Porosity Measurement

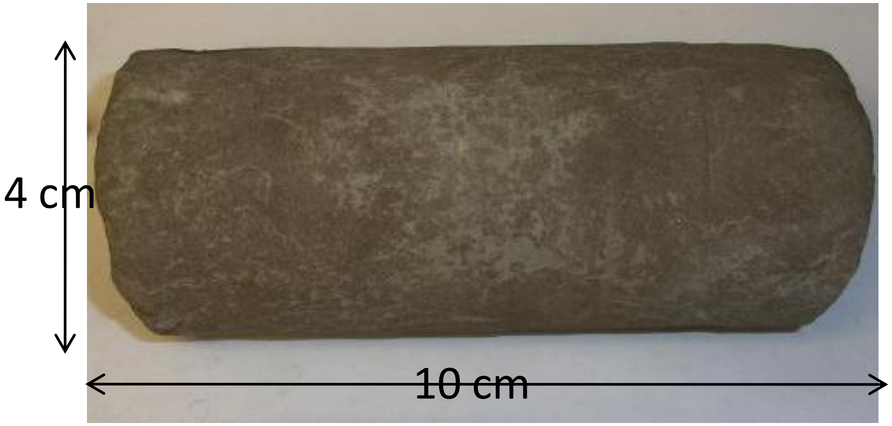
$$V_b = V_g + V_p$$

Measurement of any two of the three volumes allows for the determination of porosity

Porosity Measurement

Bulk Volume

a. linear measurements



$$V_b = \pi r^2 h$$

Porosity Measurement

Bulk Volume

b. displacement method - fluid displaced by sample measured volumetrically or gravimetrically

Prevent fluid penetration into pore space by:

i. coating the rock with paraffin
ii. saturating the rock with the fluid into which it is immersed
iii. using mercury

Gravimetric methods observe the loss in weight of the sample when immersed in a fluid, or observe the change in weight of a pycnometer filled with mercury and filled with Hg and sample.

Volumetric methods measure the change in volume when the sample is immersed.

Porosity Measurement

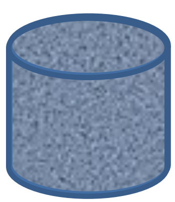
Bulk Volume

Example – displacement method

Weight dry

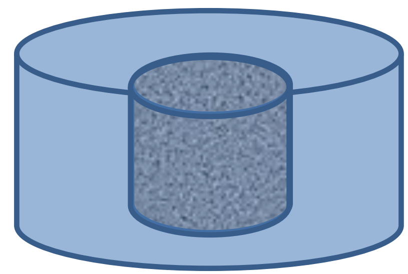
W_{dry} = 20 gms

Weight saturated



W_{sat} = 22.5 gms

Weight of saturated sample immersed in water



W_{wet} = 12.6 gms

Weight of water displaced

$$W_{wtr} = W_{sat} - W_{wet} = 9.9 \text{ gms}$$

Bulk volume

$$V_b = W_{wtr}/\rho_{wtr} = 9.9 \text{ cc}$$

Porosity Measurement

Grain Volume

a. Direct methods
  i. Dry weight of sample/density of matrix = Vg
  ii. Destructive methods (Melcher-Nutting or Russell)
    - requires sample to be crushed
    - Vg determined gravimetrically by principle of bouyancy. - not very accurate!

b. Gas Expansion methods

- Boyle's Law porosimeter
- non-destructive, reasonably accurate

Porosity Measurement

Boyle's porosimeter

- The total moles of gas is constant, thus

$$n_t = n_1 + n_2$$

- Substituting the ideal gas equation,

$$\frac{p_f V_f}{RT} = \frac{p_1 V_1}{RT} + \frac{p_2 V_2}{RT}$$

- Isothermal conditions prevail,

$$p_f V_f = p_1 V_1 + p_2 V_2$$

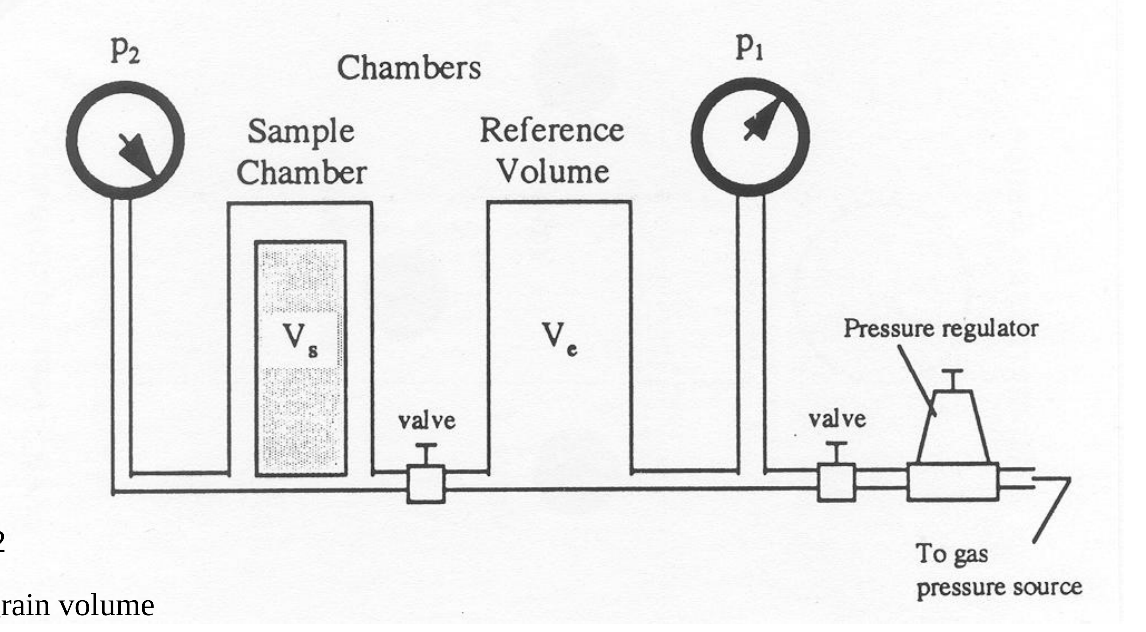
- Substituting for the volumes,

$$p_f (V_1 + V_2 - V_g) = p_1 (V_1 - V_g) + p_2 V_2$$

- Rearranging results in an expression for grain volume

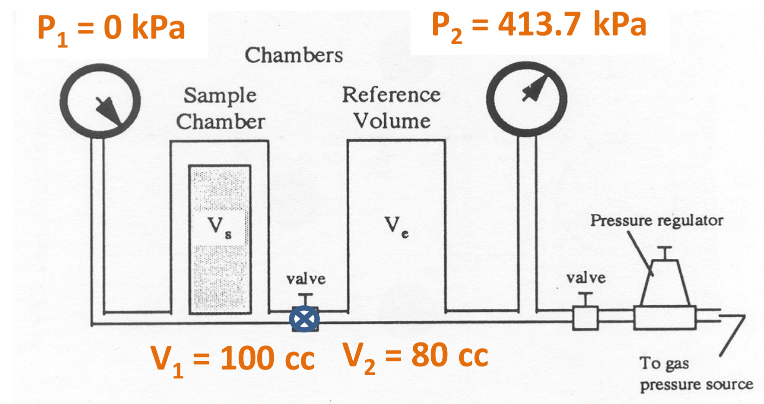
$$V_g = \frac{V_1 (p_f - p_1) + V_2 (p_f - p_2)}{p_f - p_1}$$

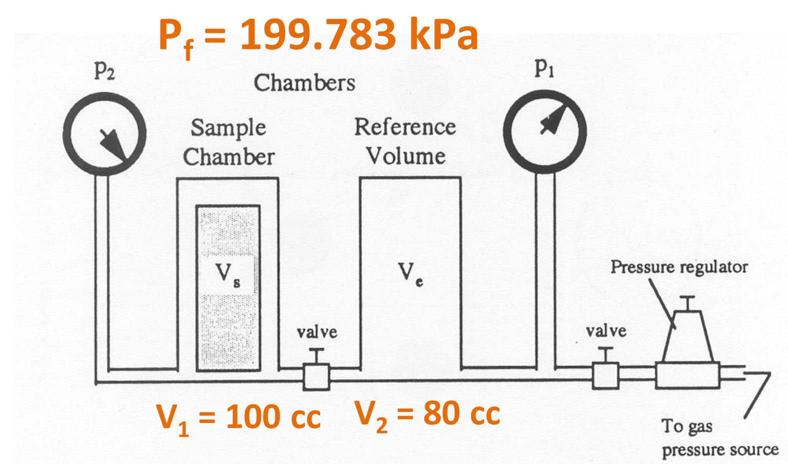
where V_1 and V_2 are the calibrated chamber volumes.



Porosity Measurement

Boyle's porosimeter - example





$$V_g = \frac{100(199.783 - 0) + 80(199.783 - 413.7)}{199.783 - 0} = 14.340cc.$$

Porosity Measurement

Pore Volume

1. Mercury Injection methods
   - destructive (contamination of sample)
   - not very accurate
   - Washbum-Bunting, Kobe, Mercury porosimeters (obsolete)

2. Fluid Saturation method (See example)
   - non-destructive
   - not suitable for water sensitive rocks, unless use oil
   - very accurate

Porosity Measurement

Pore Volume

3. Summation of fluids method (Retort method)
    - oil and water volumes calculated by retorting sample up to 1200 F.
        - vapors condense, collected, and measured
        - empirical correlation for coking and cracking of oil
    - Bulk volume and gas volume obtained from adjacent core sample using Hg PUMP
        - displacement at low pressures yields Vb
        - displacement at high pressures yields Vgas
    - Porosity determined from summation of fluids

ADV: fast

DISADV: dependent on similarity of adjacent samples coking and cracking correlation

Porosity Measurement

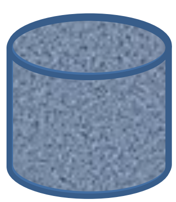
Pore Volume

Example – fluid saturation method

Weight dry

W_{dry} = 20 gms

Weight saturated



W_{sat} = 22.5 gms

Weight of water in pore space

$$W_{wtr} = W_{sat} - W_{dry} = 2.5 \text{ gms}$$

pore volume

$$V_p = W_{wtr}/\rho_{wtr} = 2.5 \text{ cc}$$

Bulk volume (from previous example)

$$V_b = 9.9 \text{ cc}$$

Porosity

$$\phi = 2.5/9.9 = 25.3\ \%$$