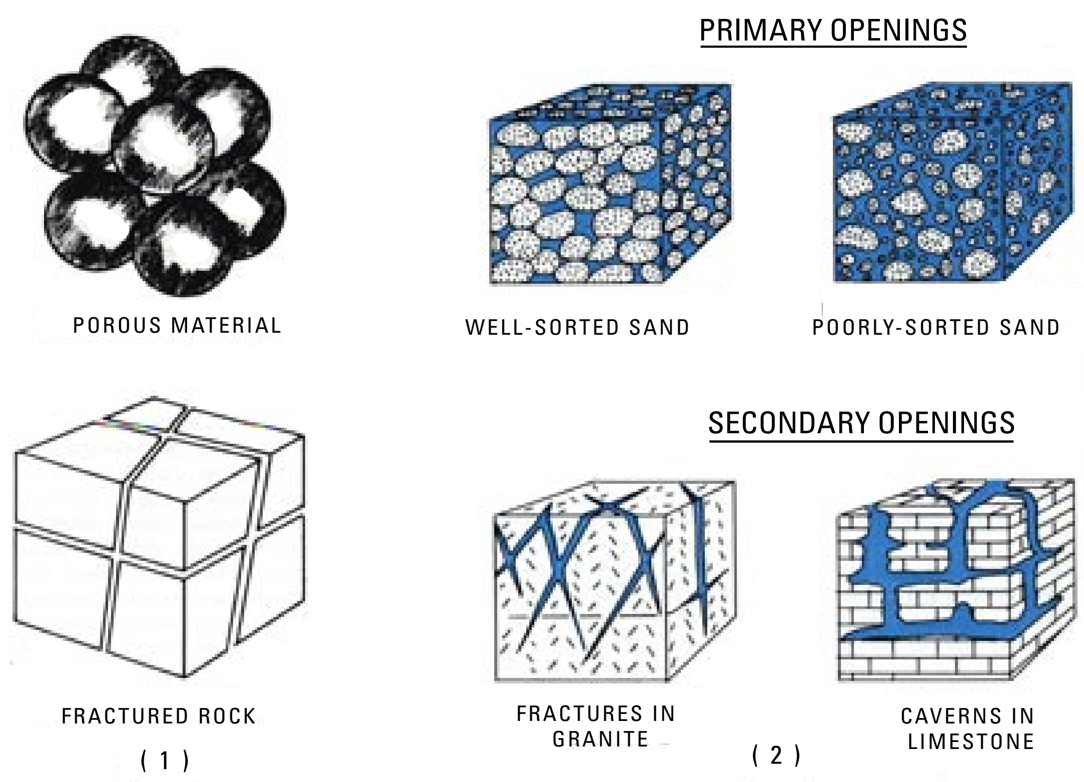
CHAPTER 7

Porosity

The study of water in the environment is called hydrology. Along these lines, a scientist who studies the occurrence and movement of water is called a hydrologist. Although many hydrologists have degrees in geology, there is a difference in the focus of each science. One can think of it in this way: a geologist is interested in the rocks and sediments that make up the Earth, whereas, a hydrologist is interested in the spaces within the rocks and sediments. The reason a hydrologist has this focus is that these spaces can hold water. Porosity is the term for the spaces in rocks and sediments. In simple terms, the more porous a rock or sediment, the more water it can store.

Porosity is the ratio of the volume of pores in a rock unit compared to the overall volume of the rock unit. Porosity is usually presented as a number (or percent), typically between 0 and 0.6 (or 0 and 60 percent).

Why do rocks have pores? Sedimentary rocks, such as sandstone and limestone, are made up of grains of rock that were deposited on the Earth's surface sometime in the past and then became cemented or tightly packed together over time. Some examples of environments that can result in sedimentary rocks are oceans, rivers, alluvial fans along the edges of mountain ranges, sand dunes, and lakes. Because the grains in sediment do not pack together edge-to-edge like a jigsaw puzzle, but rather more like ball bearings in a bucket, plenty of pore spaces exist between the grains.



Source: Heath, 1989.

Many factors control the porosity of sedimentary rocks. Some of these include the roundness of the grains (the more angular the grains, the further apart the grains will pack together, therefore the more porous), sorting (if there are two grain sizes in one deposit, the smaller grains will fill the voids between the larger grains, thereby reducing the porosity), and degree of cementation (some grains get cemented together by minerals such as calcium carbonate or by mud that fills the voids). So, assigning a number for porosity to a sedimentary rock is not a simple matter and each type of rock can have a range of porosity values that depend on these variables.

Igneous and metamorphic rocks typically have very low values of porosity. For igneous rocks, such as granites and basalts, the low porosity is because the rocks were formed from the cooling of molten magma. As the rocks formed, the crystals in the magma interlocked and formed tight bonds. This does not allow for much pore space. One exception would be volcanic rocks, which are full of hot gases when they form. These rocks can have abundant pores due to the gas bubbles present as the lava cools and the rock forms.

Metamorphic rocks are formed under extreme pressure and temperature. When other rocks, such as sandstones or granites, are subjected to great pressures and temperatures, the rocks get altered and form metamorphic rocks. Because metamorphic rocks have been under such pressures and temperatures, any pore spaces that might have been present in the rock get reduced or erased. Examples of metamorphic rocks are schist, marble, and slate.

The type of porosity discussed above is what is referred to as "primary porosity." Primary porosity is the porosity that results from the original formation of the rocks. However, many rocks undergo changes after formation that can greatly alter (usually increase) their porosity. For example, limestone can dissolve and form caves and caverns. Obviously, the occurrence of large openings such as caves would greatly enhance the porosity.

Many rocks contain joints, faults and/or fractures, which also enhance porosity. For example, most dense granite has a primary porosity of 0 to 5 percent. However, fractures in the granite can produce a secondary porosity of more than twice this amount. In many settings, secondary porosity can be much more important than primary porosity when it comes to storing water in aquifers.

Another aspect of porosity worth mentioning is effective porosity. The effective porosity relates to the connection between pores and fractures, and therefore the ability to transmit water. A rock may have a large porosity, but if the pores are not connected, then the effective porosity may be small.

An example is the volcanic rock previously mentioned, where gas bubbles in the rock gave it a large porosity. However, unless the voids are interconnected, water cannot get into and out of the rock. So, the effective porosity would be small. Effective porosity is always a smaller number than true porosity because there is always some degree of isolation of pores in a rock. For hydrology purposes, effective porosity is the value that is used when describing an aquifer.