Porosity & Permeability DBQ / Annotations

Name: ___________________

INSTRUCTIONS: Highlight or underline & make margin notes as your read through this DBQ and answer the 5 questions at the end

As we've learned, groundwater is simply water that exists underground. However, there are still lots of misconceptions about how people envision groundwater. Many envision large underground lakes and rivers, and while those do exist, they represent an infinitesimally small percentage of all groundwater. Generally speaking groundwater exists in the pore spaces between grains of soil and rocks. Imagine a water filled sponge. All of the holes in that sponge are water-filled. By squeezing that sponge we force the water out, similarly, by pumping an aquifer we force the water out of pore spaces.

There are lots of terms in hydrogeology, most of which are very simple, but essential. Here are a few of the big ones and their meanings.

Porosity

Porosity is an intrinsic property of every material. It refers to the amount of empty space within a given material. In a soil or rock the porosity (empty space) exists between the grains of minerals. In a material like gravel, the grains are large and there is lots of empty space between them since they don't fit together very well. However, in a mixture of gravel, sand and clay the porosity is much less as the smaller grains fill in the empty spaces between the larger gravel. The amount of water a material can hold is directly related to the porosity since water will try and fill the empty spaces in a material. We measure porosity by the percentage of empty space that exists within a particular porous media.

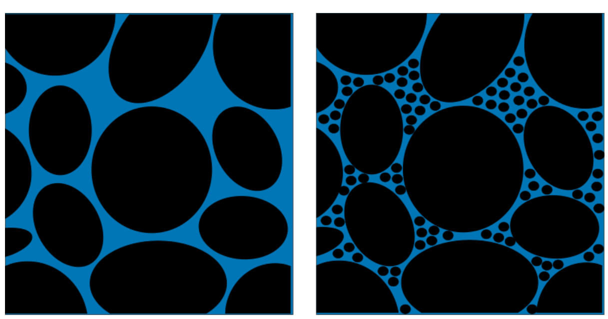
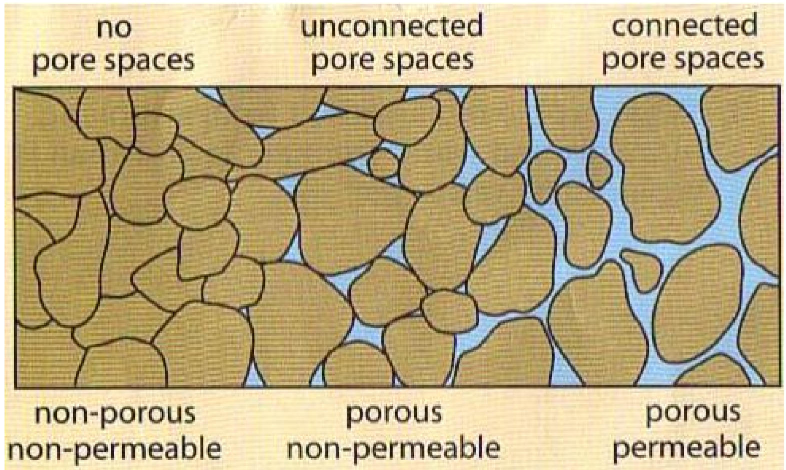


Figure 2. Porosity in two different media. The image on the left is analogous to gravel whereas on the right smaller particles are filling some of the pores and displacing water. Therefore, the water content of the material on the right is less.

Permeability



Permeability is another intrinsic property of all materials and is closely related to porosity. Permeability refers to how connected pore spaces are to one another. If the material has high permeability the pore spaces are connected to one another allowing water to easily flow through. However, if there is low permeability then the pore spaces are isolated and water will take longer to infiltrate, if it's even able to infiltrate at all. For example, in a gravel mixture, all of the pores are well connected one another allowing water to flow through it, however, in a clay mixture most of the pore spaces are blocked, meaning water cannot flow through it easily.

Aquifer

An aquifer is a body of permeable rock which can contain or transmit groundwater. As more water infiltrates the pore spaces, the rock becomes completely saturated with water. That means the layer of soil or rock that has a reasonably high porosity and permeability will allow it to contain water and transfer it from pore to pore relatively quickly until all of the pore spaces are filled with water. Good examples of aquifers are glacial till or sandy soils which have both high porosity and high permeability.

Aquifers allows us to recover groundwater by pumping up water quickly and easily. However, overpumping can reduce the amount of water in an aquifer and cause it to dry up. Aquifers are replenished when surface water infiltrates through the ground and refills the pore spaces in the aquifer, a process called recharge. It is especially important to ensure that recharge is clean and uncontaminated or the entire aquifer could become polluted. There are two main types of aquifers, confined aquifers & unconfined aquifers.

Wells can be drilled into the aquifers and water can be pumped out. Precipitation eventually adds water (recharge) into the porous rock of the aquifer. The rate of recharge is not the same for all aquifers, though, and that must be considered when pumping water from a well. Pumping too much water too fast draws down the water in the aquifer and eventually causes a well to yield less and less water and eventually run dry. In fact, pumping your well too fast can even cause your neighbor's well to run dry if you both are pumping from the same aquifer!

In the diagram below, you can see how the ground below the water table (the blue area) is saturated with water. The "unsaturated zone" above the water table (the greyish area) still contains water (after all, plants' roots live in this area), but it is not totally saturated with water. You can see this in the two drawings at the bottom of the diagram, which shows a close-up of how water is stored in between underground rock particles.

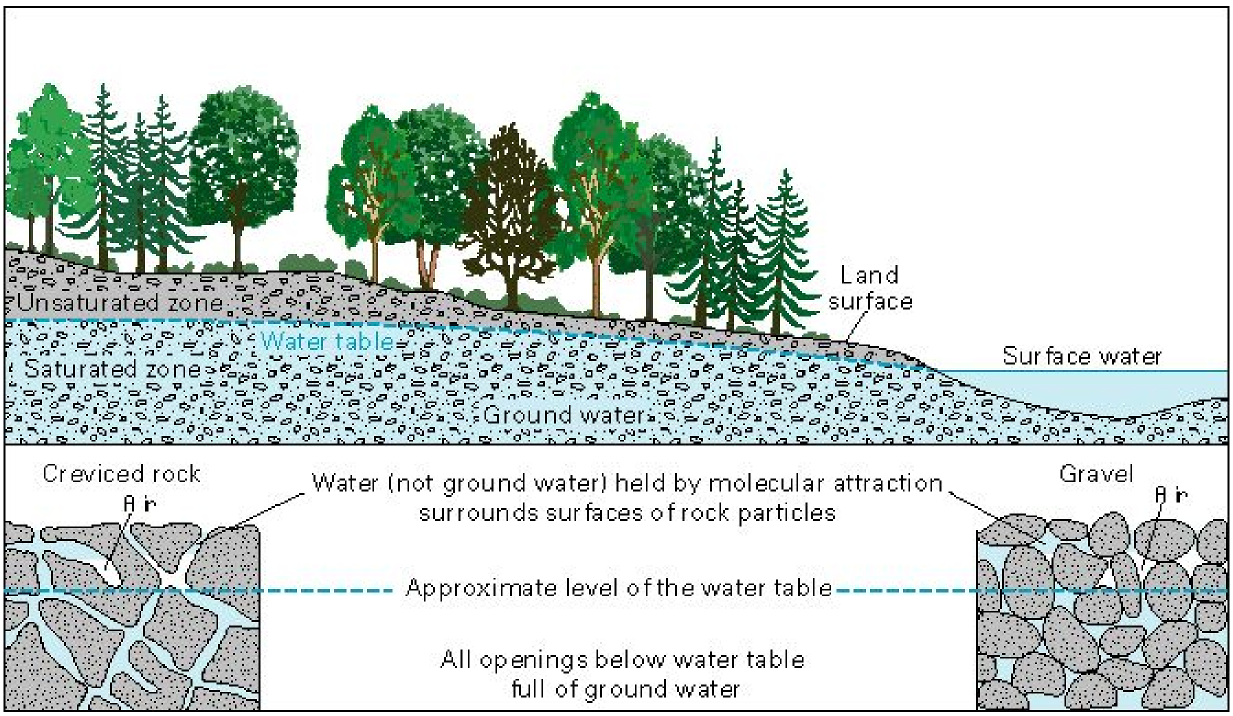


Figure 2.

Sometimes the porous rock layers become tilted in the earth. There might be a confining layer of less porous rock both above and below the porous layer. This is an example of a confined aquifer. In this case, the rocks surrounding the aquifer confines the pressure in the porous rock and its water. If a well is drilled into this "pressurized" aquifer, the internal pressure might (depending on the ability of the rock to transport water) be enough to push the water up the well and up to the surface without the aid of a pump. This type of well is called an artesian well, and the aquifer is often referred to as an artesian aquifer.

A relationship does not necessarily exist between the water-bearing capacity of rocks and the depth at which they are found. A very dense granite that will yield little or no water to a well may be exposed at the land surface. Conversely, a porous sandstone, such as the Dakota Sandstone, may lie hundreds or thousands of feet below the land surface and may yield hundreds of gallons per minute of water. Rocks that yield freshwater have been found at depths of more than 6,000 feet, and salty water has come from oil wells at depths of more than 30,000 feet. On average, however, the porosity and permeability of rocks decrease as their depth below land surface increases; the pores and cracks in rocks at greater depths are closed or greatly reduced in size because of the weight of overlying rocks.

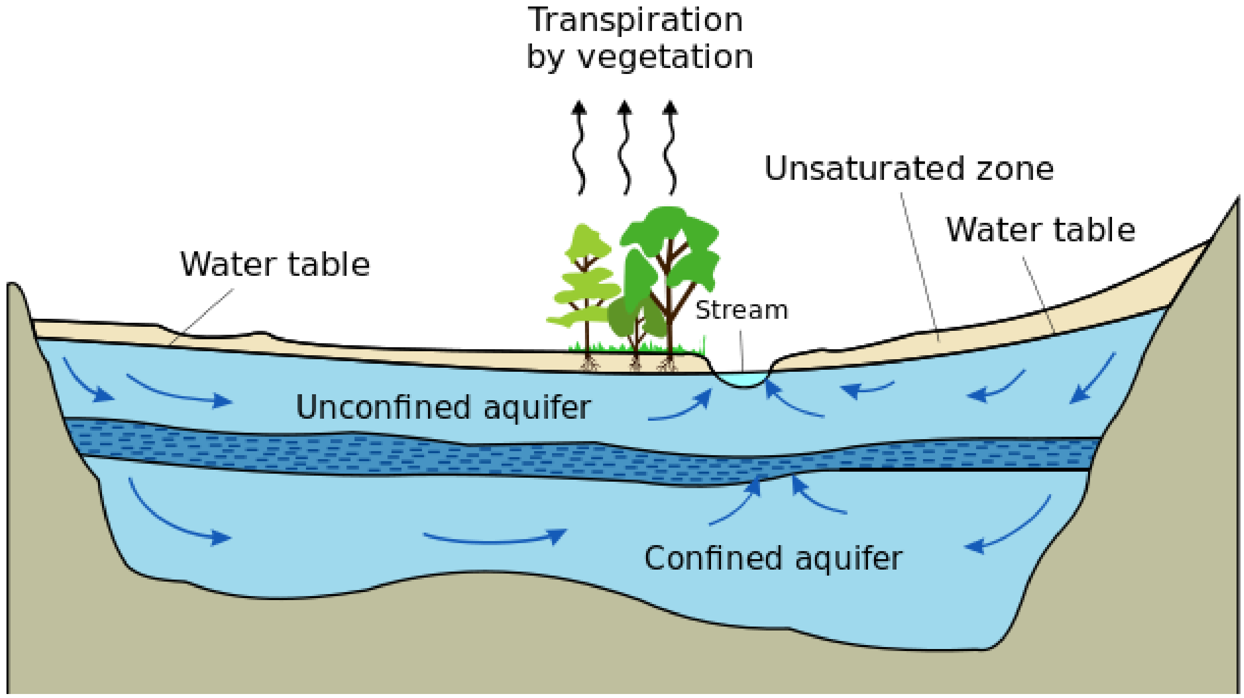
Water Movement in Aquifers

Water movement in aquifers is highly dependent on the permeability of the aquifer material. Permeable material contains interconnected cracks or spaces that are both numerous enough and large enough to allow water to move freely. In some permeable materials groundwater may move several metres in a day; in other places, it moves only a few centimeters in a century. Groundwater moves very slowly through relatively impermeable materials such as clay and shale.

After entering an aquifer, water moves slowly toward lower lying places and eventually is discharged from the aquifer via springs, seeps into streams, or is withdrawn from the ground by wells.

Aquitard

Most confined aquifers have an aquitard above and below. Aquitards have very low permeability and do not easily transfer water through its pores. In fact, in the ground they often act as a barrier to water flow and separate two aquifers from one another. An example if layer of clay which tends to be impermeable.



NAME:________________________________

1. ***Explain*** the connection between porosity and permeability.

2. Do all materials have the same porosity? Why or why not?

3. What does impermeable mean when discussing groundwater & substrate

4. What are the two types of confined aquifers?

5. Which of the following sediments would allow for the most infiltration? Least infiltration? Why? **(*sand, pebbles, lava rock, soil, clay)***