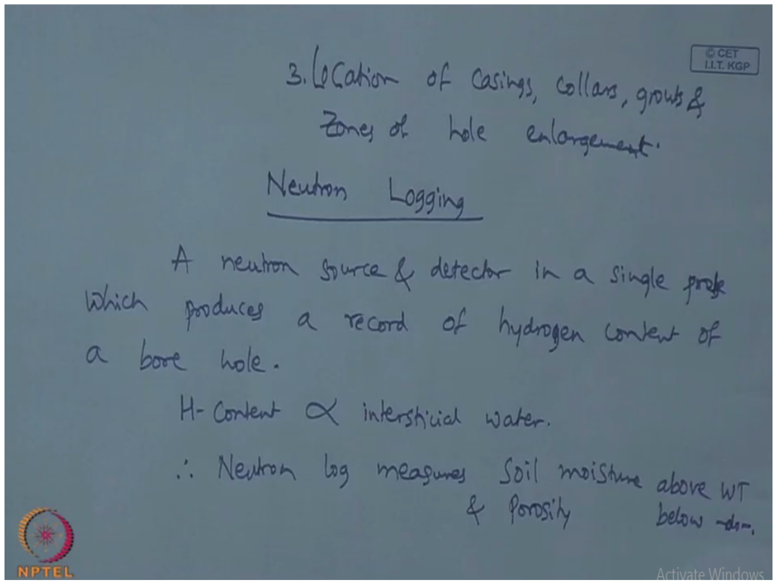

And one last application of the third application of gamma ray logging is location of casing, collars, grouts and zones of hole enlargement. So using this gamma ray gamma radiation so these casings, collars, grouts and hole enlargement zones can be located. So next we will go to another that is the last variety of the radiation logging that is neutron logging. This case so this neutron source and detector in a single probe which produces a record of hydrogen content of a bore hole.

So here so thus hydrogen content so this H content is proportional interstitial water and therefore this neutron log measures soil moisture above water table and porosity below water table. So these two can be measured so here what happens is so the mechanism is neutrons have same as hydrogen and no charge no electrical charge they are neutral.

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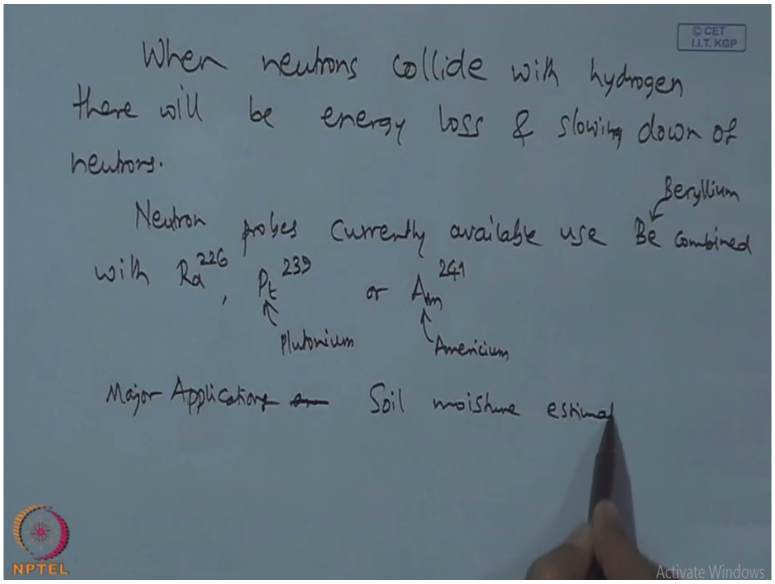

So when neutrons collide with when neutron collide with this hydrogen so there will be energy loss and neutrons are slowed and slowing down of neutrons. So here this neutron probes which are currently available use beryllium combines with so this beryllium combined with radium 226, plutonium.

So this is plutonium 239 or americium so this is 241 so these isotopes and this case so obviously so the application major application is soil moisture estimation then followed by porosity estimation. So obviously this lower moisture estimation has seen so above water table and porosity estimation this is below water table. And here so this for porosity estimation large holes is used large diameter holes are holes and larger probes are required.

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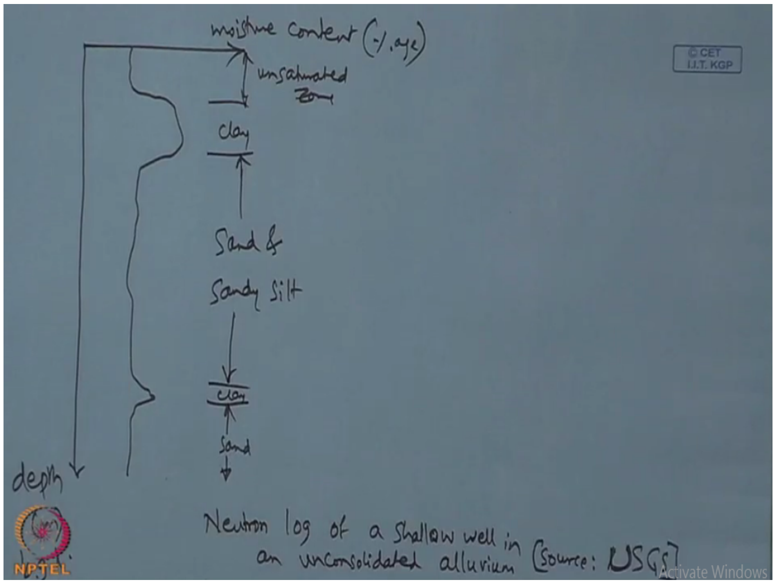

And here there is one a typical neutron log so here this is the depth in meters below the below ground level. And this is the moisture content in percentage so this is neutron log of a shallow well in an unconsolidated alluvium. So this is taken from the US geological survey and here so the so based on this we can say if the moisture is more so then we can say it indicates a clay.

This one and here it indicates unsaturated zone and so here this is sand and sandy silt again for a small depth it is clay followed by so this is sand so like this using the neutron log we can estimate the soil moisture. And also we can estimate the porosity.

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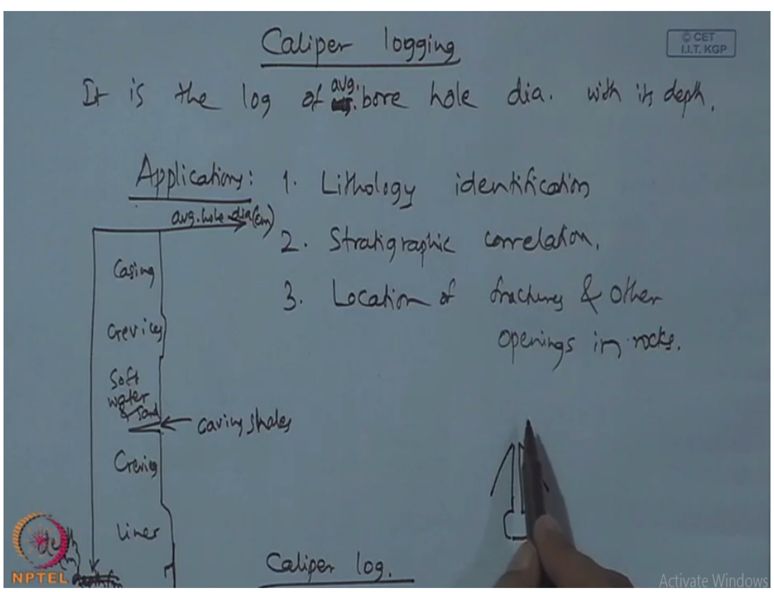

Next we will go to caliper logging caliper logging so this caliper logging it is the log of the bore hole diameter with its depth. So this is the here so the obviously so this is taken as the average bore hole diameter. Because at a particular location they can be the bore hole may have varying diameters it may not be perfect circle.

And in this case so the applications are of this caliper logging are lithology identification and next is the stratigraphic correlation so they can also be used for location of fracture sand other openings in rocks. So let us consider a typical caliper log so this case this so this is the average hole diameter in centimeter along this one here there is depth.

So this is the depth in meters and in this case so the so it may show something like this so here it represents the casing this represents crevices this represents soft water and sand and again so this represents caving shale again crevices and this represents liner and so on. So in this case so this is a caliper log.

So in this case so the typical so this caliper and then so this caliper so this goes on so this is a typical caliper. And here you can show this is the so this is the bore hole and with different rock formation. So this is a caliper so this caliper logging. So next we will go on to this fluid conductivity logging.

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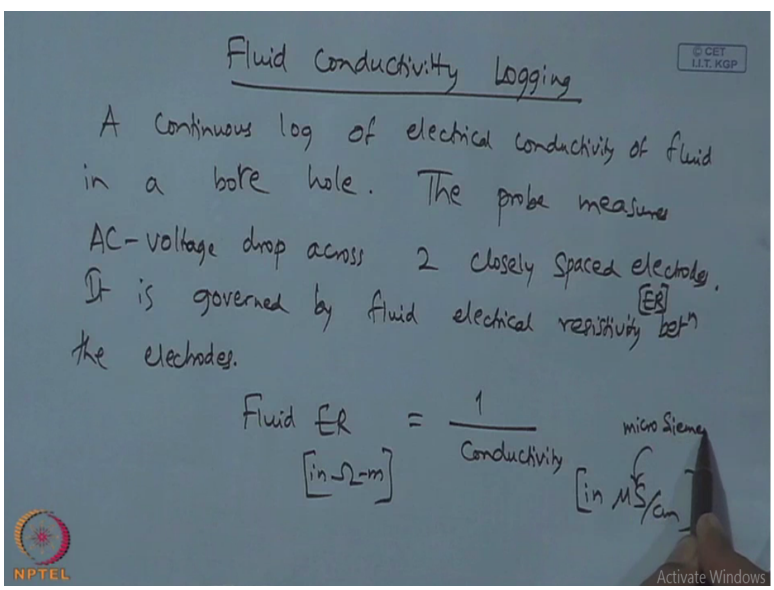

So this is a continuous log of electrical conductivity of fluid in a bore hole. So this is a fluid conductivity so the probe is the probe measures the alternating current voltage drop across two closely spaced electrodes. It is governed by fluid electrical resistivity between the electrodes and you know that the fluid resistivity so this if we abbreviate the electrical resistivity as ER so this fluid electrical resistivity which is measured in ohm meter.

So this is the reciprocal of that is the fluid conductivity and this conductivity is measured in so this is the micro Siemens per centimeter. So this is micro siemen per centimeter so this electrical resistivity is the reciprocal of this one.

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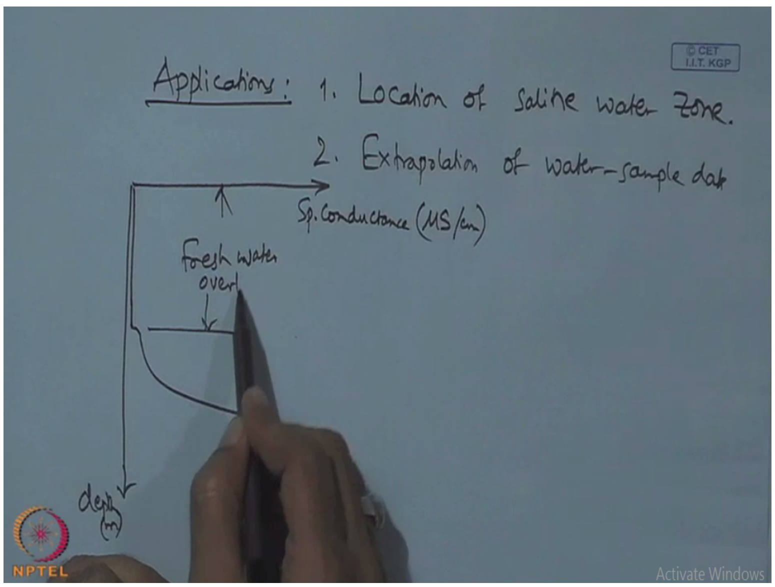

And the applications so the applications are one is the location of saline water zone two is extrapolation this fluid electrical the conductivity log can be used for extrapolation of water sample data and. In this case say for example a typical fluid conductivity log it will have so the depth in meters and then the specific conductance in micro siemen per centimeter.

In this case so suppose this fluid electrical fluid conductivity log so it has a shape something like this. So this indicates so here obviously so this is so this is fresh water over lying saline water. So obviously the saline water is a good conductor of electricity so its specific conductivity is much higher. So of the order of say something like 40000 whereas so the fresh water has the very negligible this one may be one less than a 1000 or around 1000 micro Siemens per this one per centimeter.

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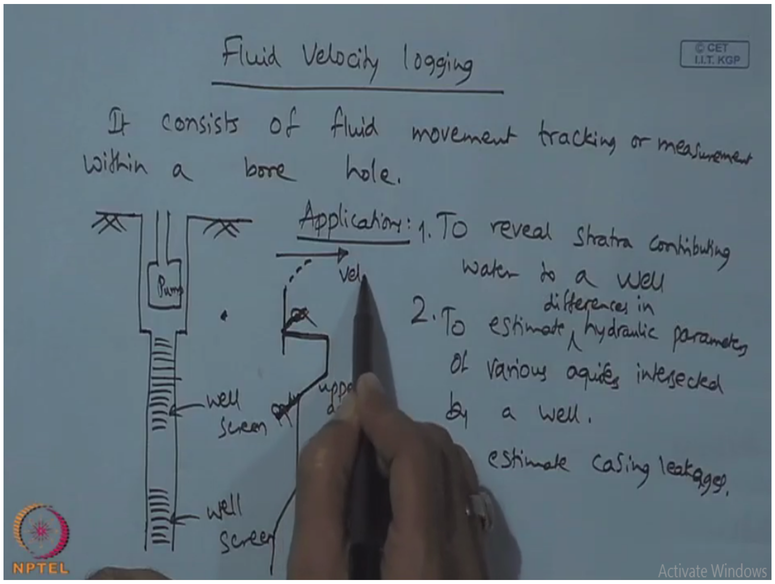

So next we will go to the fluid velocity logging so in this fluid velocity logging so it consists of fluid movement tracking or measurement within a bore hole. So its applications to reveal strata contributing water to a well to estimate the hydraulic differences. So estimate differences in hydraulic parameters of various aquifers intersected by a well and thirdly to estimate casing leakages the leakages in the casing in pipes.

Then this case says suppose so this a well and it has so there is so this is a well screen. So this is a well screen this is also a well screen and here say suppose there is a so this is a pump. This case the fluid so the fluid velocity logging it will be something like this I am sorry it starts at the pump level. And so it is so this is the upper aquifer and here this is again and so on so basically so this is a typical so this is this indicates upper aquifer.

So this indicates and this indicates lower confined aquifer and so this is the velocity so this is the depth so this is regarding the fluid velocity logging. And with these so these three applications that is the strata revelation then estimation of differences in hydraulic parameters and then the casing leakages can be can be estimated. So next we will go to the last item of this module that is on miscellaneous methods of logging.

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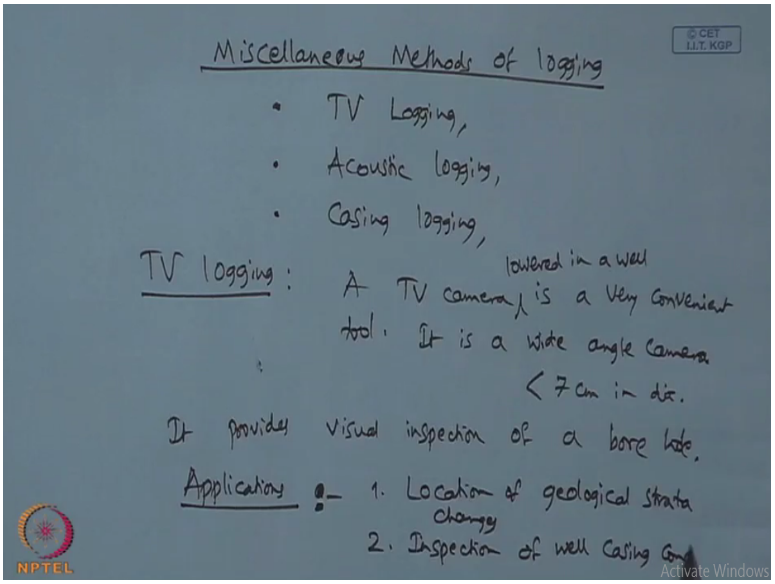

So in this there are this TV or say television logging there is acoustic logging and the third one is the casing logging. So these are the three important techniques which are grouped under the miscellaneous logging. And here so this is now let us come to this TV logging so this is in this a TV camera television camera is a very convenient tool.

So this TV camera lowered in a well so it is a wide angle camera so this is said typically less than say 7 centimeter in diameter. And when it is lowered into a well it provides visual inspection of a bore hole. So the applications so the applications are one is location of changes geological strata changes so inspection of well casing condition.

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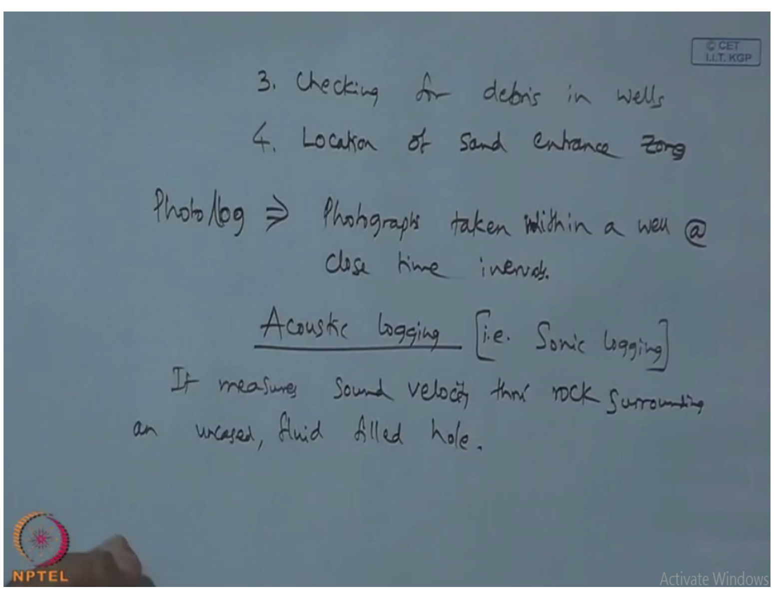

Then the third one is checking for debris in wells and location of sand entrance zones. So there is also what called photo log is so this photo log so it is basically photographs taken in a well that is within a well at close time intervals. So this is regarding the TV logging next we will go to what is called the acoustic logging.

And this is also known as sonic logging so in this the so it measures sound velocity through rock surroundings rock surrounding in an uncased fluid filled hole. And so therefore if porosity is greater is higher the closer is the measured sound velocity to that of fluid.

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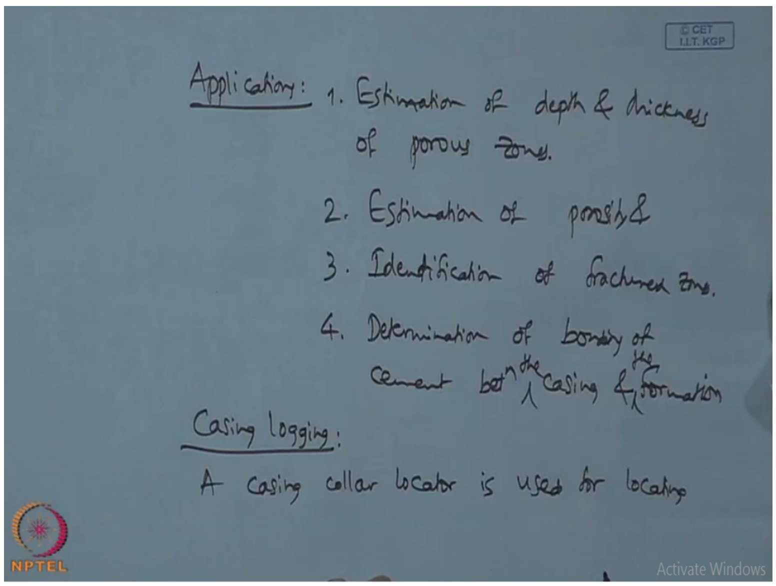

So the applications of this acoustic logging are estimation of depth and thickness of porous zones second is the estimation of porosity and third is identification of fractured zones. And next application is the determination of bonding of cement between casing and formation casing and the formation between the casing and the formation.

So these are some of the applications of acoustic logging and lastly we will go to this casing logging so this casing logging so here a casing collar locator is used for locating collars perforations and screens in casings.

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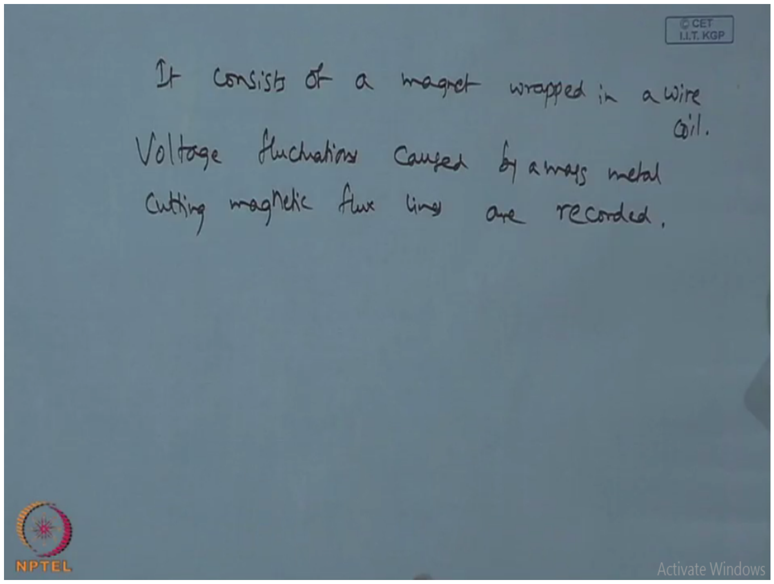

And so it consists of magnets wrapped in a wire coil so this fluctuations voltage fluctuations caused by mass metal a mass metal cutting magnetic lines of force magnetic flux lines are recorded. So there are other subsurface methods which include the pumping test the ground water level measurements water quality measurements. So all this have been already discussed most of this have been discussed in previous lectures.

And few might be discussed in the next lectures so basically this subsurface investigation of ground water it is the more complete and it provides its almost complete information as compared to the surface information as compared to the surface investigation. So that needs to be properly utilized to arrive at the ground water to arrive at a holistic investigation of the ground water thank you.