HYDROGEOLOGICAL PROPERTIES OF ROCKS

What do we mean by hydrogeological properties?

Porosity

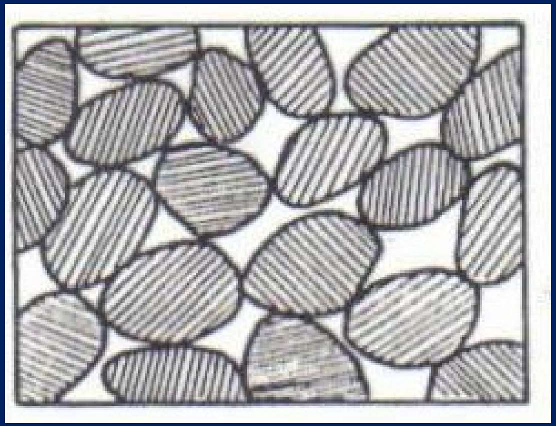
Hydraulic conductivity

Specific yield

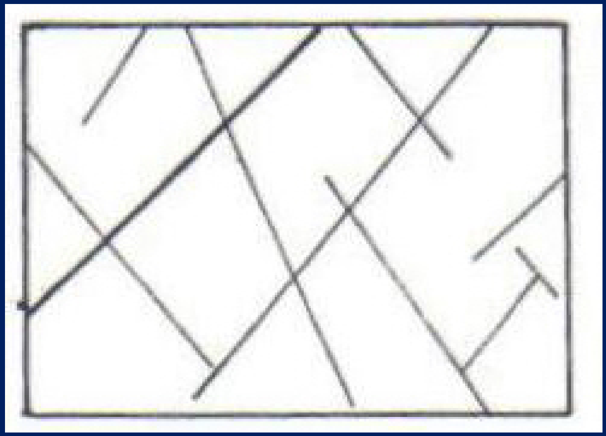
Storativity

POROSITY

Porosity is the ratio of the volume of pores (voids) in an aquifer to its total volume, expressed as a fraction or percentage.



Well-sorted sedimentary deposit having high porosity



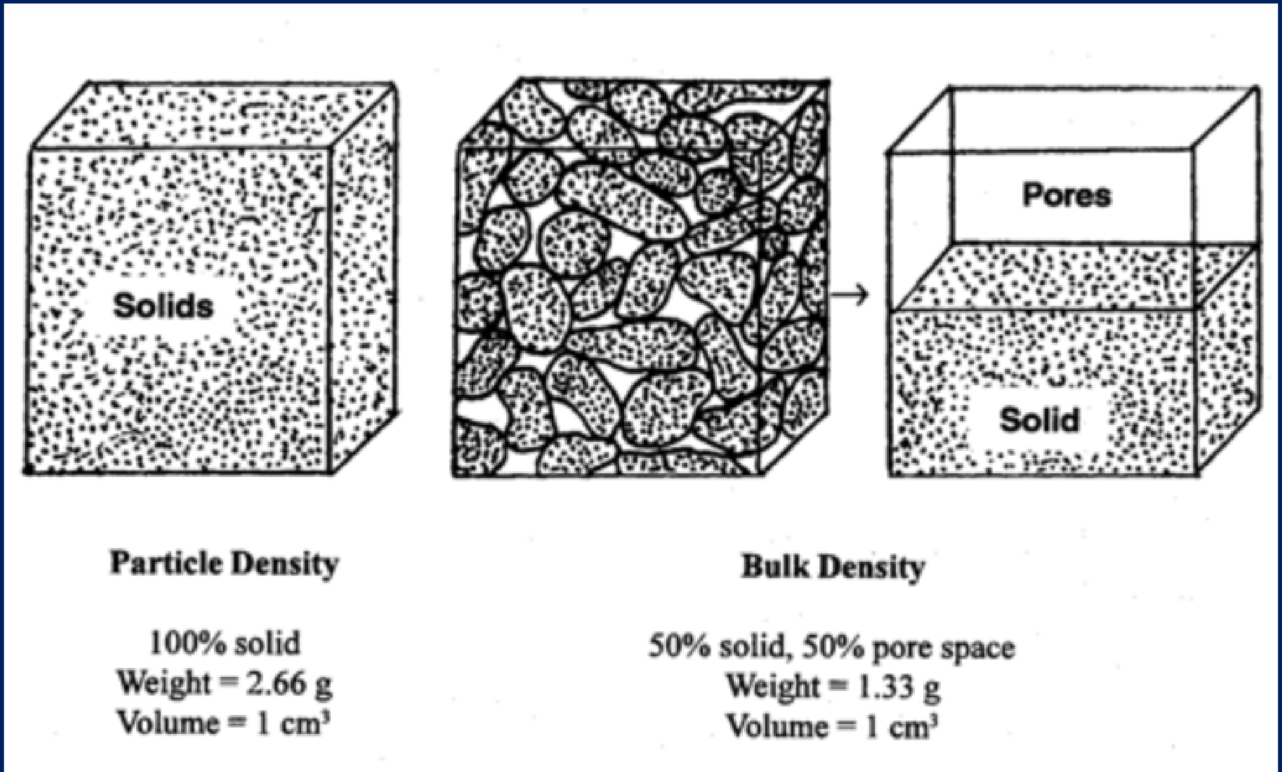
Rock rendered porous by solution or by fracturing

$$n = \frac{V_{void}}{V_{Total}} = 1 - \frac{\rho_d}{\rho_m}$$

$$\text{e(void ratio)} = \frac{V_v}{V_{Solid}}$$

ρ_d bulk density ρ_m density of mineral particles (grain density)

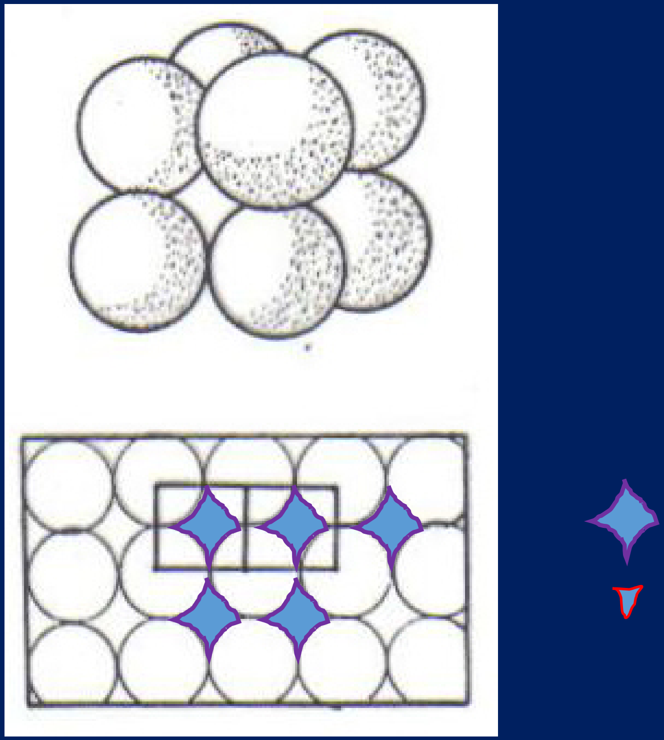
Bulk density is defined as the dry weight of soil per unit volume of soil. Bulk density considers both the solids and the pore space; whereas, particle density considers only the mineral solids. *Below figure* illustrates the difference between bulk density and particle density.

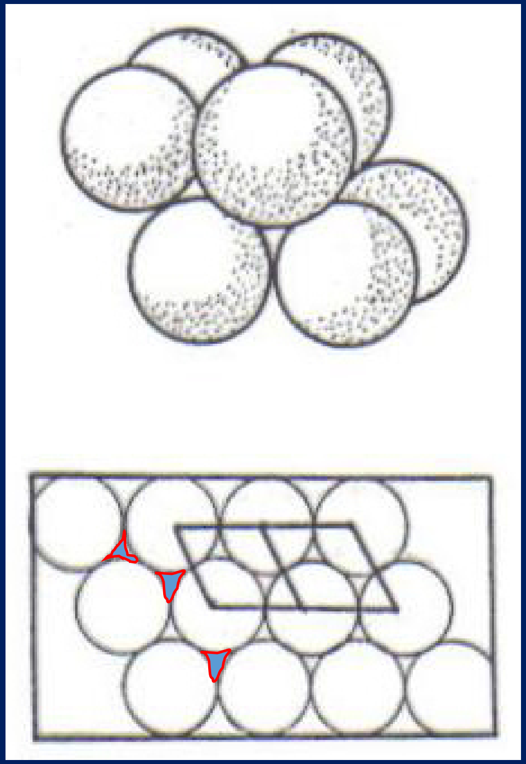


Bulk density- density of solids and voids together, after drying. $\rho_d = \frac{W_d}{V_T}$

https://passel2.unl.edu/view/lesson/0cff7943f577/6

PACKING OF GRAINS





Cubic packing (48% porosity) Rhombohedral packing (26% porosity)

POROSITY IS INDEPENDENT OF GRAIN SIZE, IT DEPENDS ON THE SHAPE, ARRANGEMENT OF INDIVIDUAL PARTICLES, DISTRIBUTION BY SIZE, AND DEGREE OF CEMENTATION AND COMPACTION.

Let’s think of a room filled with cubic packed basketballs.

Now, think of the same room filled with cubic packed tennis balls. Which one would have a higher porosity?

POROSITY WOULD BE THE SAME!

Particle shape:

Angular particles----- LOW POROSITY
Spherical particles--- HIGH POROSITY

Primary porosity- main or original porosity in a rock or unconfined alluvial deposit.
Secondary porosity- a subsequent or separate porosity sytem in a rock, often enhancing overall porosity.
Chemical leaching or generation of a fracture system

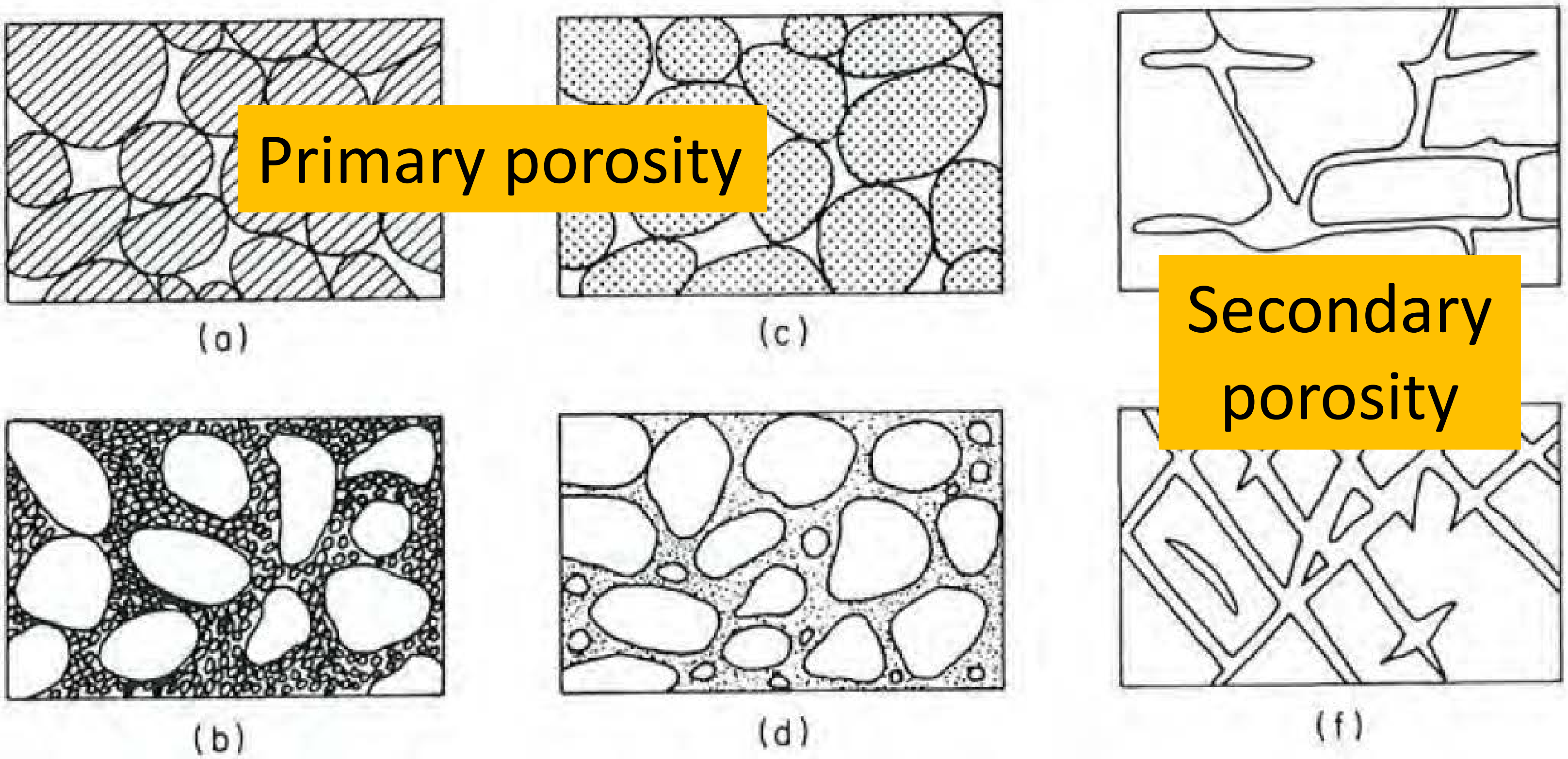


Figure 2.11 Relation between texture and porosity. (a) Well-sorted sedimentary deposit having high porosity; (b) poorly sorted sedimentary deposit having low porosity; (c) well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity; (d) well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; (e) rock rendered porous by solution; (f) rock rendered porous by fracturing (after Meinzer, 1923).

Freeze and Cherry
1979

In the zone of saturation, groundwater fills all of the interstices. The effective porosity provides a direct measure of the water contained per unit volume. A portion of the water can be removed from subsurface strata by drainage or by pumping of a well; however, molecular and surface tension forces hold the remainder of the water in place.

$$n = S_r + S_y$$

Specific retention: It is the ratio of the volume of water that the aquifer will retain after saturation against the force of gravity to its own volume.

$S_r = \frac{V_r}{V_T}$ V_r= Volume of water retained in the pores.

The storage capacity of unconfined aquifers is measured in terms of specific yield, which is defined as the ratio of the volue of water that can be drained by gravity to the total volume of the aquifer.

$S_y = \frac{V_d}{V_T}$ V_d= Volume of water drained

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$$S_y = \frac{V_d}{V_T}$$ V_d= Volume of water drained

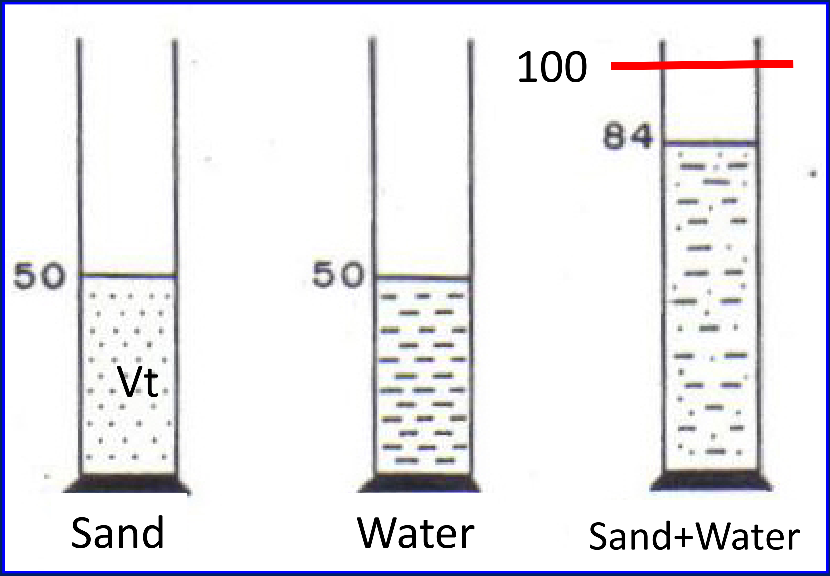
$$S_y = \frac{V_d}{A * \Delta h}$$ Δh= decline in water table

A= surface area of the aquifer in which a decline in water table has taken place.

Estimate the average drawdown over an area where 25 million m^3 of water has been pumped through a number of uniformly distributed wells. The area is 150 km^2 adn the specific yield of the aquifer is 25 percent.

$$S_y = \frac{V_d}{A * \Delta h} = 0.25 = \frac{25 * 10^6}{150 * 10^6 * \Delta h}$$

How to measure porosity?



If there was no porosity

Sieve analysis

Grain size distribution curve,

Effective particle size,

Uniformity coefficient

A 100 gr sand sample, which is thought to represent an unconfined aquifer, was taken from the field and transported to the laboratory. This sample weighed 83 g after it was filtered by gravity. Its oven-dried weight was determined as 77 g.

a) If density of the sample is 1.65 gr/cm^3, and the density of the water is 1 gr/cm^3 deterime the total porosity, specific yield and specific storage of the aquifer.

b) After a long-term rainy season, this aquifer experienced water level changes (please check the below table)

	AREA (km^2)	WATER LEVEL CHANGE(m)
A	15	2.34
B	7.5	1.22
C	18.3	0.76
D	22.5	3.44

Calculate the increase in the aquifer volume.

A storage coefficient (or storativity) is defined as the volume of water that an aquifer releases from or takes into storage per unit surface area of aquifer per unit change in the component of head normal to that surface.

For a vertical column of unit area extending through a confined aquifer, the storage coefficient S equals the volume of water released from the aquifer when the piezometric surface declines a unit distance.

Jacob (1950) formula

$$S = \gamma\alpha\beta b + \gamma b\eta$$

Expansibility of water

Compressibility of the aquifer skeleton

γ= unit weight of water= 10 kN/m^3

α= porosity (n)

β= reciprocal of the bulk modulus of elasticity of water = 4.58×10^{-10} m^2/N)

η = Reciprocal of the modulus of elasticity of the skeleton of the aquifer