Flow in Porous Media

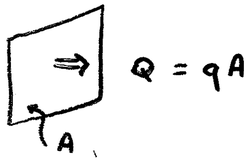
Permeability:

- ease of fluid flow in porous media
- measure of connectivity of pore space

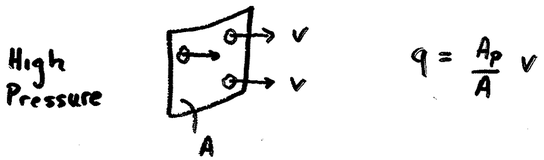
Definitions

Q - rate of volume flow/ unit time (m^3/s)

$q = Q/A$ - rate of volume flow/ unit area and time (m/s)



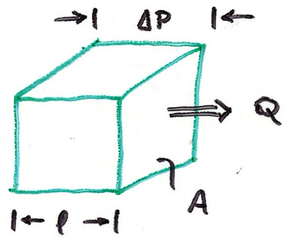
$Q = qA$



$q = \frac{A_p}{A} v$

Flow is usually driven by pressure differences

Experiments



$$Q \propto \frac{A}{\eta}\frac{\Delta P}{l}$$

η is viscosity of fluid

Let

$$Q = -k\frac{A}{\eta}\frac{\Delta P}{l}$$

where k is the permeability (units m^2)

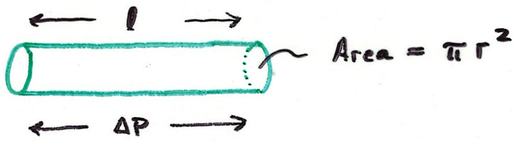
Darcy's Law

$$q = \frac{Q}{A} = -\frac{k}{\eta}\frac{\partial P}{\partial x}$$

1 darcy = 0.97×10^{-12} m^2

Model for Permeability

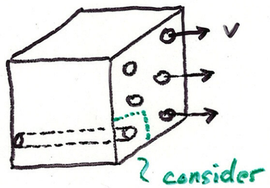
Poisseuille Flow



$$Q = -\frac{\pi r^4}{8\eta}\left(\frac{\Delta P}{l}\right)$$

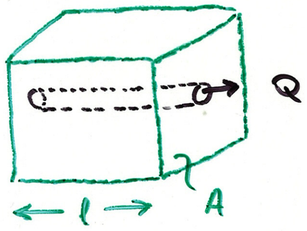
Since $A_c = \pi r^2$

$$Q = -\frac{A_c r^2}{8\eta}\left(\frac{\Delta P}{l}\right)$$



consider average area A around single tube

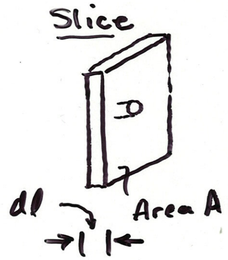
Model for Permeability (Con't)



$$q = \frac{Q}{A} = -\frac{A_c}{A}\frac{r^2}{8\eta}\left(\frac{\Delta P}{l}\right).$$

Comparing with Darcy's Law

$$k = \frac{A_c}{A}\frac{r^2}{8} = \frac{\phi r^2}{8} \quad \text{units } m^2$$



Volume of pore = $A_c \cdot dl$

Total volume = $A \cdot dl$

$\therefore \phi = \frac{V_P}{V_T} = \frac{A_c}{A}$