RESERVOIR ROCK PROPERTIES

المهندس
كرار كاظم

جامعة المعقل – كلية الهندسة

Lecture 2
Pore Volume Measurement

The most important property of a reservoir rock is the porosity.

Porosity is measure of storage capacity of a reservoir.

It's defined as the ratio of pore volume to bulk volume

$$\phi = \frac{V_p}{V_b} = \frac{V_b - V_m}{V_b}$$

where:

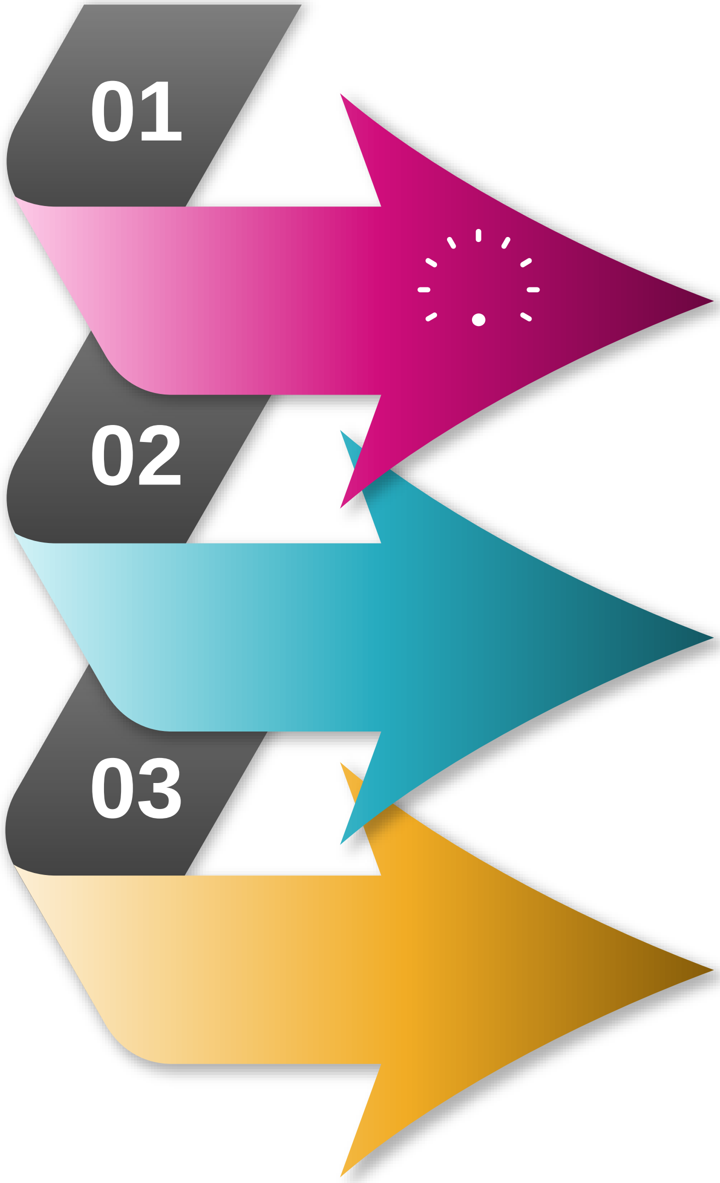
ϕ = porosity [fraction or %]

V_p = pore volume [cm3 or ml]

V_b = bulk volume [cm3 or ml]

V_m = matrix volume [cm3 or ml]

from the definition of porosity, it's evident that we can measure the porosity of a porous sample from three quantities:



Bulk volume

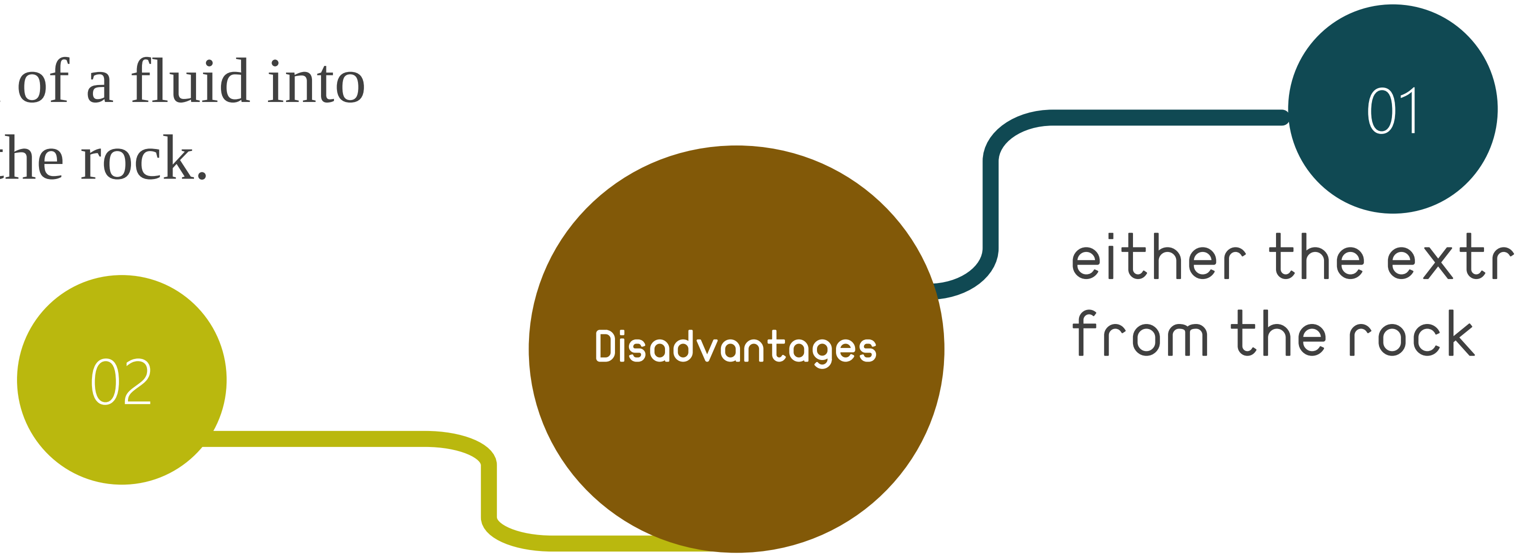
Pore volume

Grain volume

It should be noted that the porosity does not give any information concerning pore size, their distribution, and their degree of connectivity thus, rocks that have the same porosity can have widely different properties. However, in the last experiment we talked about how to measure the bulk volume to find the porosity. In this one we are interested in measuring the **pore volume**.

The methods are based on:

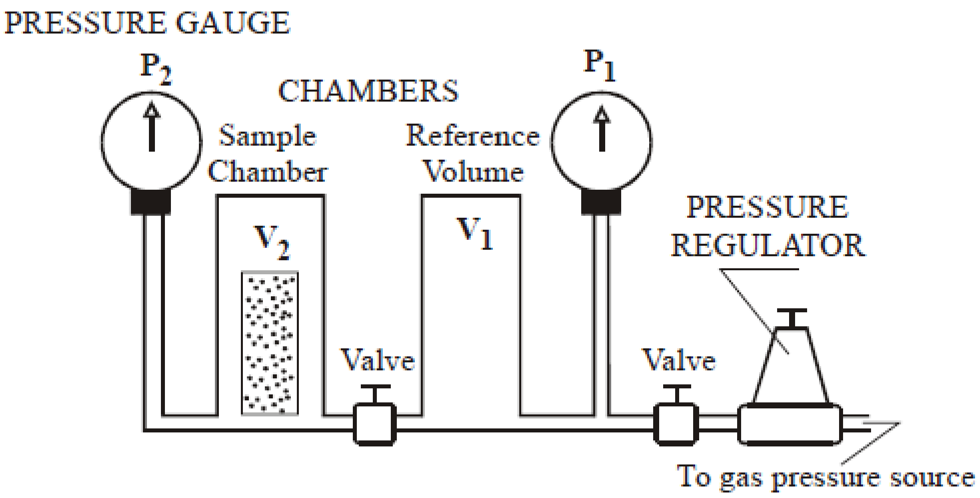
Or the introduction of a fluid into the pore spaces of the rock.



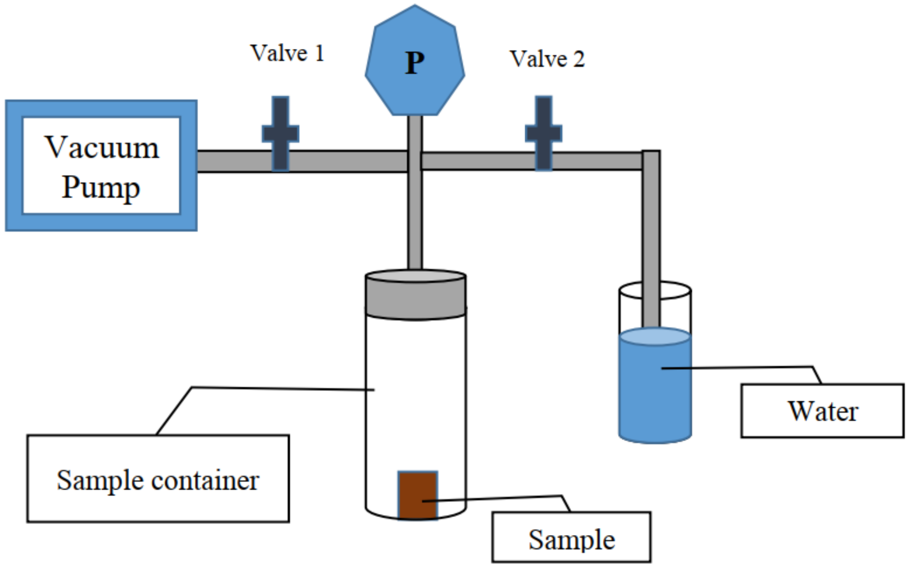
either the extraction of a fluid from the rock

There are many methods that used to measure the pore volume such as:

gas expansion, The helium gas in the reference cell isothermally expands into a sample cell



- Another method that **vacuum saturation method** that work by emptying the air that in the pore spaces of the sample by a vacuum and the saturated the sample with water.



Since the fluid can only inter or leave the connected pores, the porosity obtained from these methods is the **effective porosity**

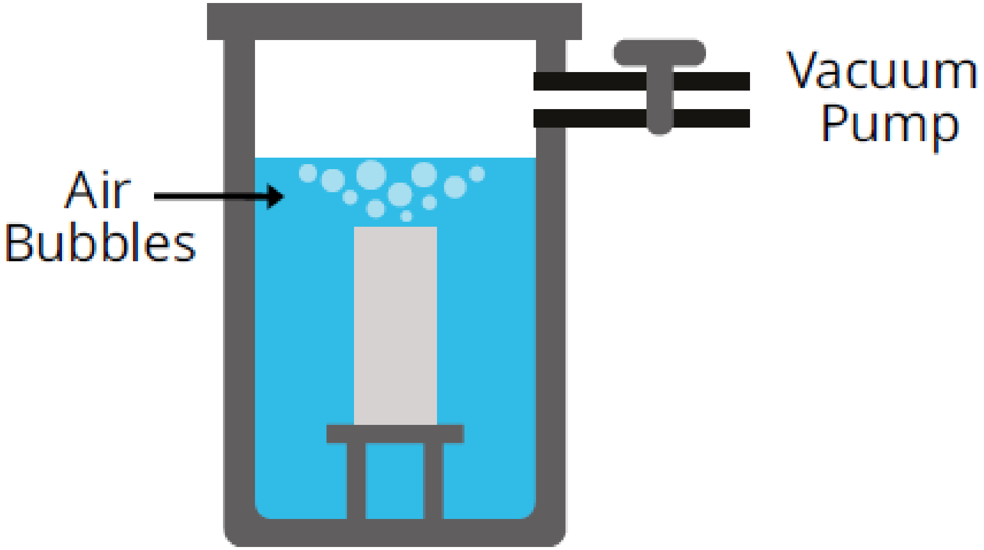
The importance of porosity lies in determining the original hydrocarbon in place, because the porosity is the container of the fluid (oil or gas).

Because pore volume is the excess of bulk volume over grain volume, values of pore volume vary with method dependent value of bulk volume.

Liquid saturation method

1- The concept of fluid displacement is based on **mass/material balance**.
In this technique, we weigh a dry core and measure the dimensions, specifically the diameter and length of the core.

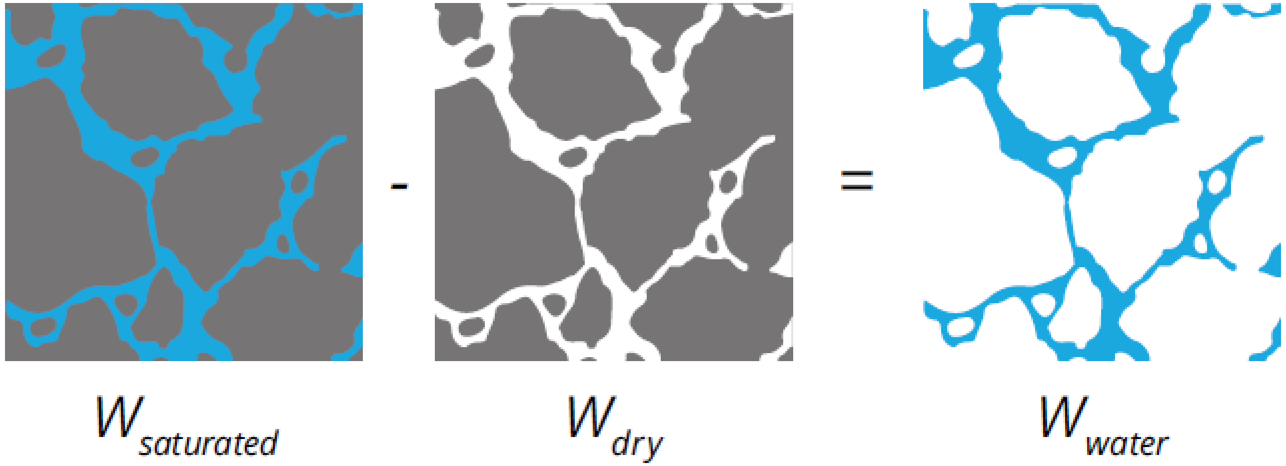
2- Then, we vacuum saturate the core with water or brine (salt water), for instance, to make sure that the water has filled all the pore spaces and no air is trapped in the core



Liquid saturation method

3- The core is then weighed to find the saturated weight. Subtracting the saturated weight from the dry weight, we obtain the weight of the water in the pore spaces. By dividing the weight of the water by the density of the water, we obtain the pore volume:

$$V_p = \frac{W_s - W_d}{\rho}$$



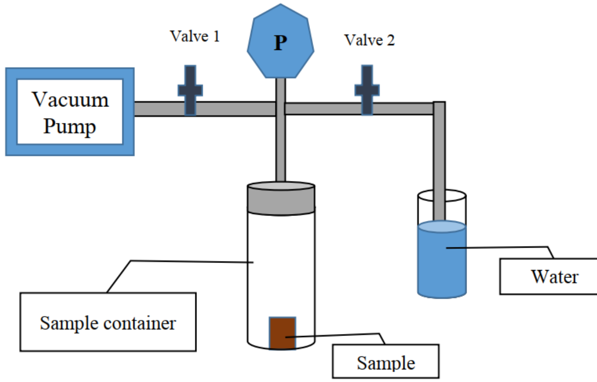
where Ws is the weight of the core saturated with fluid [g], Wd is the dry weight of the core [g], and ρ is the density of the fluid [g/cm3]; since the fluid in this case is water, the density is 1 g/cm3.

Note that the weight term is analogous to mass, unlike in physics where weight is a force.

Liquid saturation method

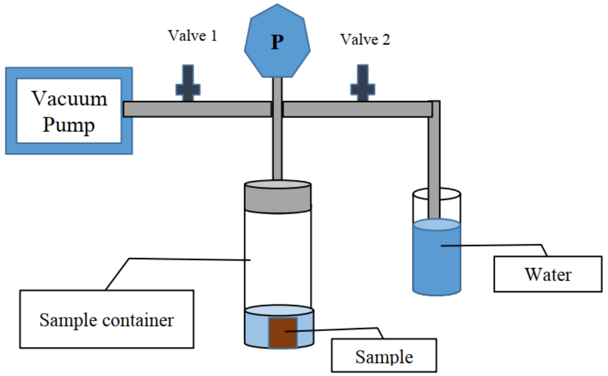
Procedure summary

1. using the analytical balance, we measure the weight of the dry core sample.



2. We close the salt water vessel valve, and we open the vacuum pump valve and we turn on the pump.

3. after sucking out all air from the chamber, we turn off the vacuum pump.
4. we open the salt water vessel's valve to let the salt water flow into the chamber and fill (saturates) the dry core sample.



5. we take out the sample and measure its weight using the analytical balance.

gas expansion (helium technique)

The second method used to measure pore volume is the method **of gas expansion** using a helium porosimeter, which relies on **Boyle's law**:

$$P1V1 = P2V2$$

The helium gas in the reference cell isothermally expands into a sample cell. After expansion, the resultant equilibrium pressure is measured.

gas expansion (helium technique)

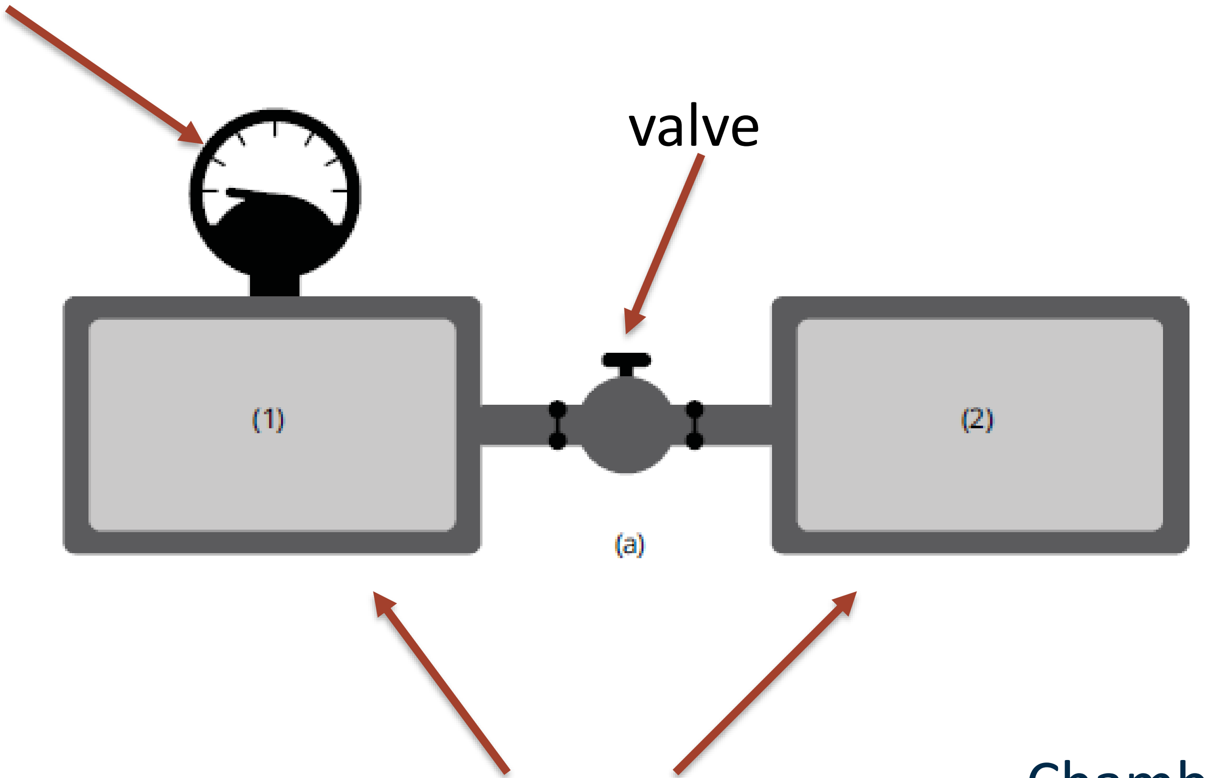
Helium has advantages over other gases

Advantages

- helium has a high diffusivity and therefore affords a useful means for determining porosity of low permeability rocks.
- its small molecules rapidly penetrated small pores
- helium can be considered as an ideal gas (i.e., z = 1.0) for pressures and temperatures usually employed in the test
- it is inert and does not adsorb on rock surfaces as air may do

gas expansion (helium technique)

system shown in **Figure**



Chambers
1 and 2 should be of fixed volumes

gas expansion (helium technique)

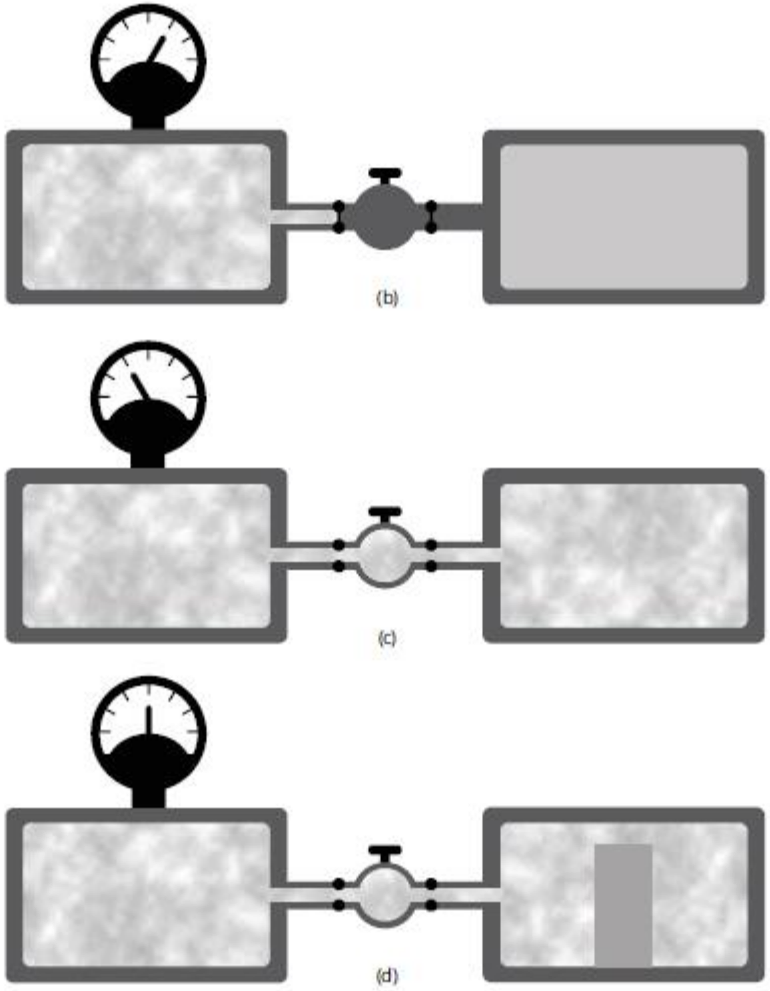
Procedure summary

1. We fill chamber 1 with helium and then record the pressure; thus, we have P_1 and V_1
2. If we open the valve to chamber 2, then Boyle's law becomes:

   $$P1V1 = P2(V1 + V2)$$

3. If we consider an actual case where we have a rock inside chamber 2 ,then Boyle's law becomes:

   $$P1V1 = P2(V1 + V2 - Vm)$$



In this case, helium will **access all the chambers and the pore spaces**. The only space helium **will not** access is the **matrix volume** as it is not porous; using this technique, we can calculate the porosity.

gas expansion (helium technique)

Procedure summary

1. We will calculate Vm from the equation, as V1 and V2 are constants and P1 and P2 will be read from the equipment.
2. After finding Vm and also knowing the bulk volume of the core, which is easy to measure, we can calculate the pore volume as Vp = Vb – Vm and the porosity is equal to Vp divided by Vb.

$$P_1V_1 = P_2(V_1 + V_2)$$

$$P_1V_1 = P_2(V_1 + V_2 - V_m)$$

$$\phi = \frac{V_p}{V_b} = \frac{V_b - V_m}{V_b}$$