Availability and Management of Groundwater Resources

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Lecture - 08
Geological Formation as Aquifer (Continued)

Welcome you all in the lecture entitled geological formation as aquifer. In this very lecture, the third part of this lecture I will try to explain the details about the formations its behaviour for storing the water and the certain characteristics which are very, very impossible for making the formation fill of groundwater. So, in we have seen from the last two lectures on the subject geological formation adjectives.

We have seen that porosity permeability very important component of any rocky formation because then only it will have the ability to store the water as well as the ability to transmit the water from one rock formation that is aquifer to another rock formation that is aquifer.

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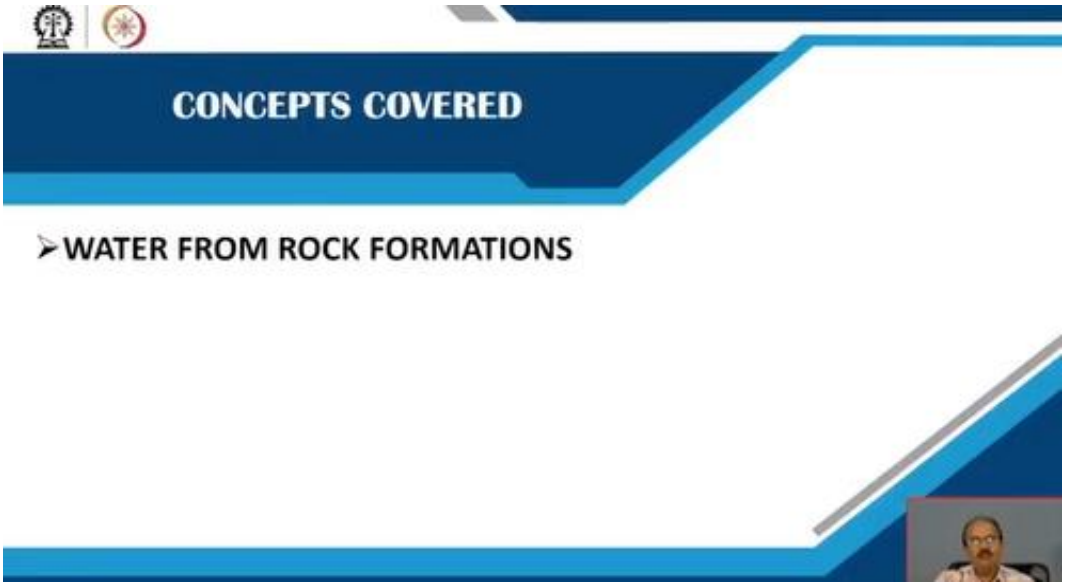

So, in this very part of the lecture just we I will discuss the different characteristics which is responsible for making the formations filled with water.

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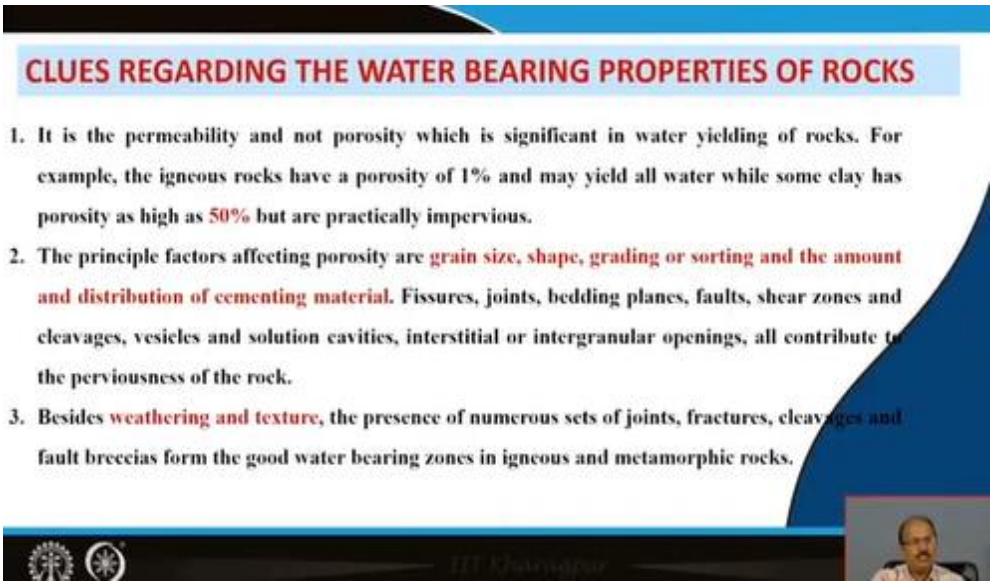

So, what there are certain clues also what I have told you at every place we are not getting ground water. But we may get certain idea if we are having certain concept in our mind that we may get water we may get groundwater. The idea is that I told you just see the types of the rocks types of the rocks which are present in the area. So, that is very, very important. Which types of rocks are present in the area?

Suppose you are having the idea that the rocks types are igneous sedimentary metamorphic then you can just on the basis of the concept predict that okay the sedimentary formations are there. So, we may get water groundwater in a good amount. So, besides this, what we have discussed in the previous lecture I have shown you the different areas different types of aquifers present all across our Indian subcontinent starting from Himalayas to down below.

So, here just I am just supplementing few more points through which you can not only guess but become confirmed that you can get the groundwater if you will just dump the place. So, in the previous lecture we have seen that porosity and permeability. Both are the important component for making any formations which enrich with your groundwater that is the aquifer. For aquifer the porosity and permeability is very, very important in the previous lecture we have discussed.

Now here I am just supplementing few more clues that it is the permeability and not the porosity which is significant in water yielding of rocks, rocks means aquifer. It is the permeability.

Permeability means ability to transmit water from one aquifer to another aquifer. So, this is called as permeability and not the porosity which is significant in water healing of rocks. For example, just igneous rocks have a porosity of 1% we are knowing I have discussed also.

In the very first lecture I have discussed in the type of rocks I have told you that the igneous rock is being formed by the consolidation of the molten magma. So, molten magma when it is just consolidating then it is all on a sudden forming a rock and the rock name is igneous rock. So, since it is forming all on a sudden then what is happening there is no pore spaces or any type of spaces left here, they are totally compact.

That is why it is hard rock also it is hard also granite we are using for the construction material. So, in this the porosity is remaining only 1% and igneous rock have a porosity of only 1%. And may yield all water may yield all water while some clay has the porosity as high as 50% clay is having too much porosity but clay is impervious having no ability to transmit the water. So, the point is that what we have learned that porosity and permeability are the two important factors which are responsible for making any formations of water rich groundwater rich. But now we are getting some more concept that permeability is more, more important than porosity. Example also been given here that clay is having porosity of 50% but clay is a very impervious rock it is practically impermeable. If you are getting clay at certain area during excavation then generally the area are being left, why?

Because for it may store more water but it is not having ability to transmit the water. So, that is why this permeability is very, very important for making any rock formation water bearing. Now the principal factors besides this affecting porosity are what are the principal factors which are affecting the porosity are grain size. What are the size of the grains? Then shape of the grain, grading or sorting and the amount and distribution of the cementing material.

So, these whole parameters that is grain size, shape, grading amount of and distribution cementing material plays very, very important role for making the rock porous. Suppose two different types of rocks are there one rock is this one this one but here grain size is more here

grain size is less. So, what will happen in the lesser grain size the more the spacecs will be there but if the grain size is more then what will happen the less space will remain there.

So, this grain size then shapes of the grain also then the amount of cementing materials just the cementing material which is just making the sediments a rock. So, these whole factors play very, very important role for making the rock porous. Fissures, joints, bedding planes, faults these are some of the geological term but these are very, very important because the branch of geology in which we are discussing about the groundwater is known as hydrology.

So, for hydrology portions generally the knowledge of geology is very, very important and for this is we are not entering into the geological concept geological subject in depth. But we are just touching the feel of the terminology which are very, very important for learning the concept of availability of groundwater resources. So, fissures, joints these are just in the rocks fissures, joints are remaining in the rocks.

So, these bedding planes suppose two different sets of rock formations have been made. So, this is the bedding planes, faults are also very important. These are some of the structures they do two different rocks are there. But one rock is just moved to the other rocks so this is the fault plane through which the rock has shifted. So, these fissures, joints, bedding plane, faults, shear zones, cleavages, vesicles and solution cavities, interstitial or intergranular all contribute for the permeability of the rock.

Because through this only the water will able to move from one place to another. So, porosity is affected by all the factors which are possible for making the rock porous grain size, shape, grading and the amount of the cementing material. These are the important factors which is responsible for making the rock porous and for making the rock permeable the fissures, the joints, the bedding planes, the faults, the shear zones.

The cleavages, the vesicles, the solution cavities, the intergranular openings these all contribute them to make the rock pervious to pervious. So, the permeability will be more because of these factors. And what we have seen? Weathering and texture, the presence of numerous sets of

joints, fractures, cleavages from the groundwater bearing zones in igneous and metamorphic rocks. So, in igneous and metamorphic rock see sedimentary rocks there are no point is their sedimentary rocks will definitely have some porous spaces.

The point important is the aquifers which are present remaining present in igneous and metamorphic rocks. So, some do because of some of the weathering phenomenon or some change in the texture of the rock or the presence of some sets of joints, fractures etcetera. The same rock will just change into a water bearing for formations and these rock igneous and metamorphic rocks will become a very good aquifer in those very areas.

So, these are some of the concept, because we have already made the concept that the rocks generally the sedimentary rocks. And the metamorphic rocks of the sedimentary origin will remain as a good aquifer but it is not important that at every place you will get these two sets of rocks some different sets of rocks. These are the three important rocks in near sedimentary and metamorphic but besides this there are several sets of rocks based on the different sets of mineral assemblages within it.

So, based on the different types of texture, structure within it. So, these rocks are only there through which the groundwater will try to remain in it and through which the groundwater will try to flow from one place to another place through it. So, that is why we are just discussing these in detail. So, groundwater movement is also very, very important factor for making for knowing about the aquifer.

So, these factors should be there, the concept should be in the mind that the different factors are responsible for making the rock porous as well as permeable.

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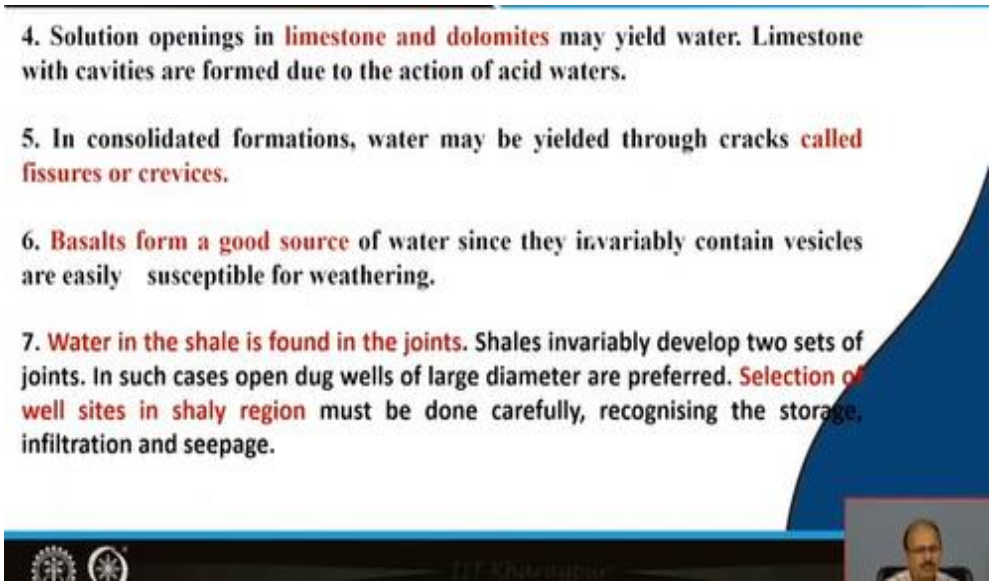

Now some of the limestone we have seen limestone dolomites the sedimentary rocks. Solution openings are making the storage point of the rock and those solution openings are just yielding the water through it. Limestone is having some cavities which are forming because of the action of waters action of your acid water. Some cavities are being formed, suppose this is the limestone. So, in it some small, small cavities will form and these cavities will ultimately hold the water.

And through it can be taken out for different purposes. So, in consolidated formation water may through cracks. So, when the rock is totally compact so here also there are some chances of storing of groundwater and the water will remain stock in certain cracks. Suppose this is a crack or some fissures small space within it some fissures. So, through it only the water will remain stored there some fissures or crevices.

Basalts which is a type of igneous rock igneous volcanic equivalent of igneous rock. Basalts form a good source of water where we are getting basalt rock means igneous rock igneous is there but basalt is a volcanic igneous rock gabbro it is just your plutonic gabbro variety whereas the basalt is the volcanic equivalent. So, basalt is forming a very good source of water since they invariably contain vesicles means small, small space by space is there just the escape of your volatile metals matters in the atmosphere.

So, here it is just remaining small, small space vesicles and then water in the cell is found in the joints also, shale is your sedimentary rock. So, here also water groundwater repository is there. But in this the joints play very, very important role for holding the water. So, these joints play very, very important role and in such cases open dug well of large diameter are preferred for the selection of well sites when we are getting some shaly region.

This is very important so last open dug wells are preferred in the shaly region because the some of the storage infiltration and seepages are also responsible for making the good storage of the groundwater in the this type of rock.

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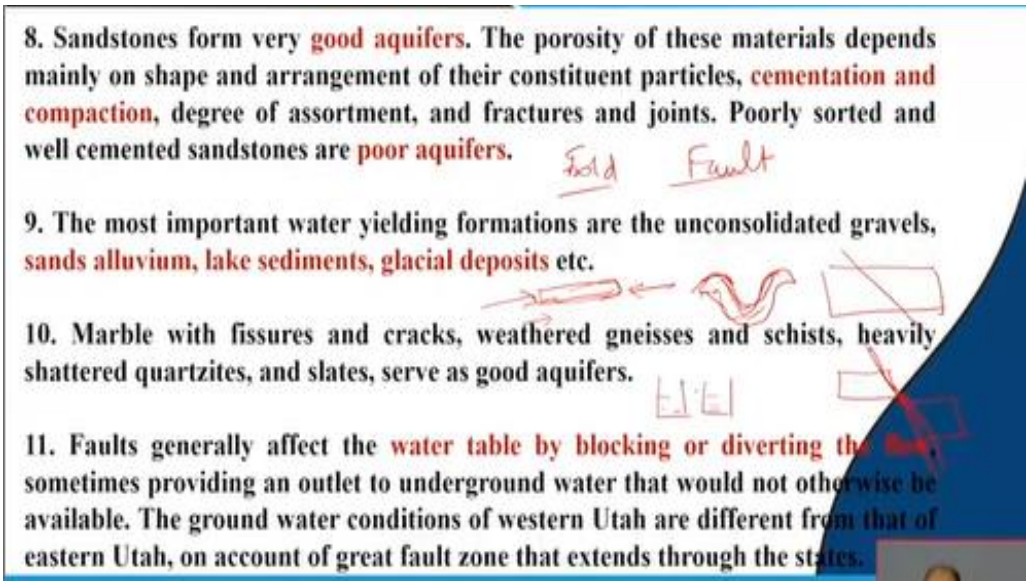

So, sandstones as we have discussed sandstone is forming a very good aquifer, the porosity of these material depends mainly on shape and arrangement of their constituent particles. Sandstone we have seen sandstone is sedimentary rock. I have discussed several times I have told you also that sandstone is forming very good aquifers. The porosity of this type of sandstone depends mainly on shape and arrangement of the constituent particles.

Just now we have discussed cementation, compaction degree of sorting and the fractures and joints. I have also told you two only sorted and well cemented sandstones are poor aquifer, why? Because this will just the pore spaces will reduce will become zero. Then what will happen? It is

not a good aquifer. So, another formation and unconsolidated gravels, sands alluvium, lake sediments, glacial deposit.

These are also forming a very, very good water holding formations in different places on the surface where we are getting unconsolidated gravels or some sands alluvium or lake sediments glacial sediments. So, there also we are getting the good formation geological formation as I prefer. Marble which is a metamorphic rock with fissures and cracks marbled with fissures and cracks, weathered gneisses and schists these all are your metamorphic rock.

But this marble is a metamorphic rock but this marble is having the fissures and cracks within it. So, some space is within it whether gneisses and schists means some gneisses and says just met with weathering phenomena. Some of the upper layer part has distorted from its natural rock type. So, in this way weathered gneisses and schists heavily shattered quartzites and slates these are also metabolic rock.

So, metamorphic rocks with fissures and cracks weathered conditions heavily shattered condition serve as a good aquifer. So, this if we are getting at certain place then we may think that we the place is having good amount of groundwater why because the rock composition at this place is the marble schists, gneisses these all are the metamorphic rocks. But condition is marble is there but marble is fissured marble or the cracked marble or the weathered gneisses so, shattered quartzites.

So, these are just the conditions of the prevailing rock metamorphic rock and if conditions are remaining like this then it will form a very good geological formation that is the aquifer. Faults generally affect the water table by blocking or diverting the path flow. So, faults we are getting two structural disturbances within the earth's surface one is the fold and other is the fault. So, here what is happening fold when the horizontal force will act on a certain rock.

Then what is happening this rock will not break whether this rock will just crumble and deform the in the shape this rock will just crumble and deform the shape. Just it will deform in this way this will just remain in this way. So, this is called as fold because here this is the trough and this

is the crest. So, this is called as fold. Fold and fault both are the structural deformation inside the surface of the rock formation.

So, in this case the formation is remaining here only thing it has just bend so just bending is there. But in another case suppose this is the rock in which some weaker section weaker point is within it. So, this portion will remain at this place and this place be shift at this place. So, this is known as the fracture your fault plane through which one part is remaining at its place other part is just shifting.

So, this type of phenomenon is called as faulting. So, here formation was remaining at the same place only thing some crumbling was there bending was there but they are just shifting of the just the relative moment of the rock formations. So, this plays very, very important role fault because of fault it is just affecting just blocking or diverting the flow of the groundwater. So, sometimes if you are getting water in this well and your neighbour is not getting water in the well.

And the only difference is one boundary between your house and is your neighbour house. The point may be formation is okay, the formation may be of the same formation because formation in general not changed in proximity. So, the point is that some structural deformation is there and if we will analyse scientifically the area you will get that fracture if a fault plane is there which is just giving you the water and just not connecting the aquifer nearby refer to your neighbours well.

And that is why you are getting the water but your neighbour is not getting the water. These are the points; these are some of the clues through which we can have the idea from where we can get the groundwater from where we cannot. So, the groundwater condition of several places are depending on such type of your know how that this type of rocks is there and rocks are remaining in this type of shapes.

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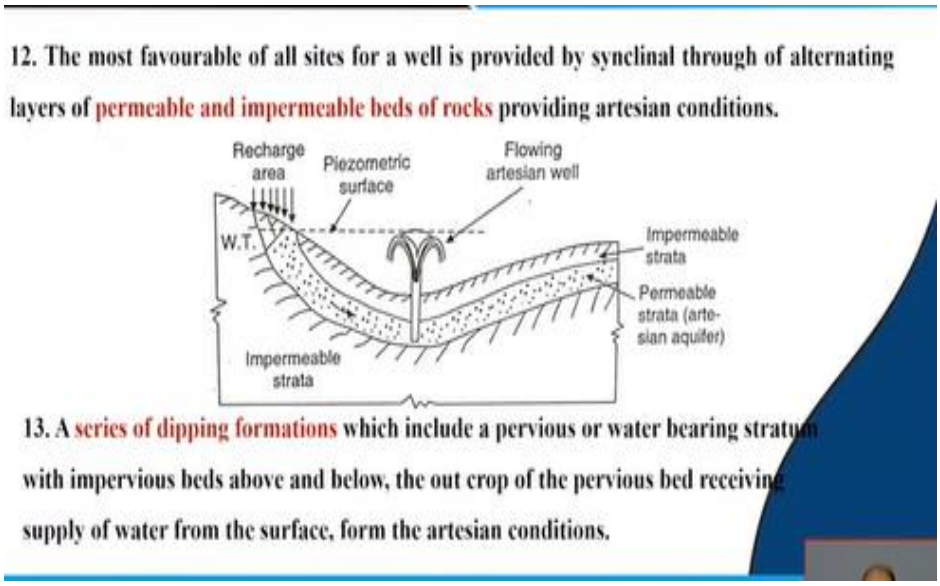

So, this is now I will try to explain some more concept. The most favourable of all side for a well is provided by syncline through alternating layers of permeable and impermeable beds. So, here we can see with a diagram that the impermeable strata is there impermeable means water will not move in this starter and here we can see a permeable starter is there means this strata means the formation.

A formation a rock, a rock type which is inside the surface which is permeable and this is not permeable. Again, we are getting some impermeable strata here. So, what we are getting? We are just seeing that water is remaining in this formation only. This we will discuss in the coming lectures also in aquifer we will discuss this thing in greater detail. But here we can see that this formation is since it is a permeable formation.

So, definitely it will hold some water. That is the water table is also there you can see the water table this is the water table in this formation. The upper layer of the water in any permeable formation is known as water table. And this is being recharged you can see here the charge area is also in this area only because this area through this area the water infiltrates and percolates and come to the aquifier.

So, here if you will puncture these permeable strata then what will happen the water will automatically move up to the level of the your earth's surface. So, this is called as piezometric

surface not the water table. Because here the water was with contact with atmosphere means atmospheric pressure but here as soon as we are puncturing because again the impermeable strata is there this is also impermeable only this one is permeable.

So, this water remains with the hydrostatic pressure as soon as it get open what is happening the water moving coming up to the your earth surface near to the surface which is termed as artesian well condition. So, generally we are getting such type of conditions also on the surface. A series of dipping formation which include a pervious or water bearing strata. We have also noticed a series of dipping formation deep form.

Which includes pervious of water being started with impermeable beds above and below. The outcrop of the pervious bed receiving supply water from surface from the artesian conditions.

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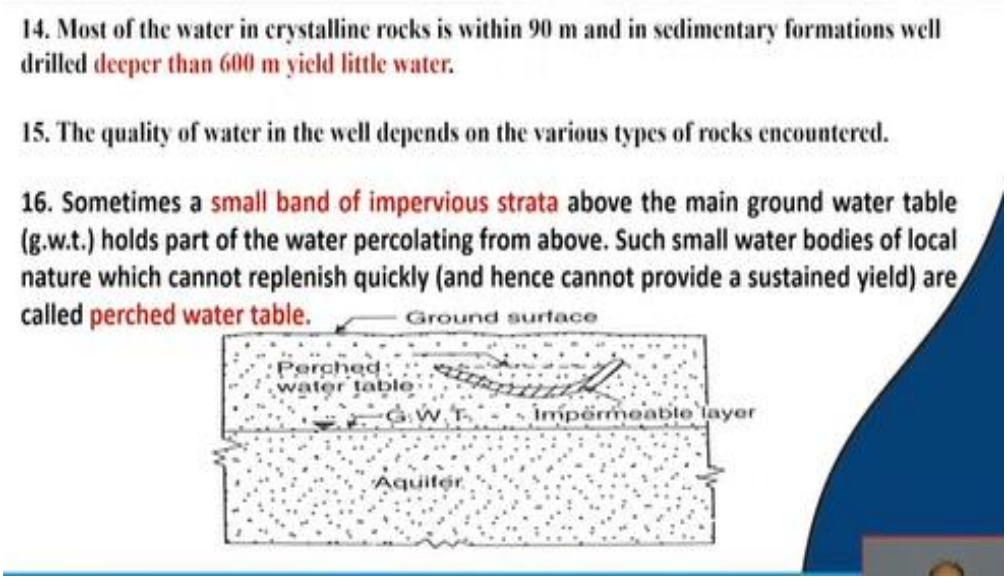

So, here we can see just most of the water in crystalline rock is within 90 meter and sedimentary formation well drill deeper than 600 meter in little water. So, yield is very less the in the sedimentary formation which are having the depth of 600 meter. The quality of the water in the well depends on various types of rocks in content. Now quantity is another concept quality another concept quantity we are discussing in this lecture about the quantity aspect not the quality aspects.

But quality is also important groundwater quality is also important and this quality depends quality of groundwater or water depends on the several, several types of factors among them is also the type of the rock is also important because somewhere we are getting the concentration of arsenic or fluoride in a greater amount. So, if you go and find out the detailed characteristics of the water sample you will notice that geogenic responsibility responsible factor is there geogenic weathering is there.

And because of this weathering the sample is containing the arsenic of fluoride within it so this is another concept. Sometimes a small band of impervious strata small band of impervious starter you can see here above the main groundwater table. This is the main groundwater table holds part of the water percolating above it is also holding the water. You can see it is also called as your groundwater first water surface.

Such a small water bodies of local nature which cannot replenish quickly it is not being replenished quickly hence cannot provide a sustained need are called perched water table. So, this thing we will discuss this we will discuss it is also called as perched water table. It cannot be replenished for a longer duration yes, small amount of water sometimes we are getting in impermeable formation.

In permeable formation sometimes we are getting some good amount of water and because of this condition.

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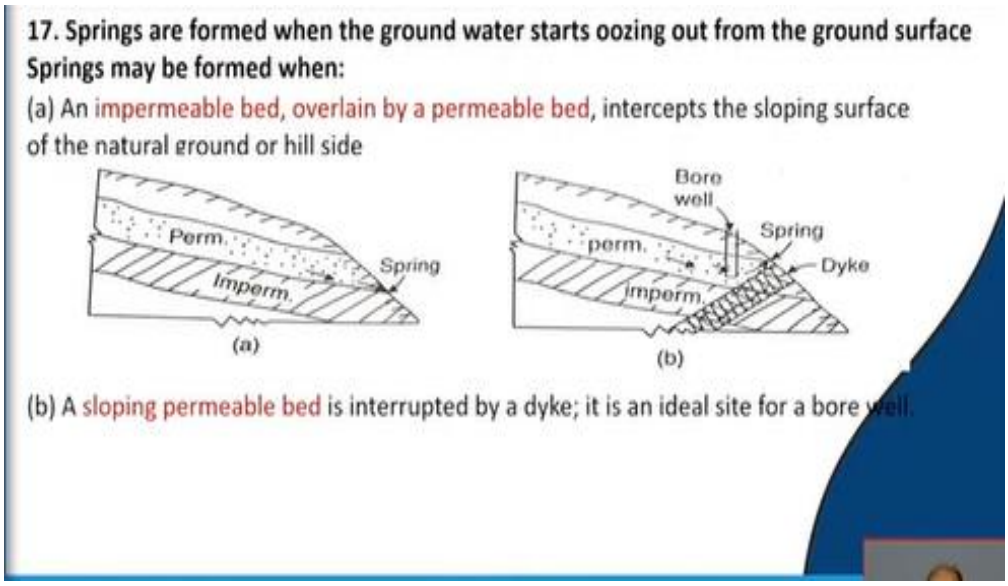

So, springs what we have discussed just now on the Himalayan region springs are formed when groundwater starts oozing out from the ground surface and just an impermeable bed overlaid by a permeable bed. Here you can see an impermeable bed. This is impermeable bed it is overland by permeable bed. So, impermeably this one permeable is this one then it will just intercept the spring will come at the intercept of the sloping surface and this generally we are getting in the hillside.

So, a sloping permeable bed is interrupted by a dike. You can see here permeable bed sloping permeable bed just a metal dike is also an structure a geological structure a type of rod just controlling the movement of the water and it is also becoming an ideal site for a bore well. It is a ideal site for borewell because then there will be no flow of water in this side, only the water will remain here and you can take out the water for a longer duration from this various area.

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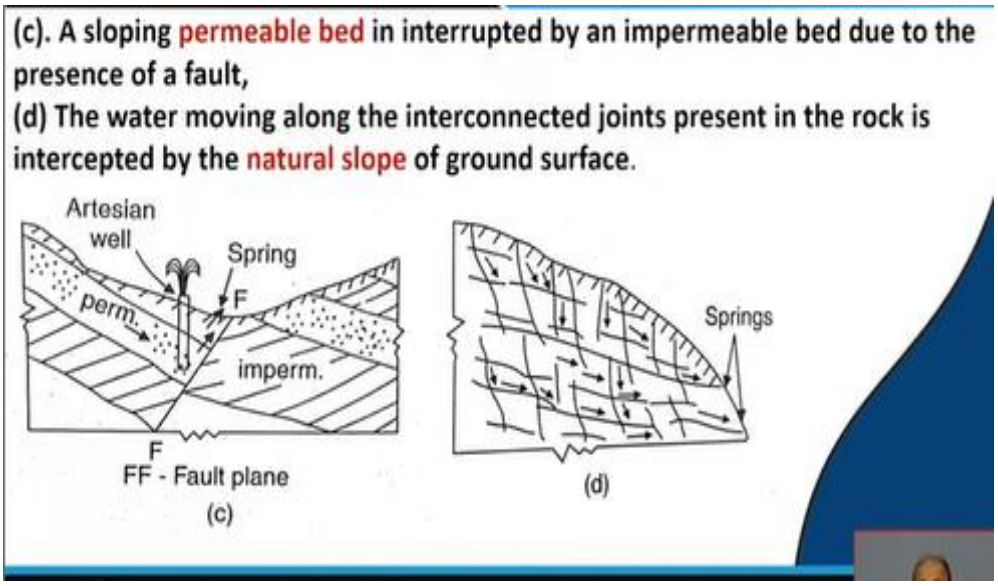

Now a sloping permeable bed is interrupted by an impermeable bed sloping permeable bed this one is interrupted by impermeable bed you can see because of the fault and just now I have discussed also this is the fault plane. So, through the fall plane the formation has just shifted. This permeable formation has come moved here and this formation has moved here. So, you can see the impermeable formations are there and this permeable formation has shifted here.

So, here you can get a very good artisan well because the fault plane is playing very, very important role. Now water moving along the interconnected joints so these are the joints present in the rock intercepted by natural slope of the ground surface. So, this is also making a good spring in certain region if the rocks which are having the joints are interconnected. So, through these rocks the water generally moves and in the form of springs there.

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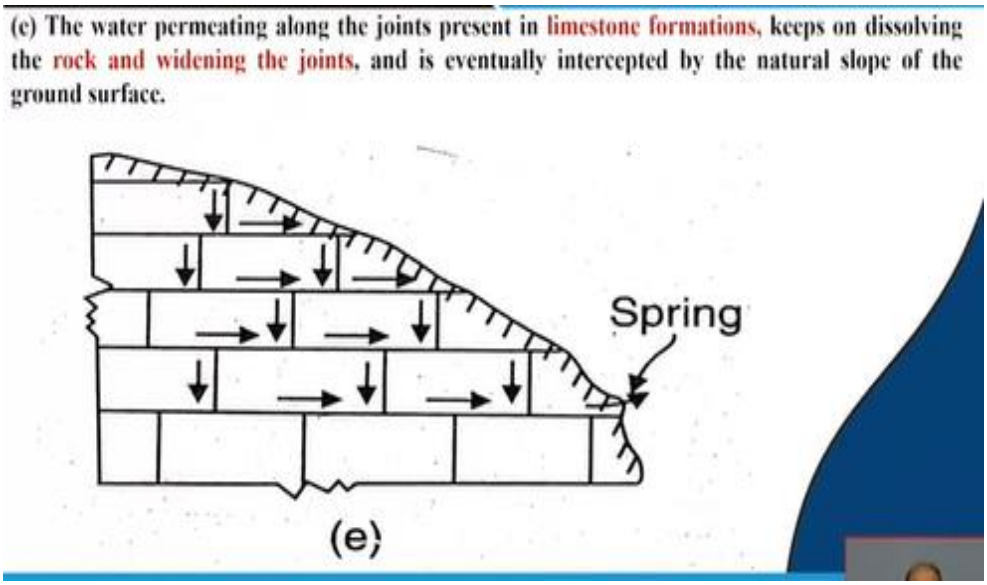

Now the water bearing the water permeating along the joint planes in limestone formations. It keeps on dissolving the rock and widening the joint. So, gradually what is happening it is just widening the joints also and eventually intercepted by natural slope of the ground surface. So, in this way the water is just permeating through the different sets of joints which are present in the limestone formation.

So, in total what we have understood? We have understood that the few of the rocky formations are very, very responsible for holding the groundwater and few clues are also there with the help of some geological structures like fold, fault, joints, fissure, fractures devices we may get idea about the storage of the groundwater resources within the earth's surface. Thank you.