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Pressure head distribution during unstable flow in relation to the formation and dissipation of fingers

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Abstract. Wetting front instability creates a shallow induction zone from which fingers emerge that rapidly transport water and solutes downwards. How the induction zone affects finger location and spacing is unknown. In the moist subsoil, fingers may well dissipate because the finger tips no longer have to overcome the water entry value. Both flow regions were investigated in a two-dimensional chamber with a fine-over-coarse glass bead porous medium. A capillary fringe was created by upward wetting through capillary rise. Upon ponding with dye-coloured water, fingers emerged, propagated downward and diverged when reaching the capillary fringe. Microtensiometers were installed in the induction zone, the fingers, and in the capillary fringe. In the induction zone, a lateral sinusoidal pressure head developed within minutes. Only in one of two experiments could the observed pressure head pattern be satisfactorily reproduced by a steady-state model assuming uniform induction zone properties and uniform infiltration. Later, fingers emerged below the pressure head minima. The induction zone did not affect finger properties. The pressure head in the induction zone was determined by the depth of the finger tips. The water requirement of the fingers dictated the lateral pressure head gradients. The pressure heads in the capillary fringe supported the hypothesis that the flow stabilised and dissipated there.

Keywords: fingered flow, wetting front instability, unsaturated flow, microtensiometers, induction zone, capillary fringe

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