Ground Water Hydrology
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Module No # 01
Lecture No # 05
Occurrence and Movement of Ground Water: Origin and Age of Ground Water, Rock Properties Affecting Ground Water, Ground Water Column

Welcome to this lecture number 5 of this ground water hydrology course.

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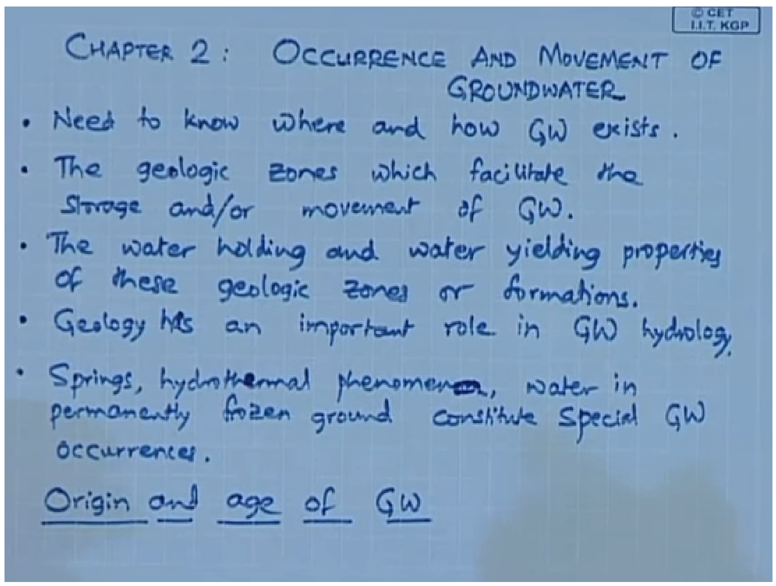

And this lecture we are starting with the second lecture that is on occurrence and movement of ground work and we will know that this ground water it so initially it appears in the below the ground and then it moves below the ground also in various locations. So all this aspects are studied in this chapter now here so the so first of all we need to know where and how this ground water exists.

Next we need to so the geologic zones which facilitate the storage and or movement of ground work. So when we are when we need to know where and how ground water exists obviously we our focus is shifted to the geologic zones or formation which exists below the ground and so not all the geological zone below the ground or conducive for occurrence and for ground water. So only certain selected geological zones are facilitate the storage as well as moment of so we need to study them.

And here the next is so the water holding and water yielding properties of these geologic zones and formation. So and of course therefore the here we cannot exclude the role of geological from ground water hydrology as this ground water hydrology implies. So the study of water the predominantly quantitative study of water below the ground or below the surface.

And here when we talk of this one the ground water hydrology so we have to consider the geology also and there are some special cases also which has say the here let me write. So geology is an important part of geology has an important role in ground water hydrology. And here so let us also let me mention here springs, hydrothermal phenomena water in permanently frozen ground constitute special ground water occurrence.

So this springs may be releasing water either at the normal temperature or they may be releasing water at a higher temperature or a lower temperature due to various hydrothermal phenomena where in so the groundwater which is getting release through the spring it is either getting heated or sometime it is also getting cool-down. So as well as so there may be some water which is permanently frozen.

So all this constitute the special cases of the occurrence of groundwater now let us come to the origin and age of ground water.

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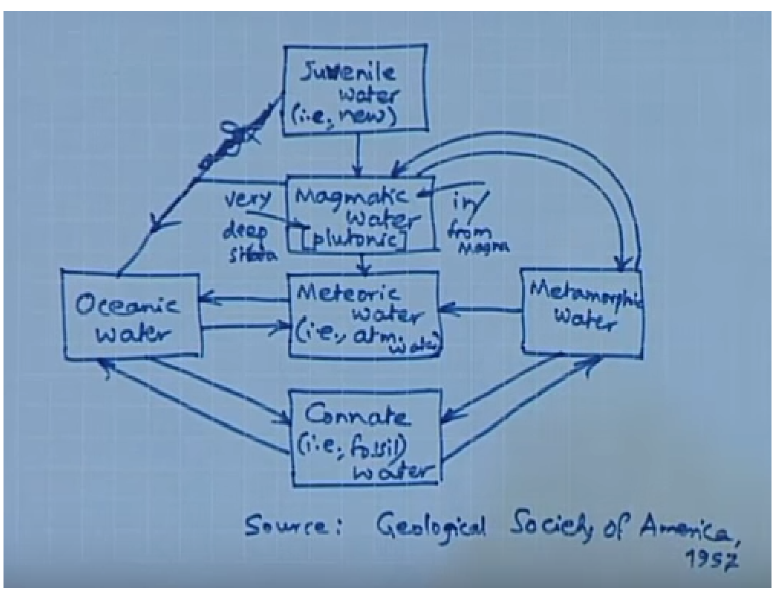

So here I would like to explain this origin age of groundwater with the below of this diagram consisting of this 6 blocks. So let us start with the newest among them which is represented at the top which is denoted as which is known as juvenile water. So that is new water in next below that is the magmatic water so this magmatic water of course this also includes plutonic so this magmatic water is in or from magma which is in the deeper strata.

And here and if it is in very deep strata so then it is known as so this is plutonic is so this is a very deep strata. Next is this meteoric water so that is atmospheric and from this atmospheric water of course so there is also I am sorry so here there is also so this from magmatic water there is a connection to oceanic water which is the water in the ocean and here there is a two way water between oceanic water and meteoric water which is essentially the atmospheric water which is you can say it is recent water.

Then there is also another two way link which is oceanic water and this carnet so which is also known as fossil water carnet water and here there is a another this one which is metamorphic water which is water which exist in the metamorphic rock undergoing change in their form again from this metamorphic water to cornet water there is a two way flow and also so here say from this metamorphic water and magmatic water there is a two way interact.

So this is a figure is taken from the geologic geological society of America in 1957. So essentially here we have say 6 types of water depending upon their occurrence and their age and here as we can say so this juvenile water as well as this meteoric water. So there the most recent ones this is atmospheric water meteoric water also means and this carnet water which is the oldest one carnet water and also say this plutonic water which is existing in the deep deeper strata.

So and in between there is magmatic water there is metamorphic water and also this oceanic water it is a mixture of all because the ocean water right at the top so it must have it might have been at the ocean surface may be could be very recent whereas the ocean water at deeper depths it could be almost as old as say connate water or say the plutonic water and so on.

So essentially what I am trying to tell you is the age of ground water depends upon the various factors the location from where it come as well as the depth of this depth below the ground where this ground water existing okay. So now so essentially as I was mentioned there are these six forms of water and it is this there is a two way interaction between magmatic water and metamorphic water.

There is also a two way interaction between connate water and metamorphic water is there is another two way interaction between connate water and oceanic water there is one more two way interaction between oceanic and meteoric or atmospheric water.

So essentially so this ocean water is in two way interaction with meteoric or atmospheric water as well as connate water and metamorphic water is in two interactions with as well as magnetic water and this magmatic as well as connate water they have two way interaction with only this this connate water has two interaction with oceanic water as well as metamorphic water.

Whereas this magmatic water it has two way interaction with only metamorphic water. So now let us come to the determination age of ground water so here in this while determining the age.

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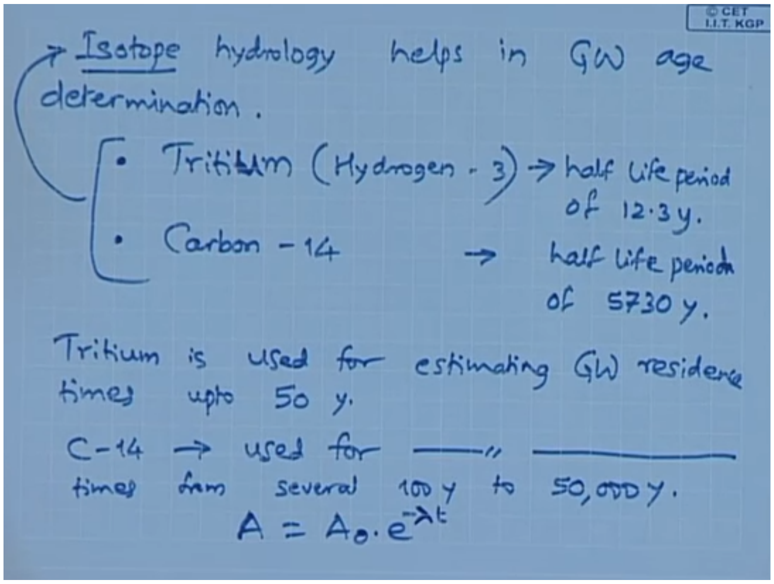

So it is the isotope hydrology helps in ground water age determination and when I talk about isotopes so two important isotopes are there that is 3 TM which is H3 that is hydrogen 3. So essentially hydrogen with 2 proton additional proton molecules proton particles and then there is carbon fourteen and this stratum three it has a half-life period. So this are the three isotopes both this are isotopes so this as a half-life period of 2.3 years and this carbon fourteen this half-life period of 5730 years.

So here because so the half-life period in case of tritium is relatively small while that for carbon 14 that relatively large so these two are used for determining the age of the ground water and various geological formation. And so this tritium is used for estimating ground water residence time up to say 50 years and this C14 that is the carbon 14 used to or used for estimating ground water residence times from several 100 years to 5000 years.

And here we should also remember that equation that which is A = A0 into E 2 the power – gamma T. Where A is the radio activity at time T and observed and 0 is the radio activity when the ground water enter the when the water enters the aquifer and this lambda is the decay constant T is the time and generally the time is measured in years okay.

So with this and also mentioned here that this carbon 14 isotope is present in ground water as a dissolved bicarbonate originating from biologically active layers of soil where carbon di oxide is generated. So basically whenever desert there is a dissolved bicarbonate which generates carbon di oxide by root respiration and you must decay so there so this carbon 14 and this isotope generally exist and mainly these two isotopes which is hydrogen three as well as carbon 14.

So they have been used to determine the age of these ground water samples all the way up to say 20,000 thousand to 30,000 years in the middle east such as the United Arabic Republic which is basically the Russia am sorry Egypt it was Egypt they it was previously known as Egypt along with I believe say any north African country. So they were together known as the United Arab Republic so essentially Saudi Arabia and Egypt.

So these two isotopes have been to determine the ground water samples having ages of say twenty thousand to thirty thousand years. So now let us come to the next part of the next article which is the tock properties which affect the ground water.

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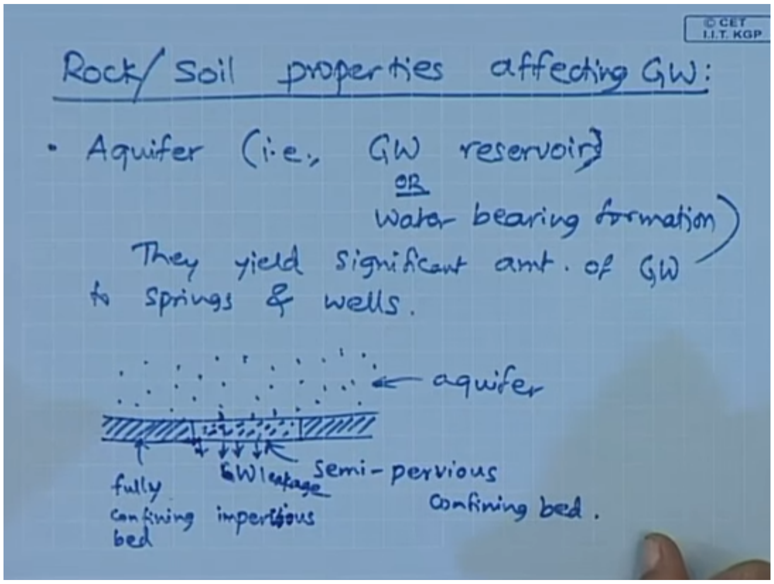

And here when I talk of this rock properties rock or soil properties implies those properties which facilitates the storage and movement of ground water. And here so before going for this rock properties we should know certain terminologies such as aquifer and so this aquifer it has the phenomena that is the ground water reservoir or so this R with the underline that means one and the same it is nominal.

So it is a water bearing formation so basically so this is aquifer it is this soil or rock formation or layer when in so there is enough of void spaces for the ground water to get stored as well as to know and here because they of the capability of storage as well as moment of ground water within the aquifer.

So these aquifers they are basically the yield significant amount of ground water to springs and wells for simple reason that. So there are lots of empty or wide spaces in which ground water gets stored and because of the hydraulic gradient. So this ground water also starts moving from higher gradient to from a higher head to lower here where there is a slope or a gradient.

So ground water starts moving and eventually so these aquifers yield significant amount of ground water to various wells which may be open wells or tube wells or even to springs where many small streams and other this water bodies so they originate or okay and this aquifers generally have a confining bed say suppose this is an aquifer it is let me represent this so a so this is an aquifer. So these represent the void presence and then so here so then I have either a fully confining bed or then I have a semi confining bed.

So this could be fully confining bed and then so this could be here you can say impervious and this is a semi pervious confining bed. So then it is semi pervious then this ground water leaks through this semi pervious confining layer. So this is the so this is the ground water leakage we can say and so now let us also know little bit about three more terminologies that is aquifuge, aquitared and then aquiclude.

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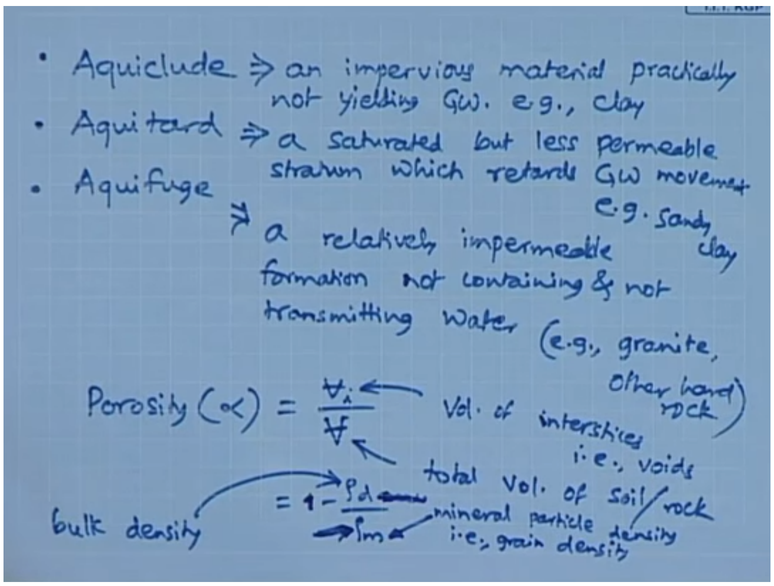

So here aqui clued, aqui tared, aqui fuge so here let us understand the meaning of this so you can remember this as aqua exclude. So water is excluded from movement that is aquiclude so basically here so this is an impervious material practically not yielding ground water so example for a aqui clude is a say clay. So clay is a soil with the finest particle size so therefore the amount of void spaces it is very limited.

So therefore this clay behaves like a aquiclude next it is the aquitade which is s a saturated but less permeable stratum which retards ground water movement and here the examples for this aquitard is a sandy clay. While the example for this aquitude is clay because clay consists of fines soil particle with the practically no wide spaces or empty spaces. On the other hand this sandy clay it will have some empty spaces through which so they there is less permeability.

And so it is saturated also so therefore it retards so it is very limited quantities of ground water next is this aquifuge. So this is a relatively impermeable formation not containing and not transmitting water that is an aquifuge. So here we can give an example of hard rock such as granite other hard rock okay. So therefore aquifuge now we learnt about aquifer which is basically a water bearing strata which can be interpreted as a ground water reservoir.

And also followed by this aquiter which is essentially which retard the groundwater moment then it is the ecuator which is practically an impervious not yielding groundwater such as clay and lastly a aquifuge which is the hard rock. So this clay will contain water this aquitude will contain water but this aquifuge does not contain and it does not transmit also what okay so these are the for the soil or rock formations and out of this for our case the aquifer is the most important in case of ground water hydrology as well as this is aquitard.

So this is we have to exploit we have to harness ground water using the aquifer and we should so ensure that so these aquifers should have a proper confining layer either at the bottom or in the sides so that these ground water is stored and it is not leak to so undesirable locations. Now the most important property of the rock or soil is known as porosity and this porosity so if we denote it as alpha then this is a volume of (()) (38:30) divided by total volume okay.

So just to distinguish this to velocity am using the hatch notation so this VI is the volume of voids interstices that is voids and this V is the total volume of soil or rock. So this porosity it ranges from say 0 to 50% and the in case of say this aquifuge so the porosity will be 0% and in case of aquitude the porosity will be very low and then in case of aquitar the porosity will be even more and aquifer will have the highest porosity.

So here so this porosity can also be expressed as 1 – Rho D / Rho M so this Rho D is the mineral particle density or rain density and this Rho M I am sorry this is a Rho M is the mineral particle density and this Rho D so this is the bulk density. So this porosity can also be expressed as 1 – bulk density divided by the grain density so this mineral particle density also known as grain density and depending upon whether this wide spaces or primary and secondary.

So there can be we can also define this primary porosity and the secondary porosity now ler us come to this the ground water column.

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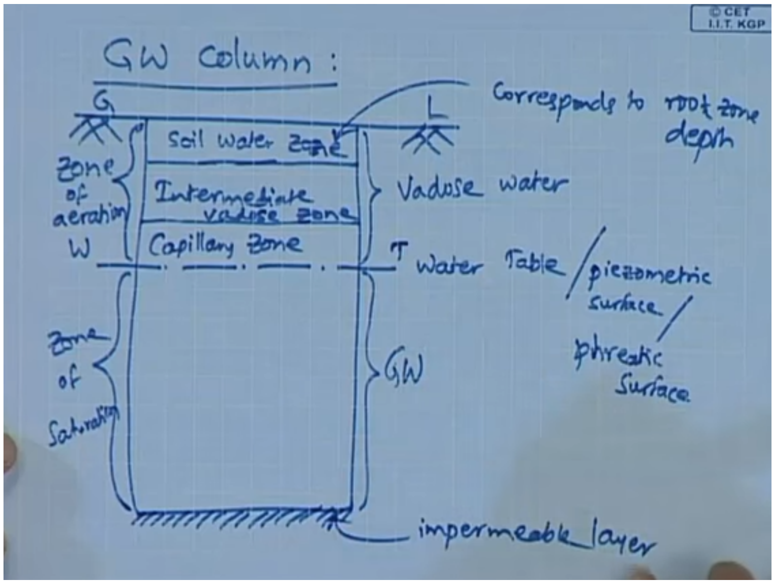

So in this we discuss about the ground water which exist which right from the ground below. So here there is a very important interface so that interface is known as the water table it is also known as so in case of piezometric surface or say phreatic surface essentially suppose this is the ground and water table is denoted by WT it represents that horizontal layer below the ground.

Below which the entire soil or rock layer is saturated and above which the soil or rock layer is either partially saturated and unsaturated. So that is the water surface and here so accordingly so this whole thing is known as groundwater column. So suppose I represent this as a column then the soil column above water table is known as zone of aeration and there is other name also and the water present in this is known as vadose water.

Water which may be present many times if it is sully dry if it is fully unsaturated then there may not be any this one at all and the soil or rock column below the water table so this is known as zone of saturation and the water which is available there is known as the ground water and again this zone of aeration so it as three zones the top one is known as the soil water zone. So this corresponding to so here this corresponds to root zone depths.

And the bottom one is known as capillary zone or it is known as capillary fringe wherein even though it is above the water table in the zone of aeration due to capillary action taking place through the thin as a capillary tubes as well as slots. And so some water rises up to this capillary up to top of the capillary zone by the action of capillarity due to surface tension of water.

And in between the soil water zone and capillary zone so there is what is known as the intermediate vadose zone. So this intermediate vadose zone is below the soil water zone when in we will find the root depths of plants and it is above the capillary zone to the top of which we will find the capillary rise of water. So essentially this soil water zone, intermediate zone and vadose zone I am sorry capillary zone.

Together constitutes what is known as the zone of aeration which is above the water table and here so this zone of saturation the at the bottom of the zone of saturation we have impermeable layer and so this zone of saturation may contain few impermeable layers or semi permeable layers within them and so accordingly it may contain one or more aquifers. So here the aquifer which is just below the water table which is known as the unconfined aquifer or the water table aquifer.

And the aquifer which is bound at the top or at the bottom by this confining layers it is known as confined aquifer and here let me also represent how the water is held in this vadose zone.

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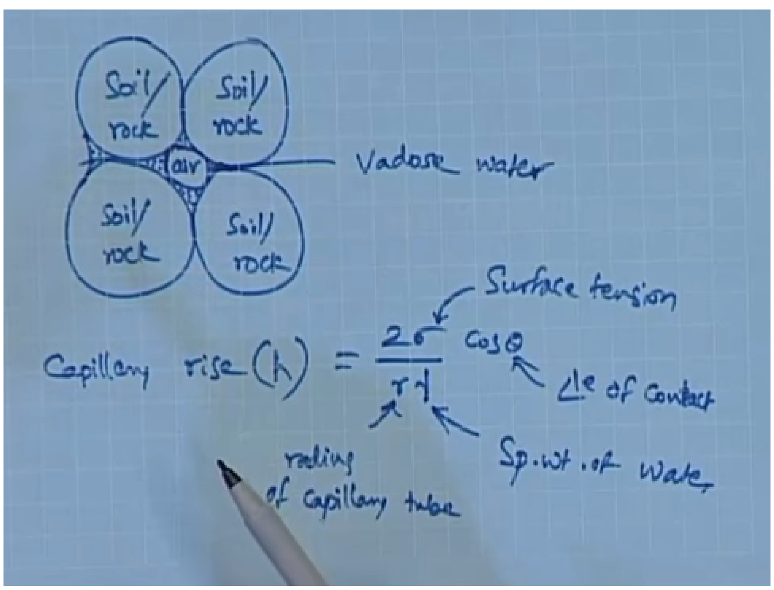

On suppose say these are the soil particles these are the soil or rock and then so this is a soil or rock particles and in between say this is the air particle and here due to the attraction between water and the soil or rock particles. So these this water so this is vadose water so which is held between the soil or rock particle as well as rock particle. So like this so in the unsaturated zone there may be vadose water if it is in the unsaturated or partially saturated zone.

And coming to this capillary zone so here obviously height of this capillary zone so depends upon the capillary rise if this is H and it is given by 2 sigma Cos theta / R gam. So this sigma is the surface tension water theta is the angle of contact and R is the so the radius of capillary tube and this gamma is the specific weight of water. So based on this four parameters surface tension which is measured as force per unit length.

And then this theta the angle of contact R the radius of the capillary tube and if it is a slot in that base it is the semi width of this slot as well as the specific weight of water. So based on this the capillary rise the height of the capillary rise can be determined which determines the depth of the capillary zone or the capillary fringe. So we will stop here and then we will continue about further and this various zones that is zone of aeration, zone of saturation thank you