Impact of gravity on pore-scale steady state flow patterns

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We present experiments with two-phase steady state flow in a quasi-two-dimensional porous medium, where we investigate the impact of driving forces on the near pore-scale flow patterns. The porous medium is rigid, and is prepared by making a confined monolayer of ~1 mm glass beads in an 80 cm long and 40 cm wide Hele-Shaw cell. The fluids, air and a viscous glycerol-water solution (85 % - 15 % by weight), are injected simultaneously with a constant flow rate at the inlet, while they are free to leave the cell at atmospheric pressure at the outlet. The available total flow rates of the setup are in the range from 0.009 to 9 mL/min. Furthermore, the flow cell can be tilted such that it makes an angle θ between the horizontal plane and the inlet/outlet flow direction. This enables the control of a second driving force, a gravitational field that goes as $\boldsymbol{g}\sin(\theta)$ where $\boldsymbol{g}$ = 9.81 m/s^2 opposite to the flow direction. The flow rate and tilting angle are systematically varied in a series of experiments to explore the impact of the imposed conditions. At regular intervals during the experiments, we capture high resolution images from a top-down view of the cell, and record the pore pressure at strategic locations. The experiments are then analyzed by image processing techniques to digitize the flow patterns over time. The image data together with the pressure data yield detailed pore level information about the spatial configuration and mechanics of the two fluids over time. We present characterizations of the evolution and statistics of the flow patterns for the different imposed conditions.