FLOW OF IMMISCIBLE FLUIDS

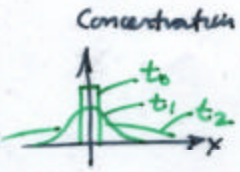
Bear, J., Dynamics of Fluids in Porous Media, Chapter 9., 1988.

1. Types of Fluid Flows:

Miscible displacement: Two fluids completely soluble

No interface ∴ no interfacial tension

Hydrodynamic dispersion / diffusion



eg. NaCl, Ca

Immiscible displacement: Simultaneous flow of two fluids

Capillary pressure difference. eg. Air-water

Oil-water (gas)

Some mixing at interface is possible but likely small.

2. Interfacial Tension and Capillary Pressure:

2.1 Saturation and Fluid Content:

$$S_\alpha = \frac{\text{volume of fluid } \alpha \text{ within REV}}{\text{volume of voids within REV}} \; ; \; \sum_\alpha S_\alpha = 1$$

$$S = V_f / V_V$$

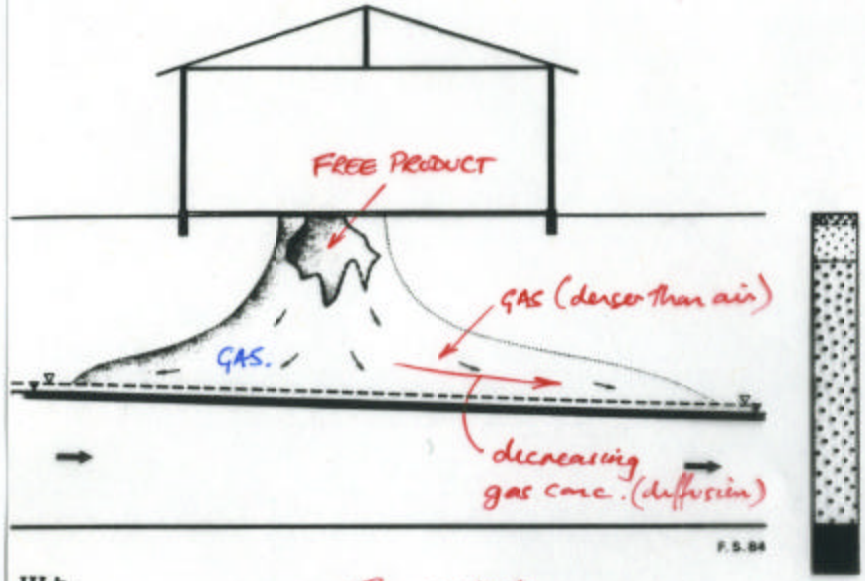
Unsaturated flow; volumetric moisture content, θ : $\theta = \frac{\text{vol. water in REV}}{\text{bulk vol. of REV}} \neq 1$

$$\theta = V_w / V_T \; ; \; V_T = V_V + V_s$$

Note that moisture content in soil mechanics is by weight, not volume. i.e.

$$m/c = \frac{W_w}{W_s}$$

III.a.



III.b.

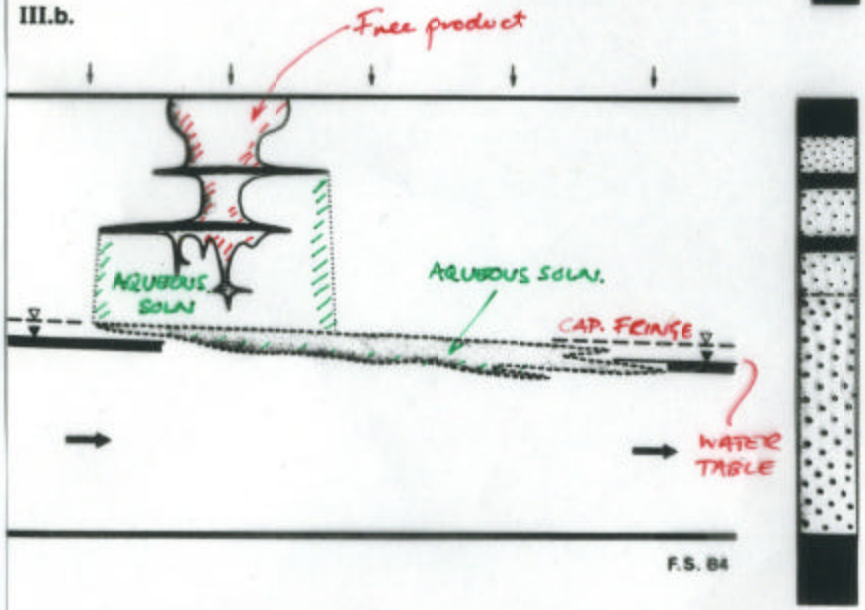


Figure III.a. Schematic of a small spill in a permeable unsaturated zone with a resulting mound of CHC gas. Concentration decreases with distance from spill. Grainsize shown at right.

Figure III.b. Larger spill than in III.a., but still not large enough to exceed the retention capacity of the unsaturated zone; no liquid CHC reaches the

XVI.a.

XVI.b.

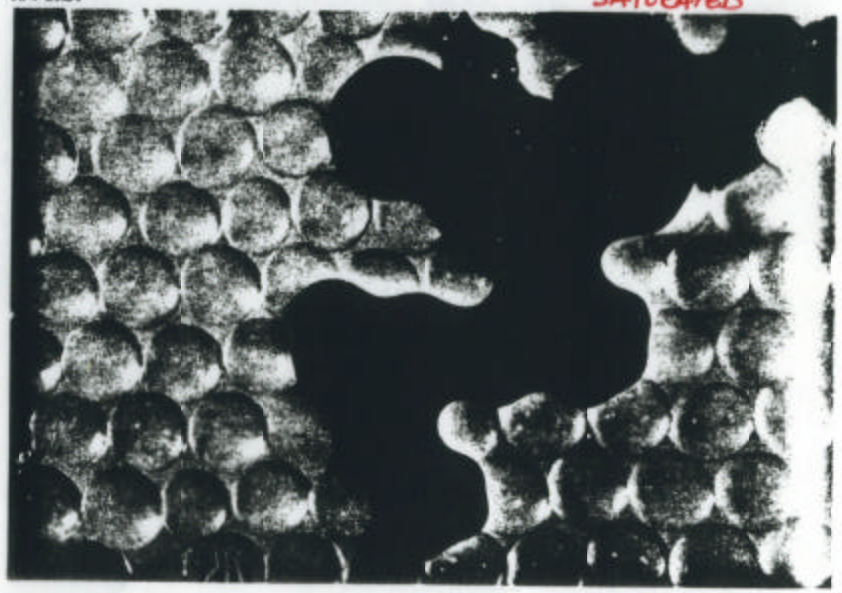


Figure XVI.a. Beads initially moist; diameter range = 0.85 – 1.23 mm. PER then dripped in from above. The PER accumulated as a sheath around a zone of high water content.

Figure XVI.b. Beads initially saturated with water; diameter range = 0.49 – 0.70 mm. PER then applied from above. When the flow of PER was discontinued, the front portion of the PER stream broke off and halted

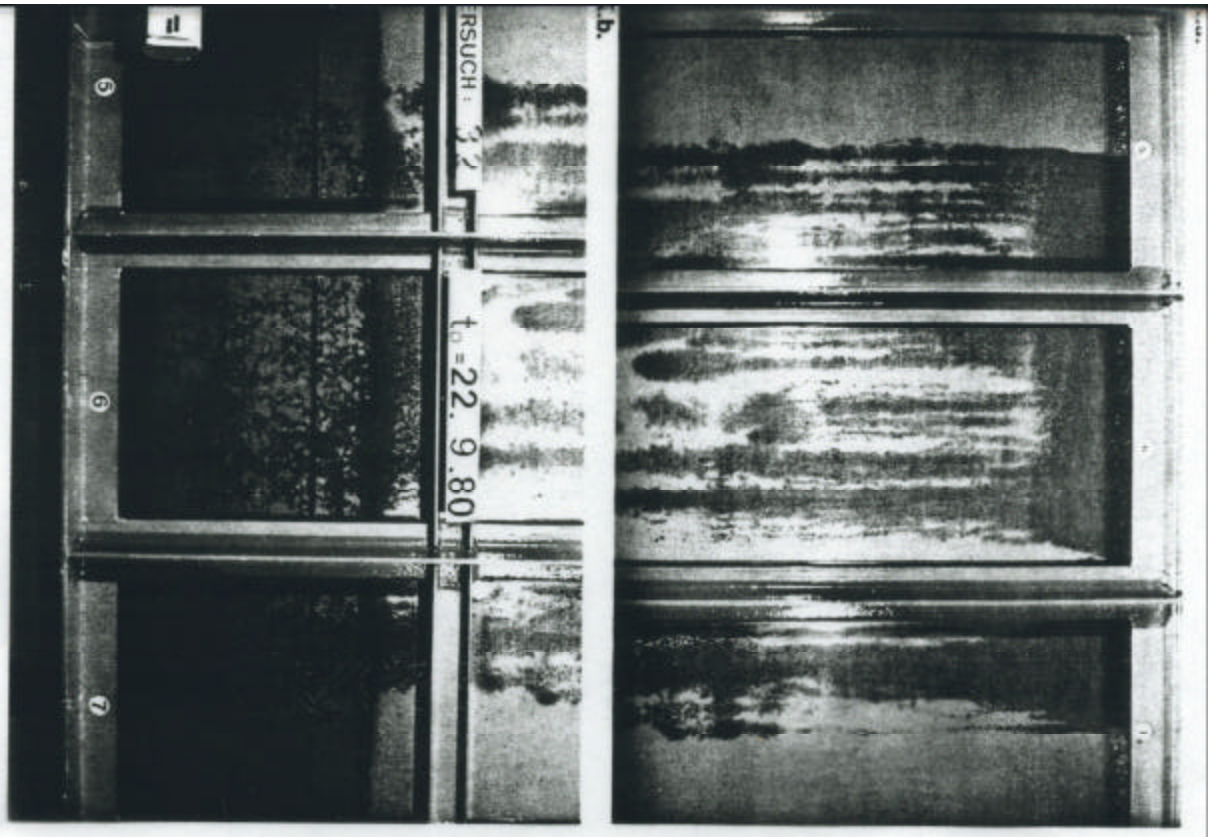


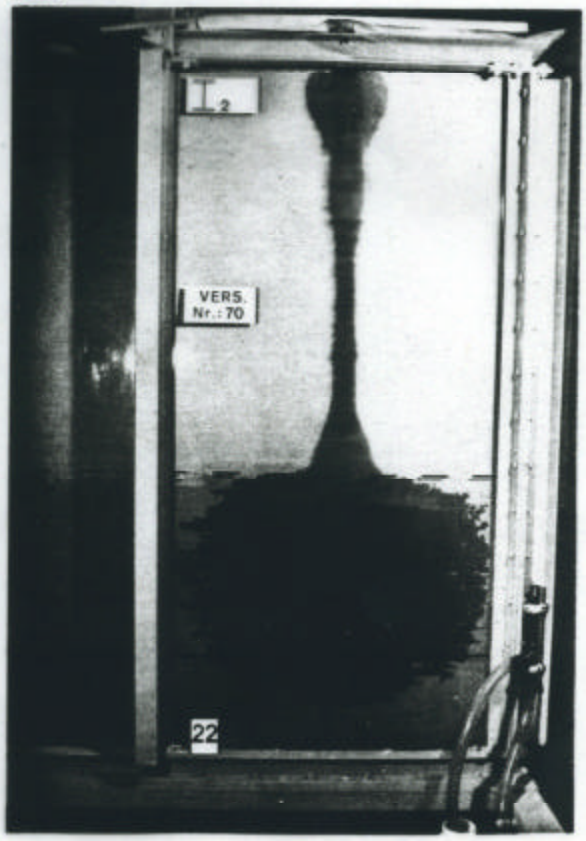
Figure X.a. Sheet-like spill of 36.3 L of PER. View of spill above the capillary fringe.

Figure X.b. Sheet-like spill of 36.3 L of PER. View of spill below the capillary fringe. Time = ~10 min.

XI.a. AFTER 1 HOUR

re XI.a.
of PER. Kinematic
sity = 0.54 mm²/s.
: = ~1 h.

XI.b.



re XI.b.
of PER. Later
: of spill depicted in
re XI.a. Kinematic
sity = 0.54 mm²/s.