

#### 4. UNSATURATED FLOW

o Contaminants traverse vadose zone

- Pesticides (deliberate application)
- Miscible
- Dissolved

o Clay mineralogy

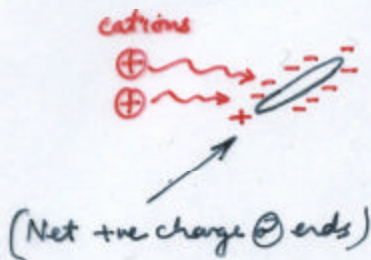
Reactive clays in many soils (clay  $< 2 \mu\text{m}$ )

Weathering products - Aluminium, Silica, Oxygen

Kaolinite (china clay)  $5-20 \text{ m}^2/\text{g}$

Montmorillonite - high surface area  $700 \text{ m}^2/\text{g}$ .

o Why important -



① Electrical double layer captures colloids  
(unbalanced -ve surface)

attracts +ve cations

∴ good buffers or attenuators

② Electrostatic double layer affects hydrology

Swelling clays swell and seal pathways.

Water salinity  $\uparrow \rightarrow$  swelling  $\rightarrow$   $\downarrow$  conductivity

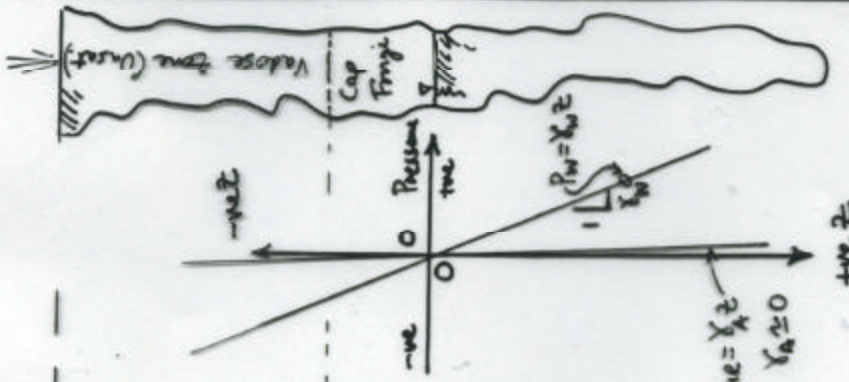
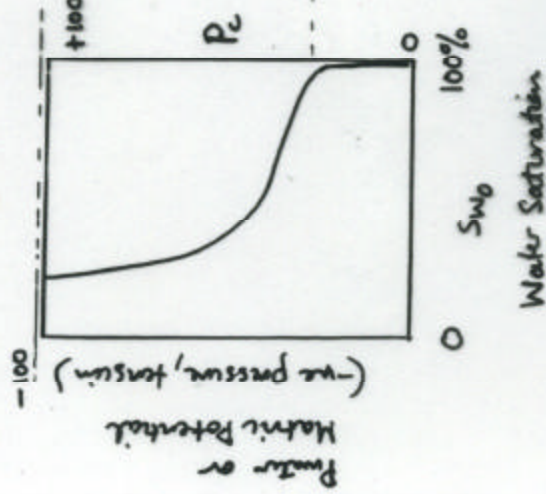
Process reverses if flushed by fresh water.

STATIC SYSTEMS

$P_c = P_{nw} - P_w$

Vadose zone

$P_c = P_{air} - P_{water}$



$P_{air} = \gamma_a z$   
 $\gamma_a \approx 0$

Capillary Fringe  $\equiv$  Tension saturated zone

NAPL in Groundwater

$P_c = P_{NAPL} - P_{water}$

$$v_x = q = -K \frac{\partial h}{\partial x} = -k_r K(\theta) \frac{dh}{dx}$$

$$= k_r \frac{K}{\mu} \left( \frac{\partial P}{\partial x} + \rho g \frac{\partial z}{\partial x} \right)$$

