INVASION PATTERNS DURING TWO-PHASE FLOW IN DEFORMABLE POROUS MEDIA

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Key words Porous media, Two-phase flow, Fracturing, Viscous fingering, Deformation

We will present our experimental study of the viscous fingering and fracturing patterns that occur when air at constant overpressure invades a circular Hele-Shaw cell containing a liquid-saturated deformable porous medium [1] – i.e. during the flow of two non-miscible fluids in a confined granular medium at high enough rate to deform it. The resulting patterns are characterized in terms of growth rate, average finger thickness as function of radius and time, and fractal properties. Based on experiments with various injection pressures, we identify and compare typical pattern characteristics when there is no deformation, compaction, and/or decompaction of the porous medium. This is achieved by preparing monolayers of glass beads in cells with various boundary conditions, ranging from a rigid disordered porous medium to a deformable granular medium with either a semi-permeable or a free outer boundary. We show that the patterns formed have characteristic features depending on the boundary conditions. For example, the average finger thickness is found to be constant with radius in the non-deformable system, while in the deformable ones there is a larger initial thickness decreasing to the non-deformable value. Then, depending on whether the outer boundary is semi-permeable or free there is a further decrease or increase in the average finger thickness. When estimated from the flow patterns, the box-counting fractal dimensions $D_b = 1.59 \pm 0.06$ are not found to change significantly with boundary conditions, but by using a method to locally estimate fractal dimensions, we see a transition in behavior with radius for patterns in deformable systems; In the deformable system with a free boundary, it seems to be a transition in universality class as the local fractal dimensions decrease towards the outer rim, where fingers are opening up like fractures in a paste. In addition, we show a collapse of mass N plotted as function of radius r for the patterns at different snapshots, when normalized by obtained power laws with time $N(t) \propto t^{\alpha}$ and $r(t) \propto t^{\beta}$.

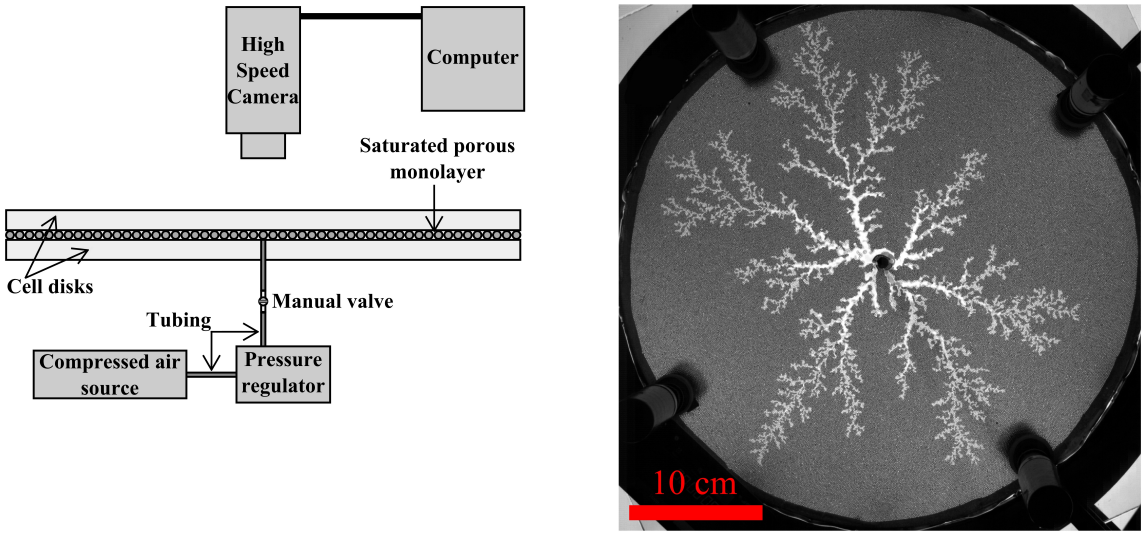

Figure 1. Sketch of our experimental setup seen from the side (left), and a top-down image at the breakthrough time of an experiment (right). During the experiment, air invades the saturated porous medium from the center, forms viscous fingers and induces deformations in the surrounding medium.

References

[1] Eriksen F.K., Toussaint R., Måløy K.J. and Flekkøy E.G. (2015), *Invasion patterns during two-phase flowin deformable porous media*, Front. Phys. 3:81. doi: 10.3389/fphy.2015.00081