Lecture 10c – Soil water pressure and retention curves

Learning Outcomes

- Be able to name and explain the processes by which water infiltrates and is redistributed within soils, and why it is important
- Be able to explain the factors which determine what type of soil forms and use a soil texture triangle
- Be able to calculate the material properties of soil: volume, porosity, bulk density, particle density
- Be able to calculate the soil water storage/soil moisture content: volumetric water content, gravimetric water content, saturation, field capacity, permanent wilting point
- Be able to explain why different soils have different properties such as porosity, field capacity, permanent wilting point and identify this information from graphs
- Understand and be able to explain how water moves in soil
- Be able to understand and interpret water retention curves and describe how soil water content/soil water pressure varies in a typical soil profile

Surface tension and capillarity

Upward force = $\sigma \cos\theta_c \, 2\pi r$

Downward force = $\rho \, g \, \pi \, r^2 \, h_{cr}$

Where:

σ = surface tension

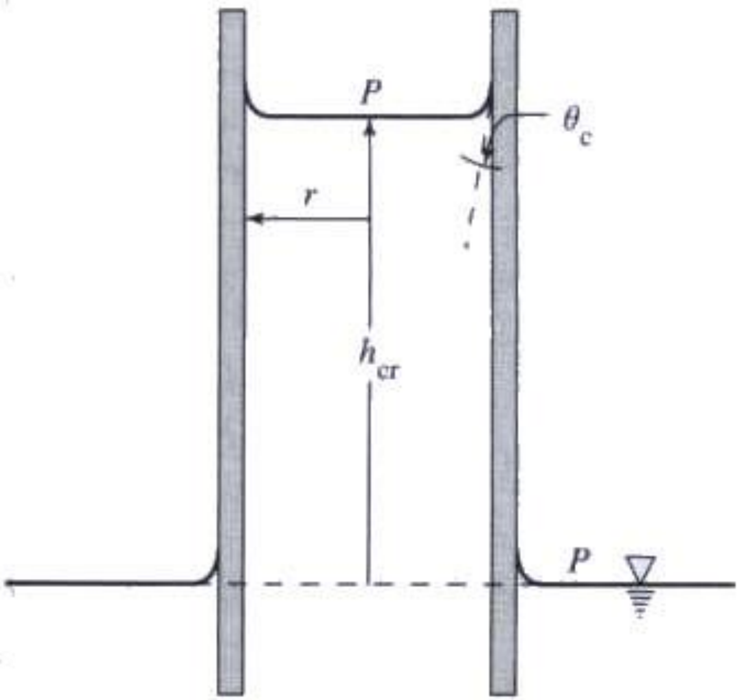
θ_c = contact angle between meniscus and wall

r = radius of tube

ρ = density of water

g = acceleration due to gravity

h_{cr} = capillary rise



Write an equation for h_{cr} assuming that it is in steady state.

How can we relate this to pressure? (Note: pressure = force/area)

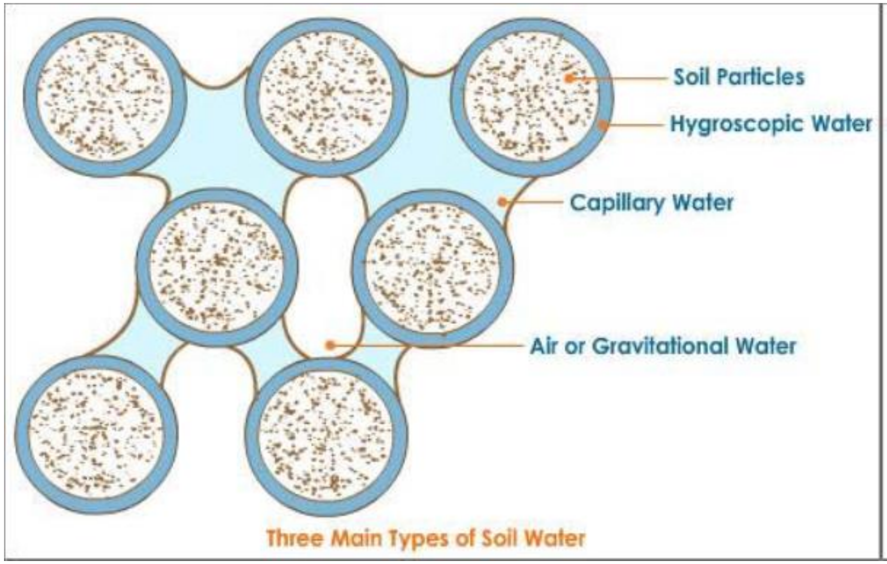
Soil water pressure

Soil water pressure and so pressure head are defined:

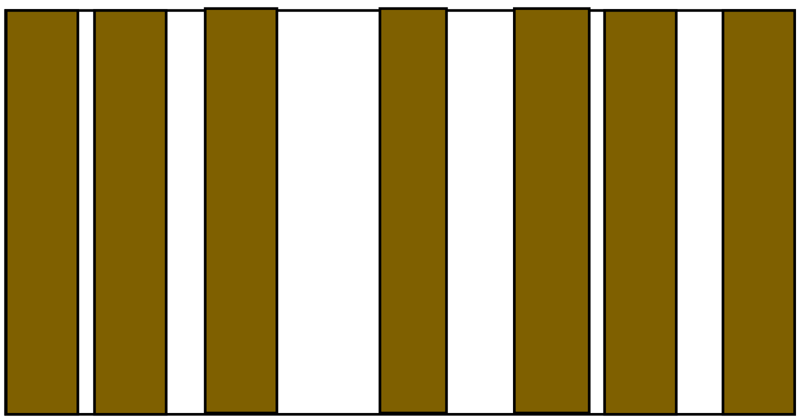
- in unsaturated soil as <0 (less than atmospheric pressure i.e. tension)
- in saturated soil as >0 (greater than atmospheric pressure)
- at water table p = 0 (atmospheric pressure)

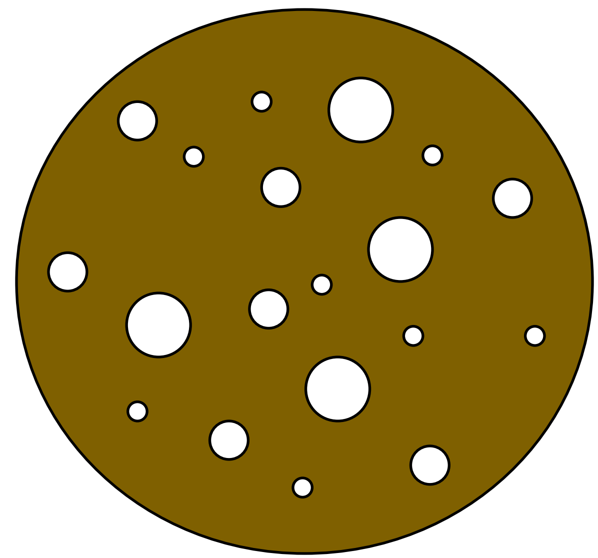
As water content decreases, water tension increases and water is held more tightly to soil grains.

If there is a vertical soil water pressure gradient soil will move from higher pressure (lower tension) to lower pressure (higher tension) = suction flow



Tension and retention curves



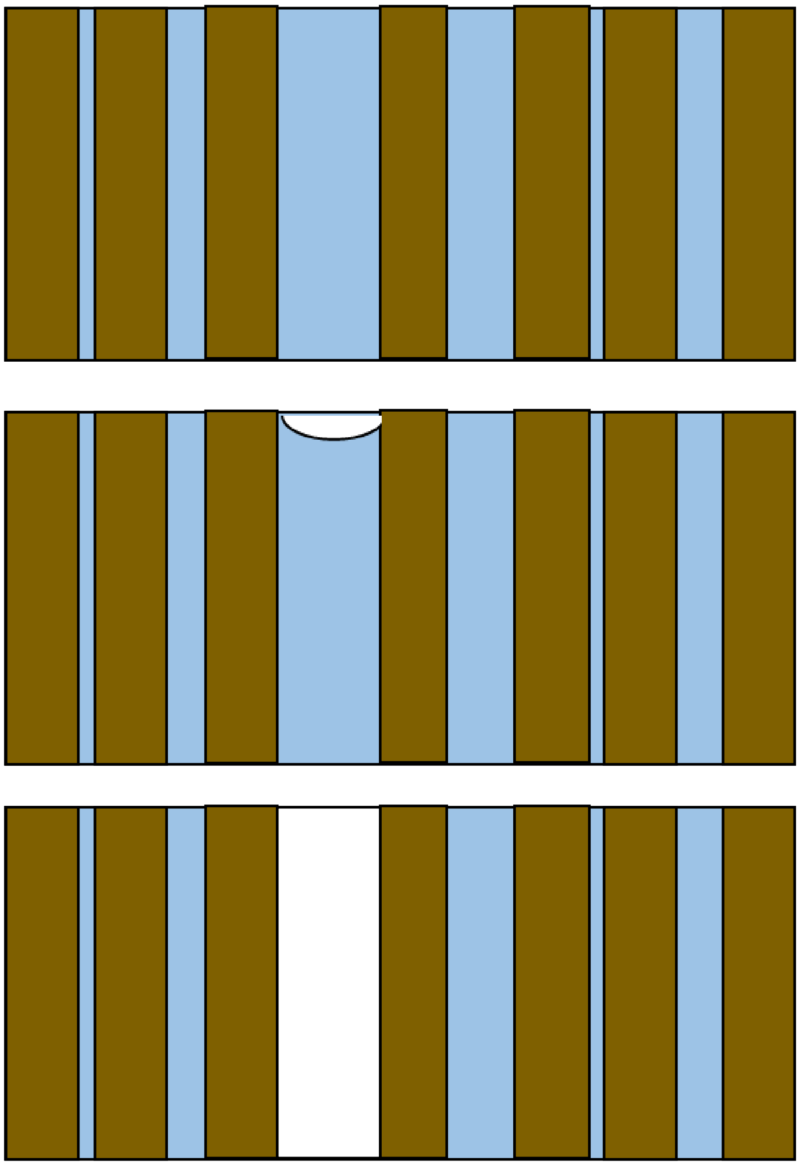


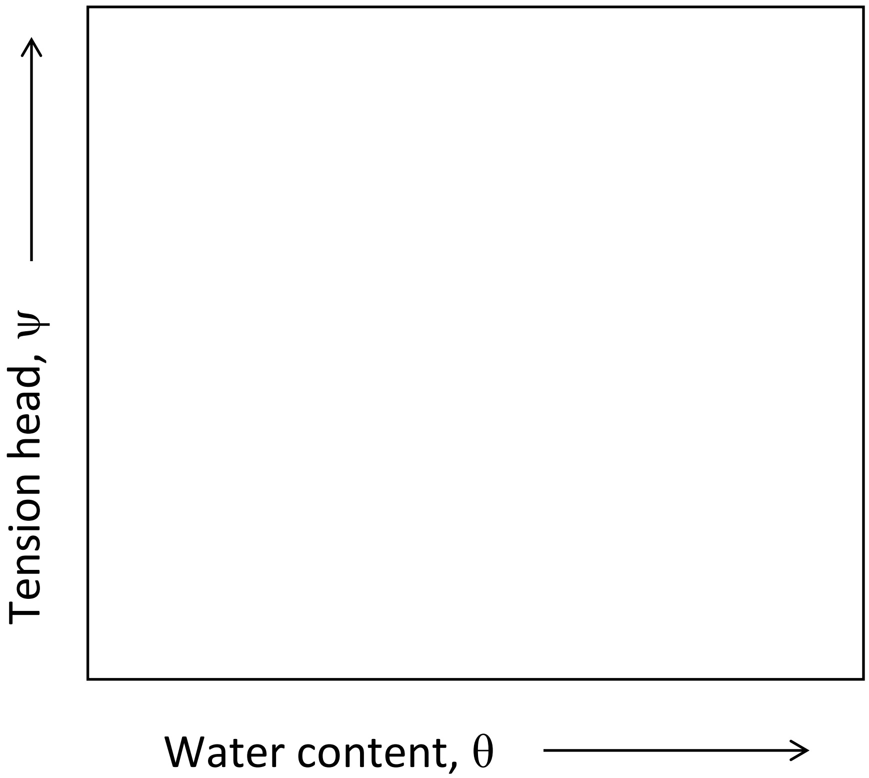
Pressure head (ψ) = $\frac{p}{\rho g} = \frac{2\sigma\cos\theta_c}{\rho g r}$

Pressure head is in units of length (i.e. h_{cr})

As radius increases, pressure/tension head ……

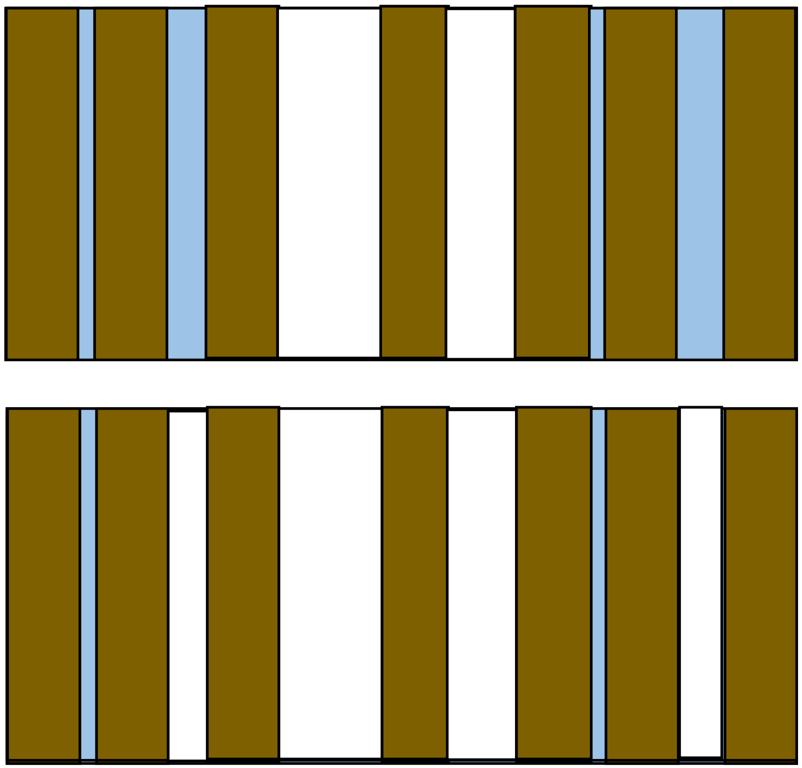
Tension and retention curves

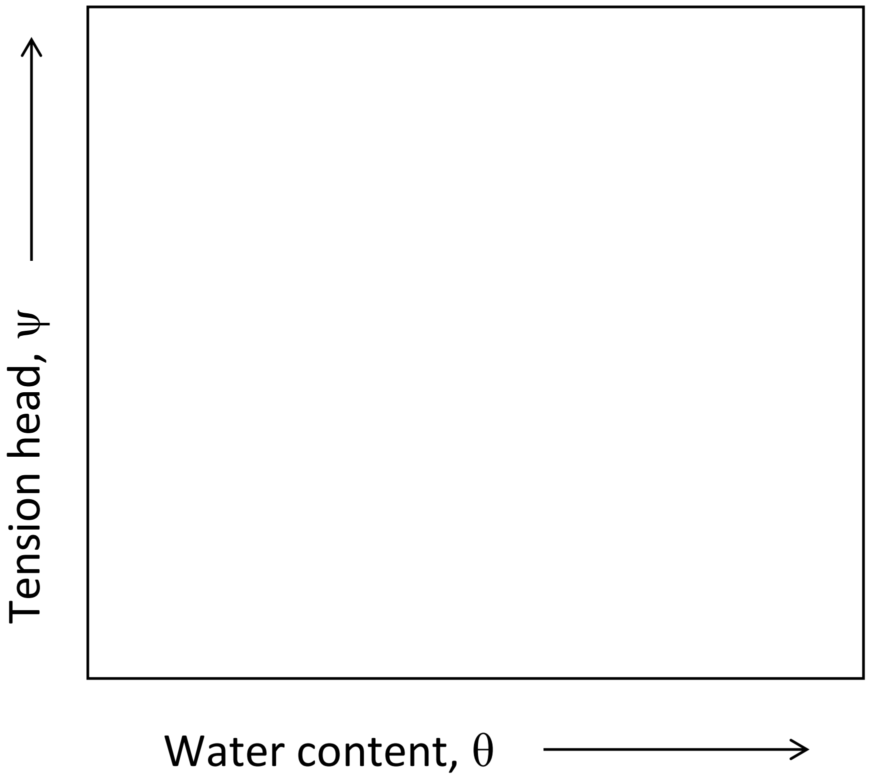




What sets upper limit on water content?
As water content decreases, water held more tightly to soil grains and creates more "tension head".

Tension and retention curves

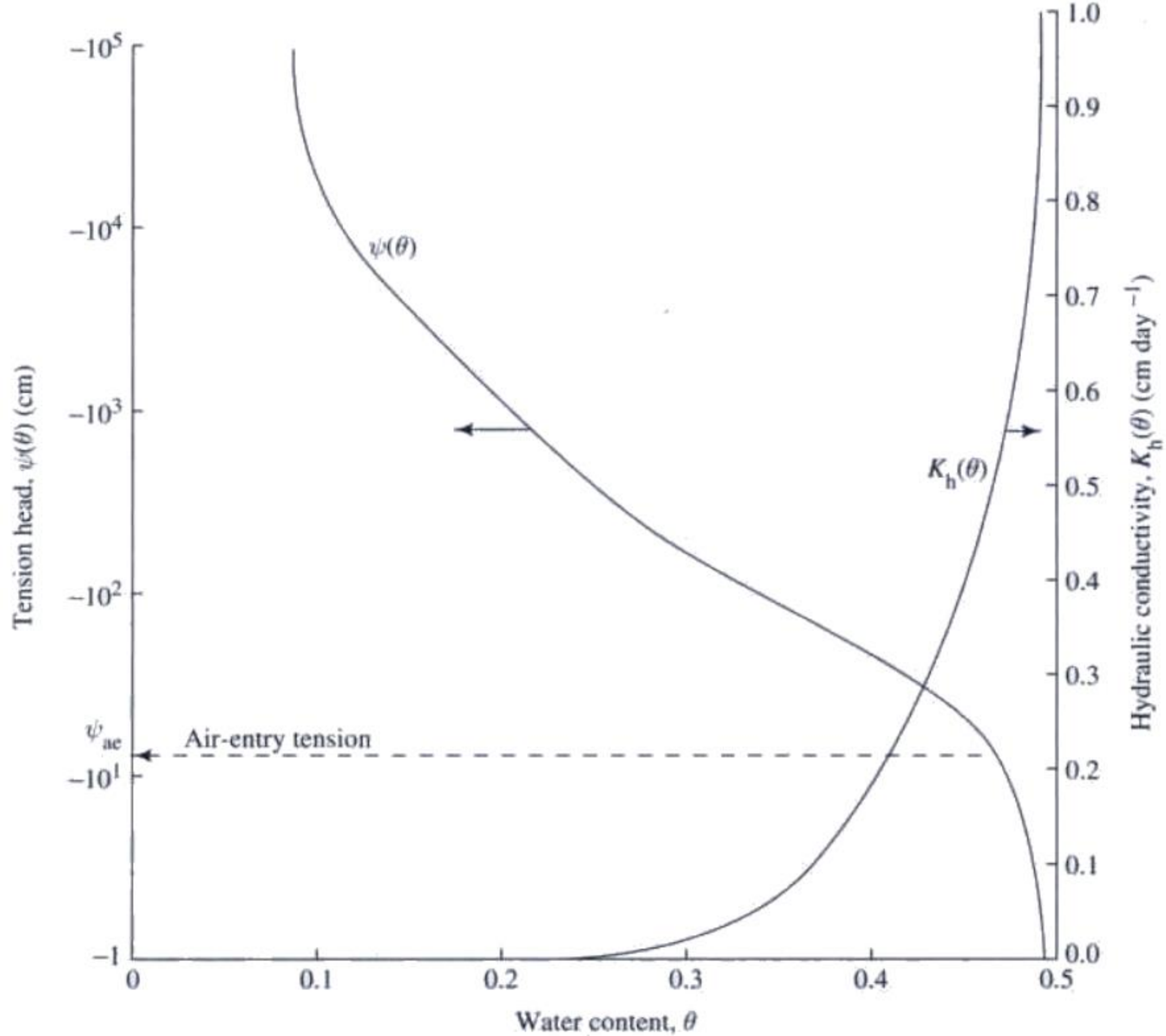




What sets upper limit on water content?
As water content decreases, water held more tightly to soil grains and creates more "tension head".
What sets lower limit on water content?

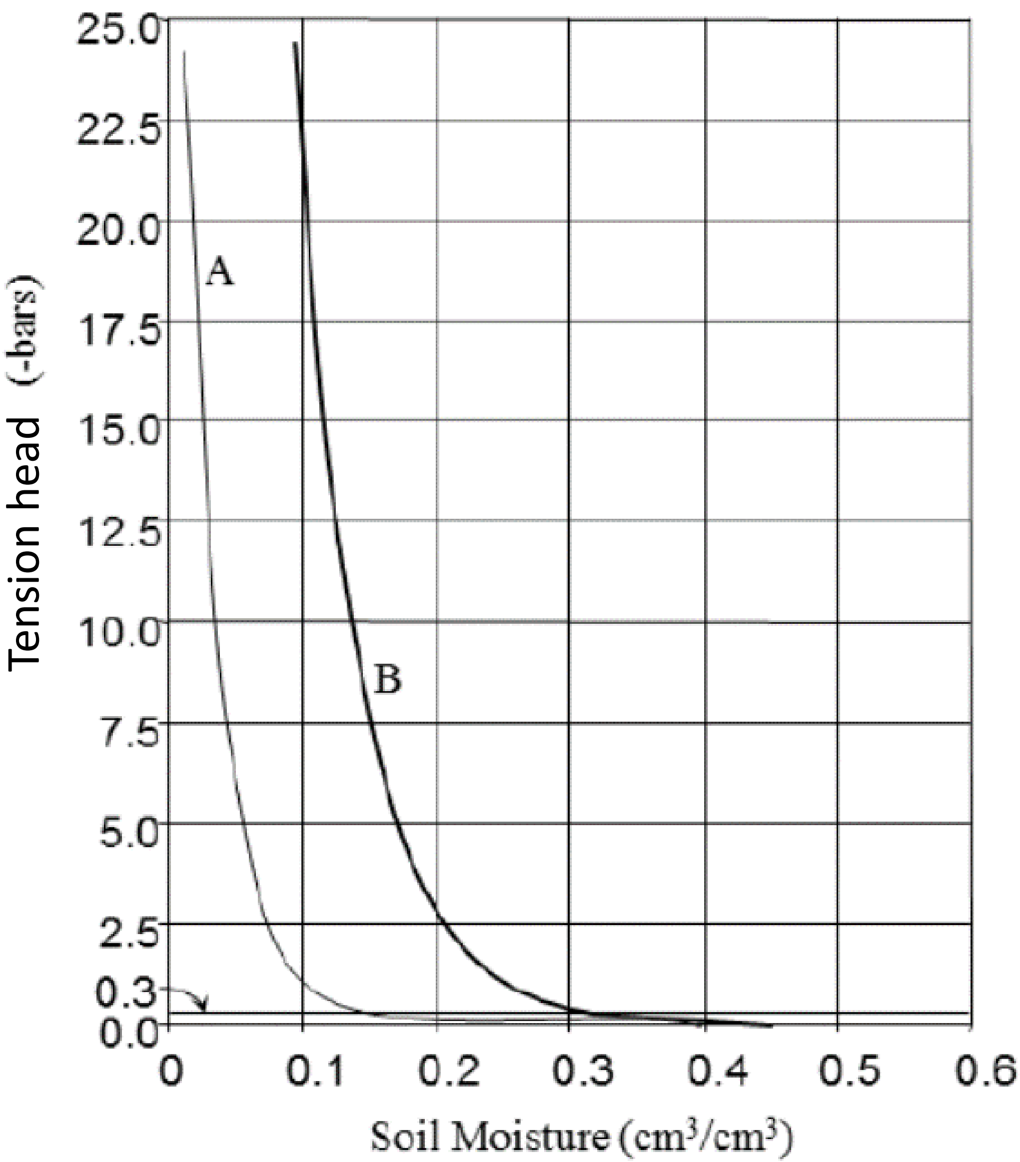
Tension and retention curves

Relationship between pressure/tension head and water content for a particular soil is its **moisture-characteristic curve**.



Tension and retention curves

Which soil (A or B) has greater available water?



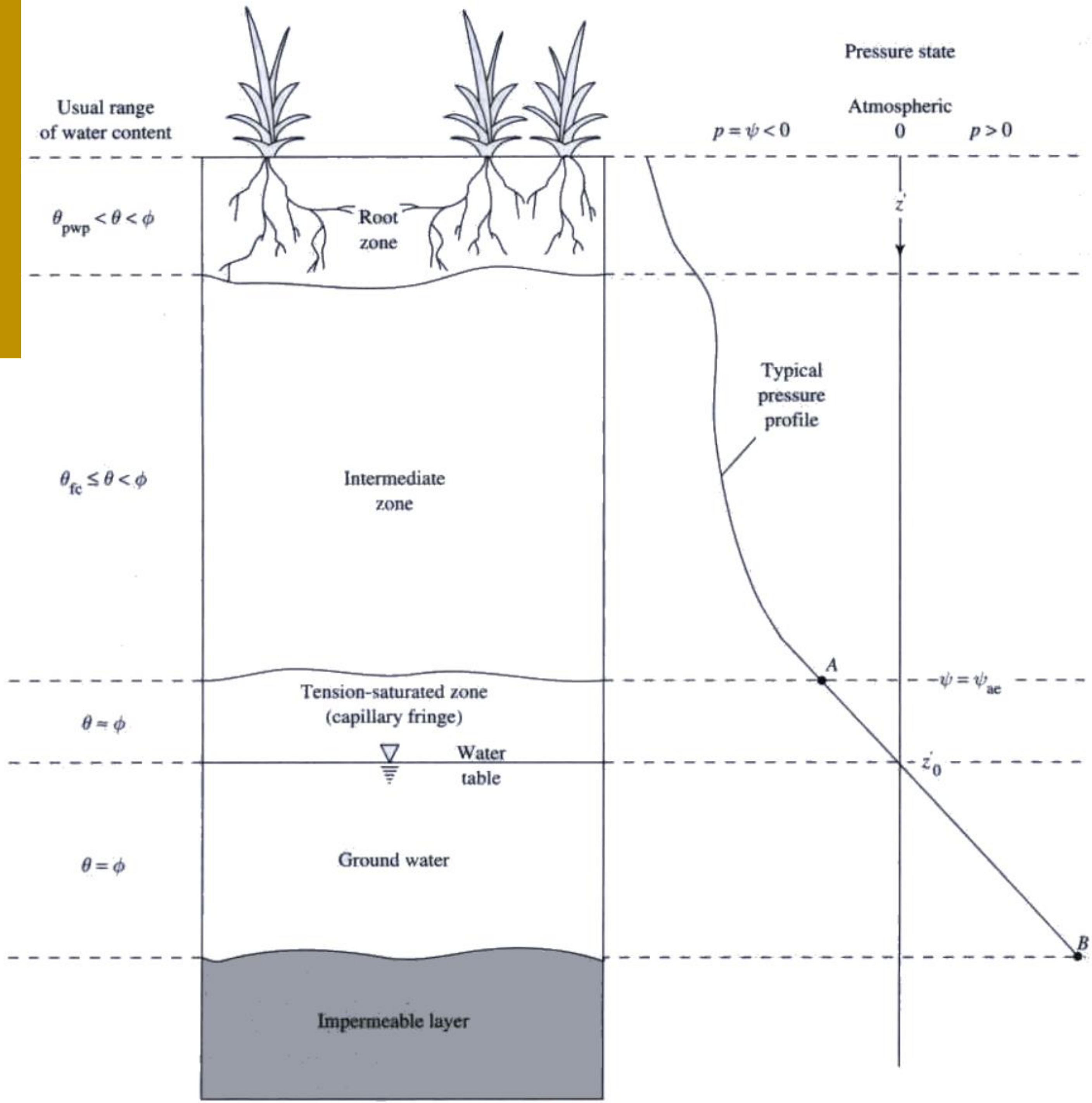
Scales for pressure/tension:

-80 kPa = -0.8 mbar = -800 cm

Field capacity = -330cm

Permanent wilting point = -15000cm

Idealized soil hydrologic horizons



Flow summary

Soil water will flow upwards when:

- the upward decrease in pressure head > gravitational potential energy (GPE) gradient (elevation head)

Soil water will flow downwards when:

- The upward decrease in pressure head < GPE gradient (elevation head)
- There is an upward increase in pressure head which works with the GPE gradient (elevation head)