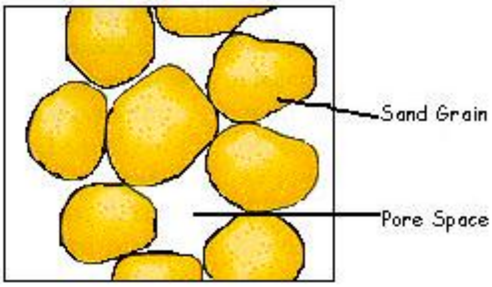
Porosity

Porosity is the ratio of void space in a rock to the total volume of rock, and reflects the fluid storage capacity of the reservoir.

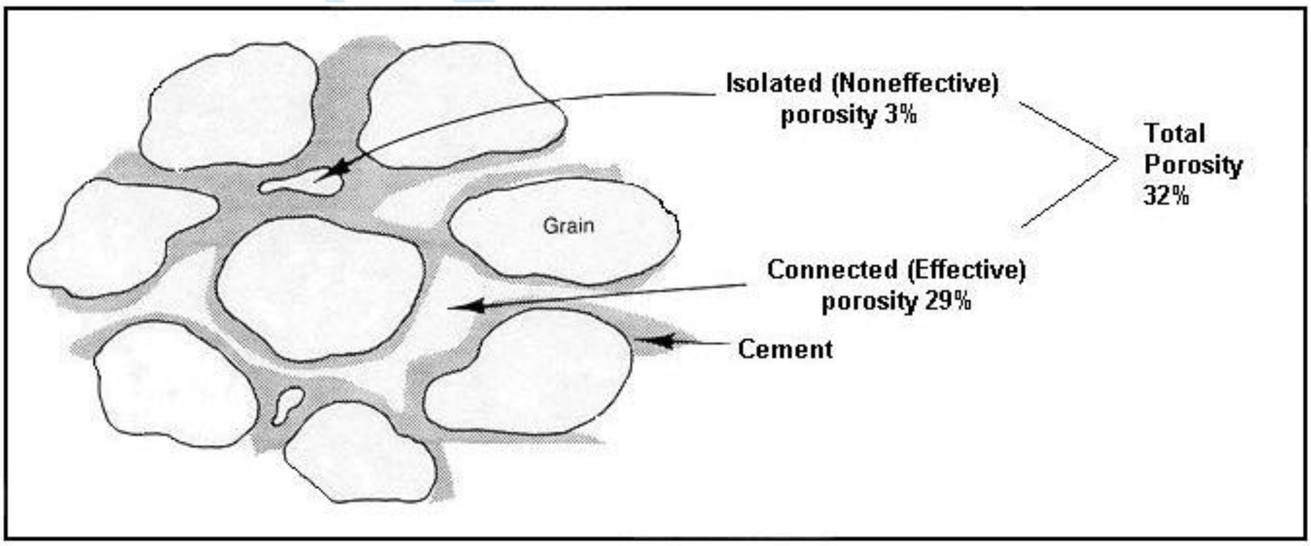
$$\text{Porosity } (\Phi) = \frac{\text{volume of void space}}{\text{total volume of rock}}$$



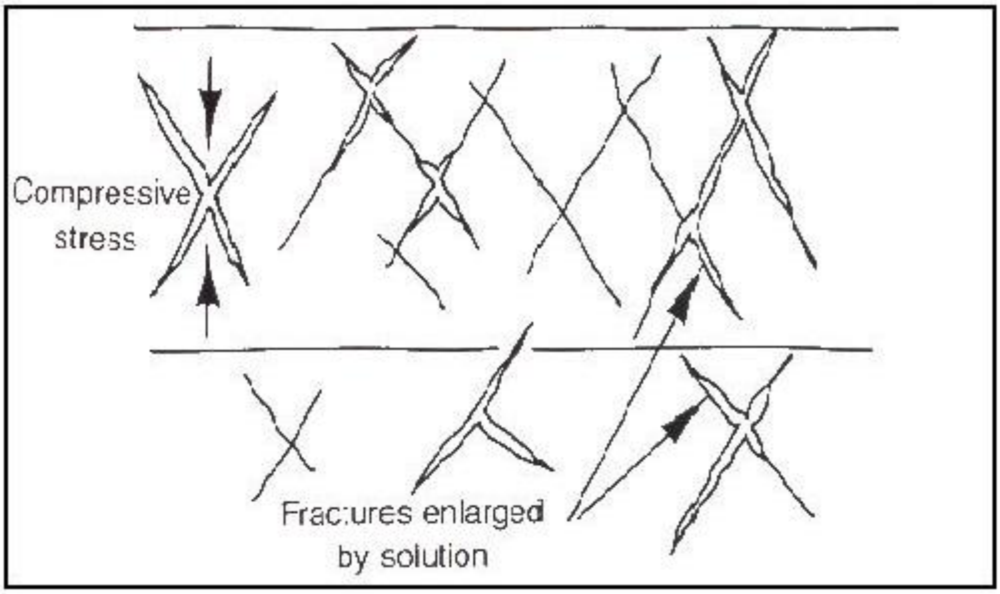
- **Primary Porosity**— Amount of pore space present in the sediment at the time of deposition, or formed during sedimentation. It is usually a function of the amount of space between rock-forming grains.

- **Secondary Porosity**— Post depositional porosity. Such porosity results from groundwater dissolution, recrystallization and fracturing.

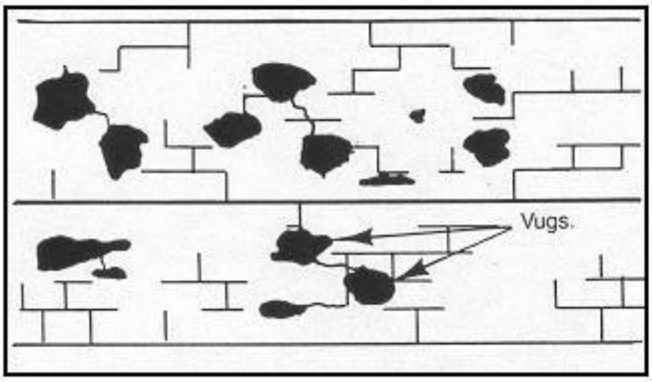
- **Effective Porosity vs. Total Porosity**— Effective porosity is the interconnected pore volume available to free fluids. Total porosity is all void space in a rock whether effective or noneffective.



• **Fracture porosity —**results from the presence of openings produced by the breaking or shattering of a rock. All rock types are affected by fracturing and a rocks composition will determine how brittle the rock is and how much fracturing will occur. The two basic types of fractures include natural tectonically related fractures and hydraulically induced fractures. ***Hydraulic fracturing*** is a method of stimulating production by inducing fractures and fissures in the formation by injecting fluids into the reservoir rock at pressures which exceed the strength of the rock. Hydraulic fracturing can tremendously increase the effective porosity and permeability of a formation.



• **Vuggy porosity** is a form of secondary porosity resulting from the dissolution of the more soluble portions of rock or solution enlargement of pores or fractures.

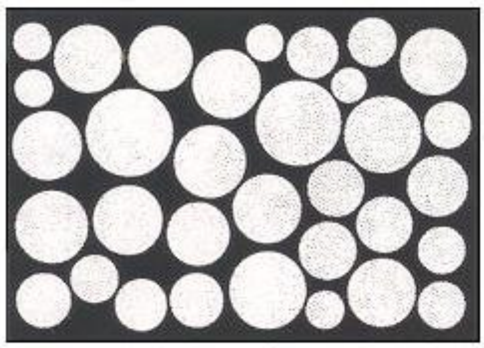


• **Maximum Porosity vs. Realistic Porosity**— Porosity can approach, in a very well is typically much lower due to cementation and compaction. In a carbonate, it is possible to greatly exceed the theoretical maximum porosity. This may be achieved if the carbonate is highly fractured along with vuggy porosity.

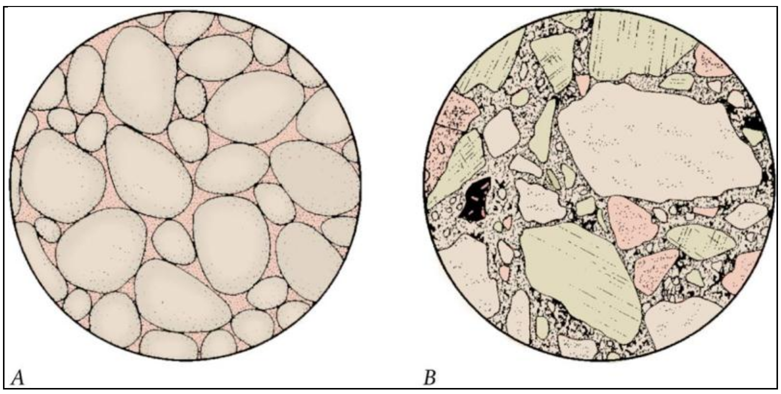
Factors affecting the porosity

In sandstone, porosity is largely controlled by sorting. Sorting is a process by which the factors of transportation, especially running water, naturally separate sedimentary particles that have some particular characteristic (such as size, shape or specific gravity) from associated but dissimilar particles. Other important controlling factors include grain packing, compaction, and cementation.

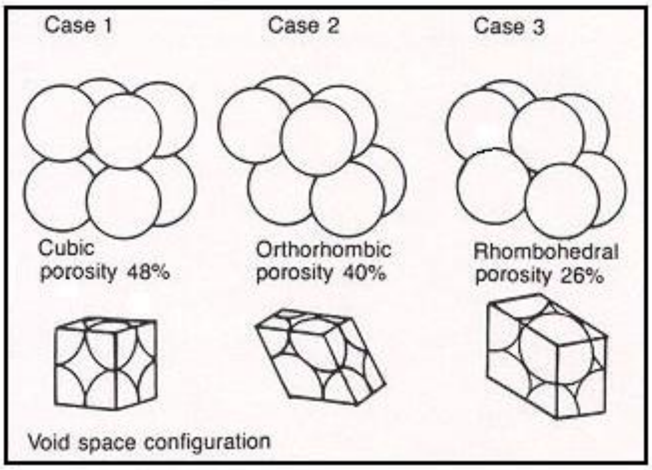
• **Well Sorted Rock**— Grains are generally of the same size and shape. If the grains are well rounded and of similar size, then they will not fit well together, thereby leaving a large amount of pore space between the grains. Porosity in a well sorted rock is generally high.



• **Poorly Sorted Rock**— Rock that is composed of a wide variety of grain sizes and shapes. Porosity can be reduced considerably because smaller or irregularly shaped grains can be inserted in between the larger grains, thereby reducing the amount of pore space.



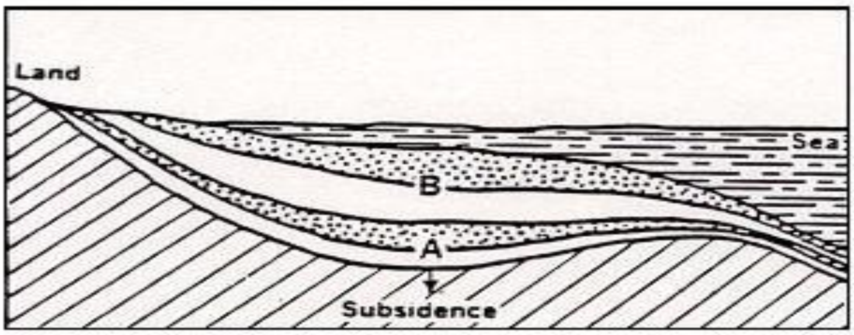
• **Grain Packing**— Refers to the spacing or density patterns of grains in a sedimentary rock and is a function mainly of grain size, grain shape, and the degree of compaction of the sediment.



Packing strongly affects the bulk density of the rocks as well as their porosity and permeability. The effects of packing on porosity can be illustrated by considering the change in porosity that takes place when even-size spheres are rearranged from open packing (cubic packing) to tightest or closed packing (rhombohedral packing).

Cubic packing can yield a porosity of 47.6%. Rhombohedral packing yields approximately 26.0%.

• **Compaction**— Over along period of time sediments can accumulate and create formations that are thousands of feet thick. The weight of the overlying sediments squeezes the particles together into the tightest arrangement possible. The load pressure also squeezes out the water that occupies the pore spaces between the particles, thus reducing the bulk volume of the formation. Compaction is dependent not only on overburden pressure but also on the different types of clastic materials present in the formation. Compaction affects porosity and permeability by reducing the amount of interconnected pore space.



• **Cementation** —Cementation is the crystallization or precipitation of soluble minerals in the pore spaces between clastic particles. The process of lithification (the conversion of unconsolidated deposits into solid rock) is completed by cementation. Common cementing agents include calcite ($CaCO_3$), silica (SiO_2), and iron oxide (Fe_2O_3). Minerals in solution crystallize out of solution to coat grains and may eventually fill the pore spaces completely. Porosity and permeability can be reduced significantly due to cementation.