2.2 Interfacial Tension and Wettability

Interfacial tension due to molecular attraction — different in two fluids

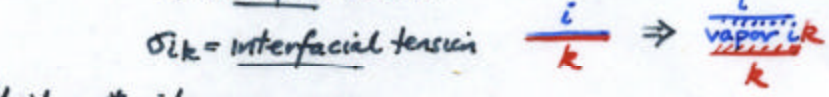
Interfacial tension, σ_{ik}, between two fluids i and k.

σ_{ik} is temperature dependent ∴ Capillary pressure = $f(T)$.

Dupré's formula $W_{ik} = \sigma_i + \sigma_k - \sigma_{ik}$ ⇒ work to separate into solutions i and k with vapor interface

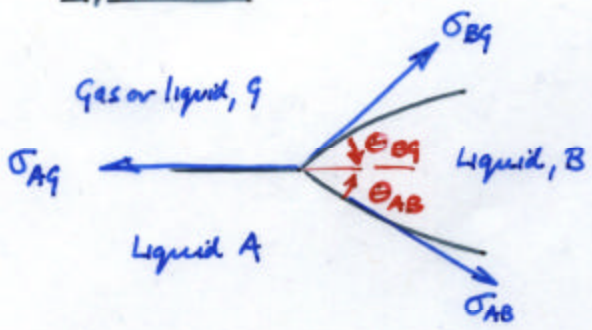
σ_i = surface tension

σ_{ik} = interfacial tension



σ_i = surface tension of fluid with its own vapor.

Equilibrium



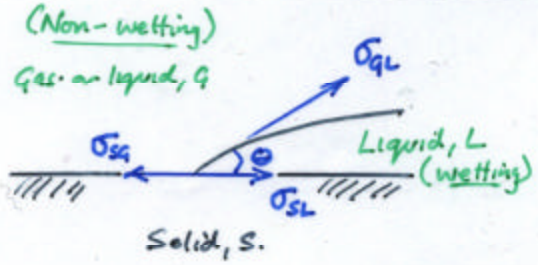
Equilibrium: $\sigma_{AG} = \sigma_{AB}\cos\theta_{AB} + \sigma_{BG}\cos\theta_{BG}$

Only satisfied if $\sigma_{AG} < (\sigma_{AB} + \sigma_{BG})$

∴ lense of B formed.

If $\sigma_{AG} > (\sigma_{AB} + \sigma_{BG})$

then B spreads between A and G.



By convention, θ measured in denser fluid

Equilibrium: $\sigma_{GL}\cos\theta = \sigma_{SG} - \sigma_{SL}$

$$\cos\theta = (\sigma_{SG} - \sigma_{SL})/\sigma_{GL}$$

∴ May determine interface angle for known σ (contact angle, θ).

— influenced by surface roughness.

If $(\sigma_{SG} - \sigma_{SL})/\sigma_{GL} > 1$ $\Rightarrow$ No equilibrium

Liquid flows over solid $\rightarrow$ wettability

Wettability Defined by θ

$\theta < 90°$ eg Fluid, L wets the solid; wetting fluid

$\theta > 90°$ eg Fluid G, is non wetting fluid

$\theta = 90°$ Zero adhesion tension since equal affinity.

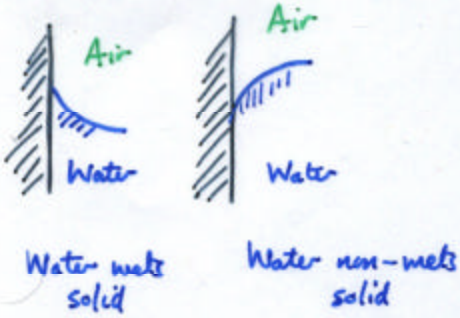
Wettability is controlled by: a) Chemical composition of fluids

eg. adding dopant

b) Sequence of wetting

eg. Advancing or receding.

∴ hysteresis – wetting or draining



Water wets solid

Water non-wets solid

Most geologic systems are water wet.

petroleum/water

air/water

NAPL/water

IMPORTANT ASPECTS OF WETTING

Water-Wet

a) Pendular rings @ grain contacts
   - no continuous water phase
   - except mono-molecular coating of H_2O

b) ↑ wetting phase saturation →
   - continuous water (wetting) phase
   - equilibrium saturation = when phase is continuous (wetting)

Implication: wetting phase may be removed.

c) Above critical saturation (equilibrium) funicular saturation
   - Now non-wet phase non-continuous.
   - Can only remove non-wetting phase if large pressure gradient to squeeze through pore throat.

Funicular saturation critical in remediation!

Remediation @ residual saturations: Grains

Important since difficult to remove last few % of saturation.

Pools

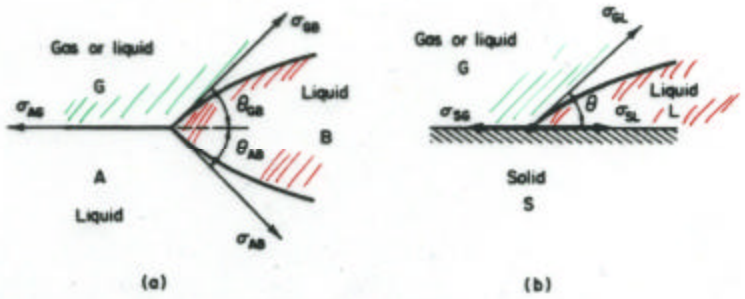


FIG. 9.2.1. Interfacial tensions.

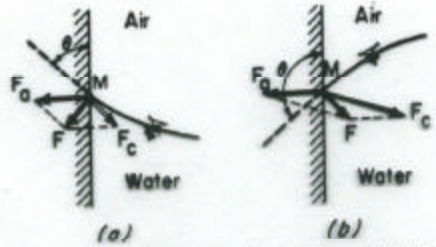


FIG. 9.2.2. Contact angle between a water-air interface and a solid. (a) Water wetting the solid. (b) Water nonwetting the solid.

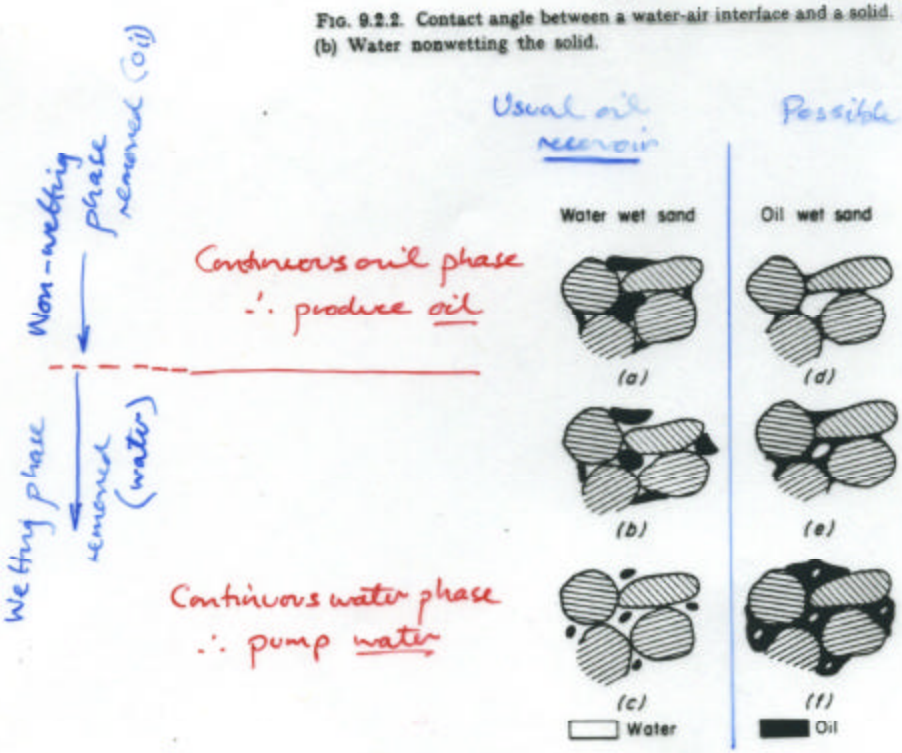


FIG. 9.2.3. Possible fluid saturation states.