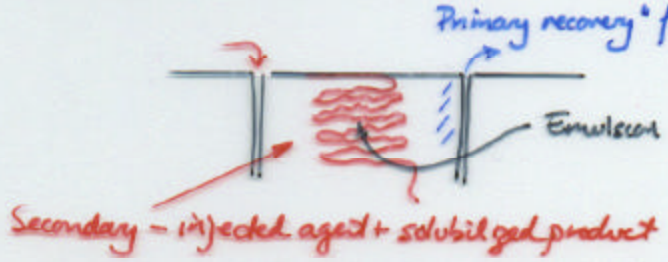
4. SOIL WASHING PROCESSES

Fluid – fluid displacement { Water / Alkalis / Surfactants / Co-solvents } ← { Physical displ. (reducing surface tension) / Solubility changes.

Effectiveness controlled by { Phase equilibria / Hydrodynamics eg. Heterogeneity / fluid props. / aquifer geometry

Two forms of recovery



Isotropic media

Front stability

controlled by • Mobility ratio, $M = \frac{V_w}{V_{nw}} = \frac{\mu_{nw} k_w}{\mu_w k_{nw}}$ — $M<1$ good !!

• Gravity number, $N_g = \frac{N_B}{N_c} = \frac{\text{gravity forces}}{\text{viscous forces}}$ { Indicates gravity over-ride potential / Defines slope of advancing fluid front.

Bond No. $= N_B = \frac{(\rho_{nw} - \rho_w) g k}{\sigma_{nw}} \doteq \frac{\text{buoyancy forces}}{\text{interfacial forces}}$ (vertical direction)

Capillary No. $= N_c = \frac{\mu_w v_w}{\sigma_{nw}} \doteq \frac{\text{viscous forces}}{\text{interfacial forces}}$ (horizontal direction).

Heterogeneous media complicate this issue.

Alkali: Enhance NAPL removal by "saponifying" the organic acids and produce natural surfactants → ↓ σ

Cosolvents: Creates plug of single phase water – cosolvent – DNAPL to move without surface tension effects

Surfactants: Reduce σ_{nw}

All EOR methods → not significant recovery.