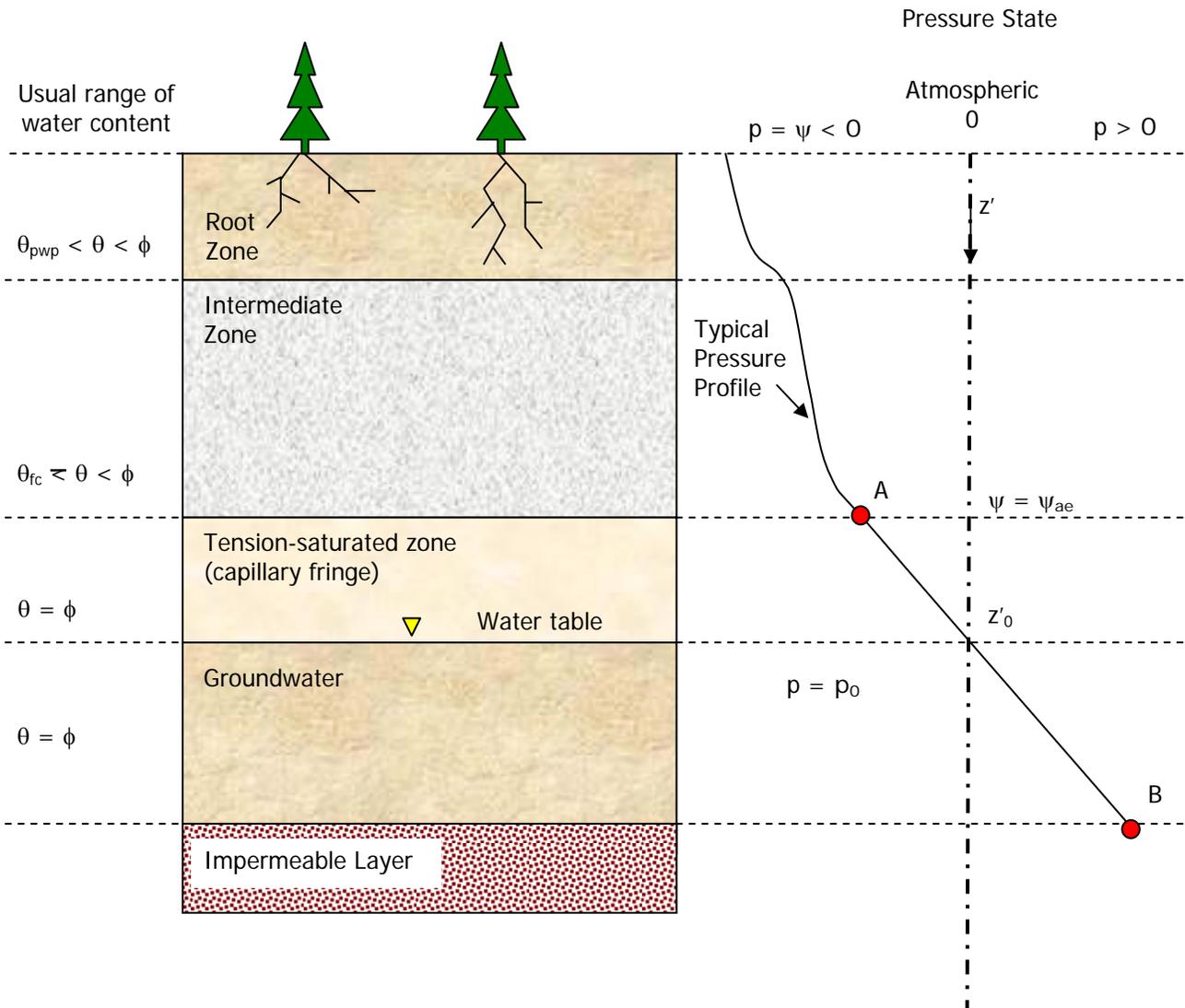


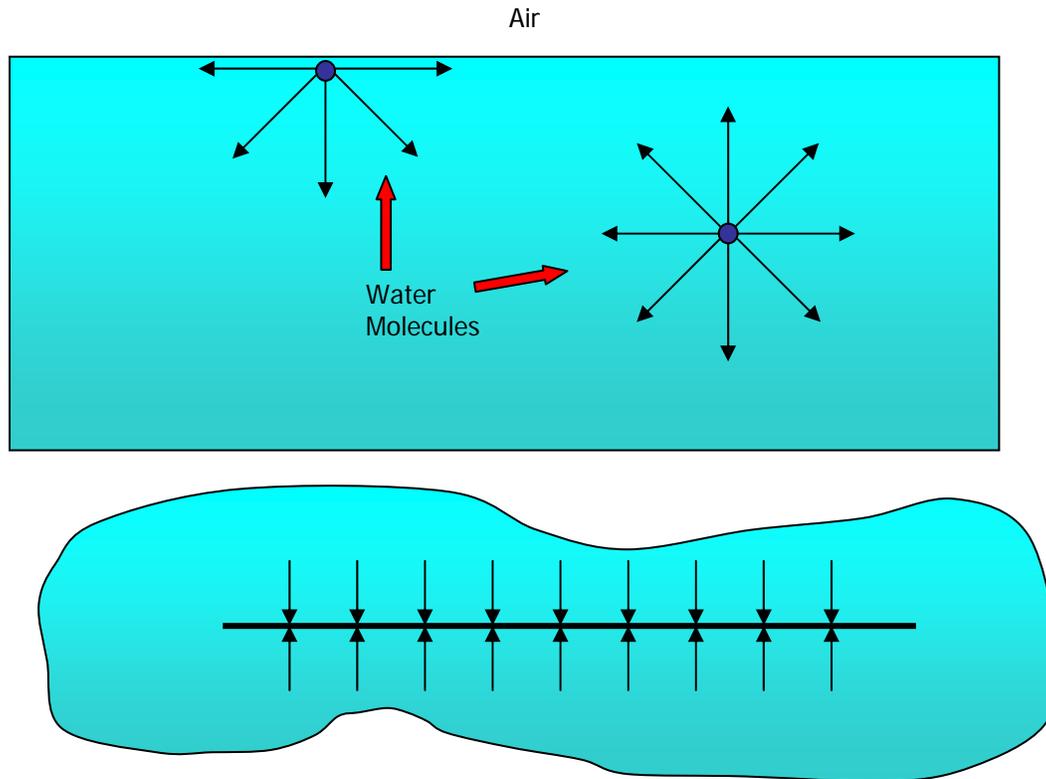
1.72, Groundwater Hydrology
 Prof. Charles Harvey
Lecture Packet #12: Soil Moisture



Terms and Interpretations	
Symbol	Definition
θ_{pwp}	Permanent wilting point water content
θ_{fc}	Field capacity water content
ϕ	Porosity
ψ_{ae}	Pressure at which air enters the system (top of the capillary fringe)
p_0	Atmospheric pressure; underground, the definition of water table
$\theta = \phi$	Saturation point

Unsaturated Flow: Movement of Soil Moisture

Water molecules attract each other so that at the surface there is a net downward pull on the molecule. The net effect is **surface tension**.



$\gamma = 72.7 \text{ dyn/cm}$ for water and air [F/L]

$\gamma = 29 \text{ dyn/cm}$ for benzene

$\gamma = 430 \text{ dyn/cm}$ for mercury

Energy/L² – the energy required to increase the area. Unlike a membrane, the surface tension doesn't change with expansion.

Surface tension depends on:

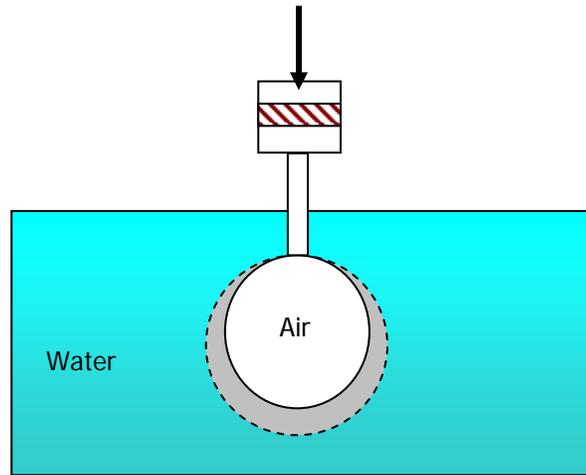
The substances

Any solutes

Temperature

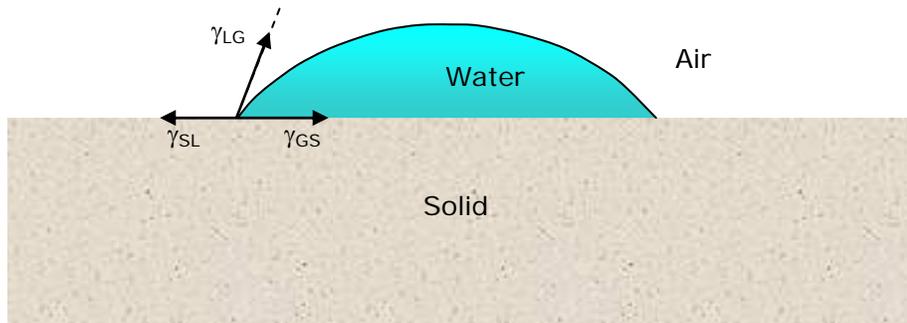
Gas Pressure

Consider a bubble of air in water:



$$\Delta P = 2\gamma/R$$

Blowing air into the bubble decreases the pressure.

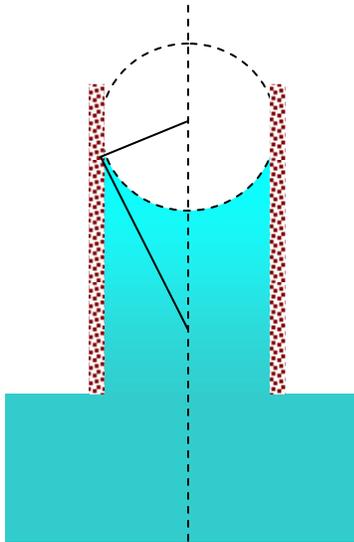


$$\gamma_{SL} = \gamma_{GS} + \gamma_{LG} \cos(\alpha)$$

$$\cos(\alpha) = \frac{\gamma_{SL} - \gamma_{GS}}{\gamma_{LG}}$$

GS = gas-solid
SL = solid-liquid
LG = liquid-gas

Capillary Rise



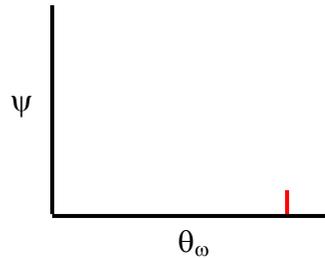
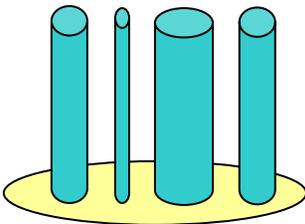
$$\Delta P = \frac{2\gamma \cos(\alpha)}{r}$$

When the height of the meniscus is at steady-state, then the hydrostatic tension must balance the effect of surface tension.

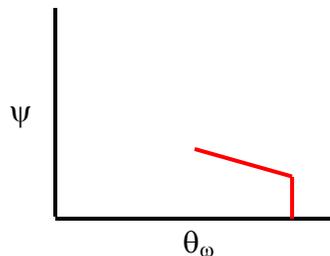
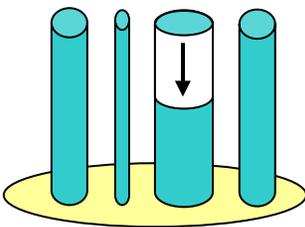
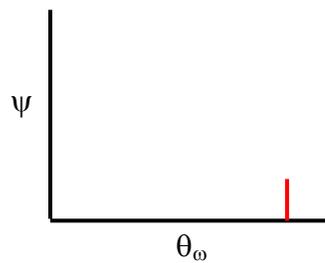
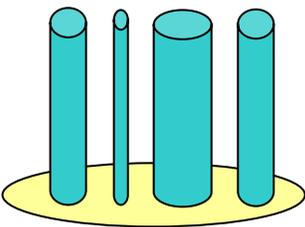
$$hg\rho = \frac{2\gamma \cos(\alpha)}{r}$$

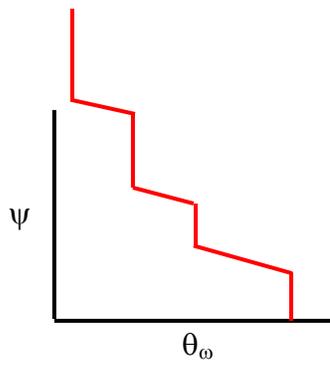
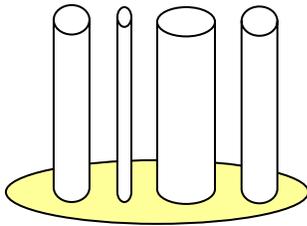
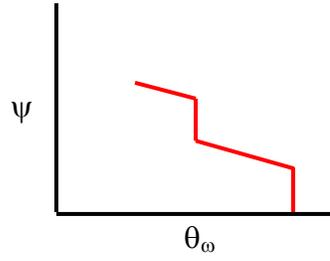
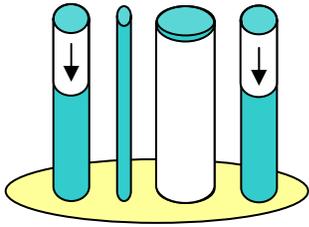
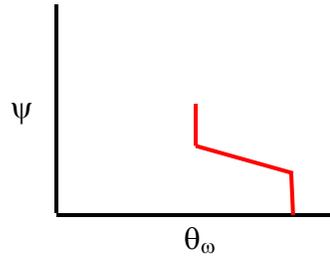
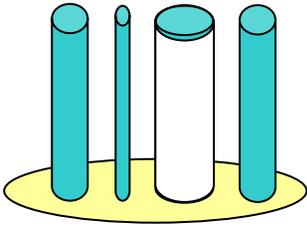
Retention Curves or Soil Moisture Characteristic Curves

A bundle of capillaries (hydrophylic) all of the same length with pressure adjusted at the bottom. The bundle contains a range of radii. Measure average water content as the suction is gradually increased at the bottom. Plot suction versus water content.

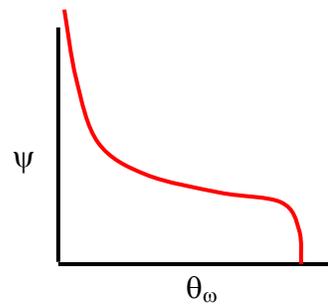


ψ = suction
 θ_w = water content



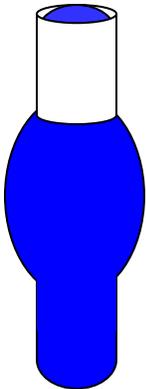
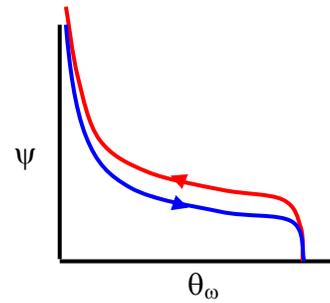


Pore space in rocks and soil is much more complex geometrically but analogous phenomena give rise to characteristic retention curves for a given sample material.

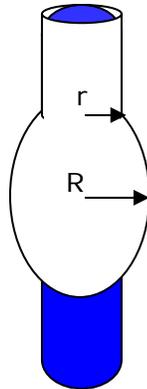


The shape of the retention curve for a given porous material is influenced by:

1. Texture and Structure
 - a. Particle-size distribution
 - b. Pore-size distribution
 - c. Particle shape
 - d. Specific surface
2. History of wetting and drying – Hysteresis
 - a. Non-wetting phase entrapment
 - b. Swelling and shrinking
 - c. Ink-bottle effect – Haines Jump



Drainage



Filling