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Unstable fingered flow during infiltration in homogenous sands

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Fingered flow is an instability that occurs during infiltration into initially dry porous media. We study the dynamics of such fingers in a Hele-Shaw cell ($160\times60\times0.3$ cm) with a shallow fine-textured layer on top of a homogenous coarse-textured layer for different flow rates. The key to understanding fingered flow are rapid high-resolution measurements of the water saturation. These measurements are obtained from light transmission images (recorded with a digital camera) that have been calibrated by X-ray absorption where the relation between transmission and saturation is nonlinear. After fingers had fully developed, we added a dye tracer to the flow in order to distinguish mobile and immobile water fractions. Many pressure sensors are installed over the cell to monitor the potential energy of the water. We corroborated some well-known facts: (i) Fully developed fingers consist of a high saturated tip, a core with mobile water and a hull with immobile water fringe. (ii) Once a finger is developed, the saturation profile along its core is invariant as the tip progresses. (iii) The width of a finger increases slowly but steadily for a long time. We gained some further insights: (i) When two fingers are present, the velocity of their tips are in general not constant and they are anti-correlated. (ii) Pressure drops in the overlaying fine-textured layer upon initialization of a new finger.