Earth Science   Name: ______________________________
Unit 7: Freshwater   Period: __________

LAB # 20

POROSITY, PERMEABILITY AND CAPILLARITY

Introduction:

Two separate characteristics of rocks control how effective rock types are as aquifers (water storage underground):

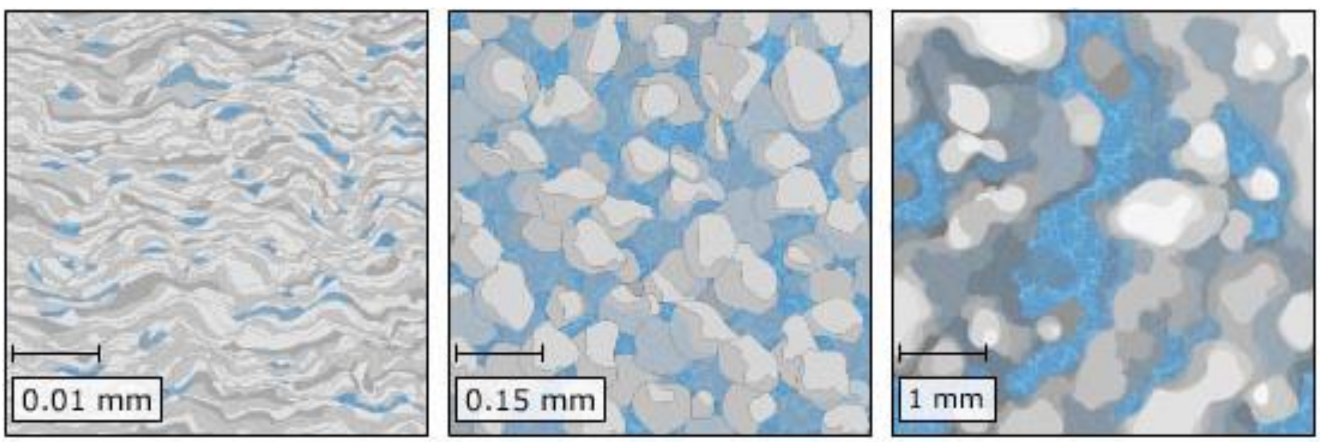
Porosity is a measure of how much of a rock is open space. This space can be between grains or within cracks or cavities of the rock.

Permeability is a measure of the ease with which a fluid (water in this case) can move through a porous rock.

The ***pore space***, or ***porosity***, of a rock or sediment is the amount of the material that is open space.

Capillarity is the rate at which water is pulled upward from the water table into pore spaces by capillary action.

In general, particles with larger pore spaces have better permeability and poor capillarity.



Microscopic structure of shale, sandstone, and limestone with water in pore spaces. Note differences in scale among views of each rock type.

Objectives: To measure and compare the porosity, permeability, and capillarity of several particle sizes.

Materials:

Coarse, medium and fine sand Mix of all three (3)	2 – 100 ml clear graduated cylinders Stop watch	2 – 400 ml beakers Paper towels

Procedures:

1. Use one of the beakers to obtain a sample of one of the four (4) sand samples assigned to you by your teacher.
2. Fill one of the graduated cylinders to the 50-ml level with the sand sample. Gently tap the cylinder to settle the particles.
3. Fill the other graduated cylinder to the 50-ml level with water.
4. *Read this entire procedure step before starting it*.
   - √ The 50 ml of water is to be poured gently but quickly by one student into the cylinder containing the sand.
   - √ Record the time between the instant the water is poured into the cylinder and the instant the first drop of water reaches the bottom of the cylinder. This time indicates the permeability of the sample. Record the time in Table 1.
5. When the water has completely wet all of the particles in the graduated cylinder, tap the cylinder gently to remove any air bubbles left between the particles.
6. Read the level of the water in the cylinder to the nearest 0.1 ml.
   - √ When you added water to the sediment, any pore space in the sediment was replaced by water.
   - √ The water level is the volume of the water plus the sediment alone (no pore space). Record this volume in Table 1.
7. To calculate a value for the porosity of the sample:

   Volume of Pore Space = 100 ml – Row 2 value

   Record this value in Table 1.
8. To determine the percent porosity of the original dry sample:

   $$\% \text{ Porosity} = \frac{\text{Volume of Pore Space}}{50 \text{ ml}} \times 100$$

   Record the porosity in Table 1.

9. **Place the used, wet sample in the container for particles of that size. <u>DO NOT</u> pour particles into the sink. Wash out the graduated cylinder.**

DATA TABLE 1				
	Coarse Sand	Medium Sand	Fine Sand	Mixed Sand
Time for Water to Reach Cylinder Bottom (SECONDS)				
Volume of Water + Sediment (mL)				
Volume of Pore Space (mL)				
Porosity (%)				

Analysis and Conclusions:

1. The graduated cylinders held 50 ml of sediment and 50 ml of water. Why wasn't the final volume of water and sediment 100 ml? Where did the water go?____

   ____

2. For which sample was the water level in the graduated cylinder (volume of water + sediment) highest? Why? ____

   ____

3. Which sand size (coarse, medium, or fine) has the greatest permeability? What is the evidence for your answer? ____

   ____

4. Why does the mixture of sand sizes have the poorest permeability? ______________________________

   ____

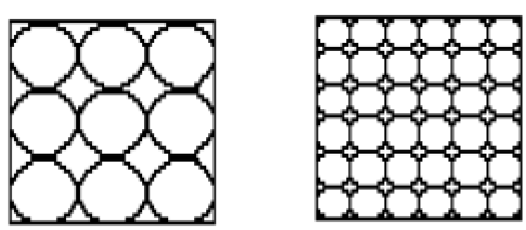
5. Look at your values for the porosity of the coarse, medium and fine sands. What is the average of your three values? Are all three values within 10 % of this average? If differences within 10% are ignored, how do your values for the porosity of these three samples compare? ____________________________

   ____

   ____

Conclusion Questions:

1. The diagram below represents two identical containers filled with samples of loosely packed sediments. The sediments are composed of the same material, but differ in particle size. Which property is most nearly the same for the two samples?



   A) porosity B) water retention C) infiltration rate D) capillarity

2. As the temperature of the soil decreases from 10DC to -5DC, the infiltration rate of ground water through this soil will most likely

   A) decrease B) remain the same C) increase

3. Which earth material covering the surface of a landfill would permit the *least* amount of rainwater to infiltrate the surface?

   A) sand   B) silt   C) pebbles   D) clay

4. Water will infiltrate surface material if the material is

   A) permeable and saturated
   B) permeable and unsaturated
   C) impermeable and saturated
   D) impermeable and unsaturated

5. Which property of loose earth materials most likely increases as particle size decreases?

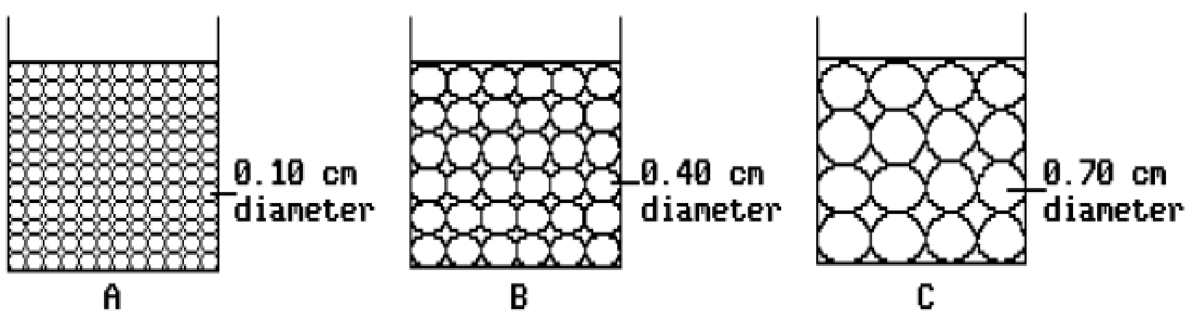
   A) infiltration B) capillarity C) permeability D) porosity

6. Why does water move very slowly downward through clay soil?

   A) Clay soil has large pore spaces.
   B) Clay soil has very small particles.
   C) Clay soil is composed of very hard particles.
   D) Clay soil is composed of low-density minerals.

Questions 7 through 9 refer to the following:

The diagrams below represent three identical beakers, *A*, *B*, and *C*. Each beaker contains solid plastic spheres. The diameter of the spheres in each beaker is shown.



7. Which beaker contains material with the *greatest* capillarity?

   A) *C*   B) *B*   C) *A*

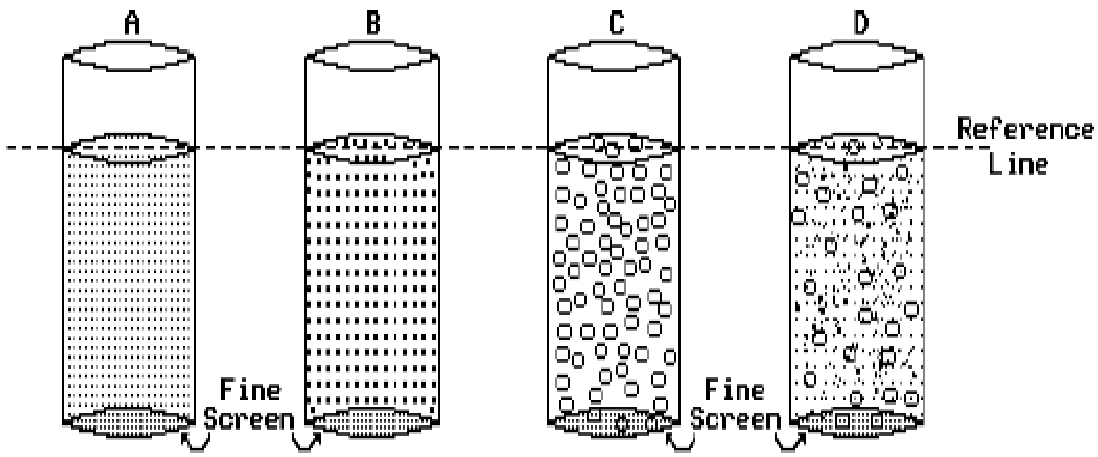
8. A mixture of 0.10-centimeter spheres and 0.70-centimeter spheres is placed in a fourth beaker, *D*. Beaker *D* is filled to the same level as beaker *C*. Compared to the porosity of *C*, the porosity of *D* is

   A) less   B) the same   C) greater

9. Which beaker contains material with the *greatest* permeability?

   A) *B*   B) *C*   C) *A*

Questions 10 through 12 refer to the following diagrams below which describe an investigation with soils. Three similar tubes, each containing a specific soil of uniform particle size and shape were used to study the effect that different particle size has on porosity, capillarity, and permeability. A fourth tube containing soil which was a mixture of the same sizes found in the other tubes was also studied and its data are recorded in the table. [Assume that the soils were perfectly dry between each part of the investigation.]



Tube	Paricle Size (diameter in cm)	Porosity (%)	Capillarity (nm)	Permeability (sec)
A	Fine (0.025 cm)	40	20	14
B	Medium (0.1 cm)	40	15	8
C	Coarse (0.3 cm)	40	7	6
D	Mixed (0.025 to 0.3 cn)	20	12	20

10. Each tube was placed in a shallow pan of water. In which tube did the water rise the highest?

A) *C* B) *A* C) *D* D) *B*

11. The bottom of each tube was closed and water was slowly poured into each tube until the water level reached the dotted line. Which statement best describes the amount of water held by the tubes?

A) Tube *A* and *D* held the same amount of water and twice as much as tubes *B* and *C*.
B) Tube *C* held more water than any other tube and tube *D* the least.
C) Tube *A*, *B* and *C* held the same amount of water and tube *D* half as much.
D) Tube *D* held more water than any other tube and tube *A* the least.

12. When water was poured into the top of each tube at the same time, which tube allowed the water to pass through most quickly?

A) *B* B) *D* C) *C* D) *A*