# MEASURING PORE WATER VELOCITIES AND DYNAMIC CONTACT ANGLES AT UNSTABLE WETTING FRONTS- SUPPLEMENTAL VIDEO FILES

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Abstract

The imbibition of fluids in porous media has been studied widely. Still, processes of preferential flow under gravity due to instability at the wetting front, crucial in groundwater contamination, have yet to be fully understood. Recent theories using dynamic contact angles could describe unstable flow phenomena but have not been proven experimentally. Therefore, infiltration experiments in small sand-filled chambers were conducted to explore the effect of dynamic contact angles. A high-speed camera recorded pore invasion at the unstable imbibition liquid front. Since water moves in a plain in the 2-D finger experiment, the camera can be used to measure the velocity of water. However, the hydrophobic front and back walls possibly altered the flow dynamics. Therefore, these two additional 3-D experiment runs (Run III and IV) were performed to compare the wetting front advancement characteristics in 2-D and 3-D. Specifically, we investigated in 3-D whether the wetting front is

discontinuous and water advances one pore at a time, which are the required conditions for the Hofmann-Baver equation.

Experimental setup

A 4 mm thick layer of unwashed 20/30 sand (Unmin Corporation, Ottawa, MN), with grain size 0.6-0.8 mm, was packed in a transparent flow cell without a front plate that was 50 mm long and 18 mm wide. The cell was placed at a 30-degree angle, the maximum possible incline, without the sand spilling out. Water with 1 mg of brilliant blue/liter with a syringe pump (KD Scientific Inc., Model 101) at a rate of 15 µl/min was added to the flow cell to form the finger. The high-speed camera, a grayscale-sensitive Photron Nova S6-800, was placed above the cell, pointing down at a 60-degree angle. During the experiment, the camera captured 21821 images at 500 fps, resulting in a video length of 43.642 seconds. The camera resolution was 1024 by 1024 pixels. The cell and camera setup are presented in Figure 1. Background lighting consisted of a 40W LED lighting array (SP-E-365D LED Light, Genaray USA). The resolution in Run III was 0.009 mm/pixel, and in Run IV, 0.0201 mm/pixel.

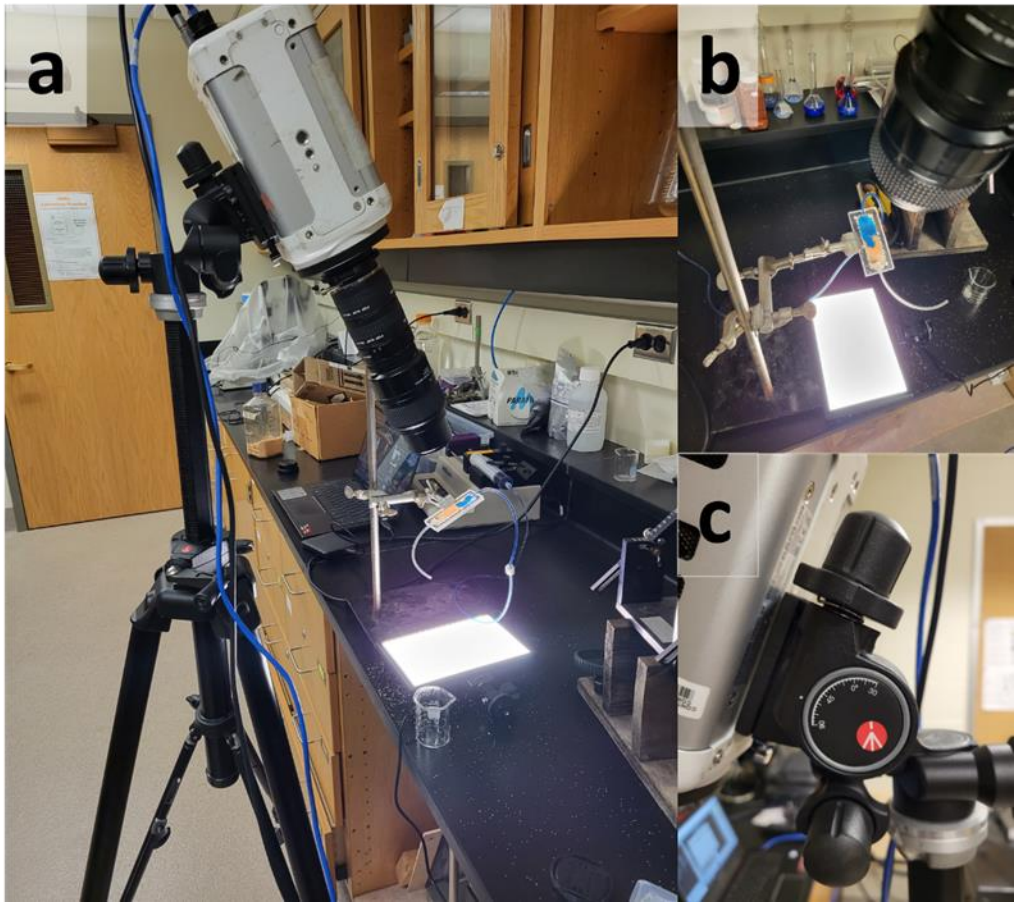


*Figure 1, experimental setup for the wide cell experiment with (a) a wide view of the setup including the camera, the cell, the backlight, and the pump at the back, (b) a close-up of the cell mid-experiment, and (c): the angle of the camera orientation*