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Three-phase fracturing in granular material

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There exist numerous geo-engineering scenarios involving the invasion of a gas into a water-saturated porous medium: in fracking, this may occur during the fracking process itself or during subsequent gas penetration into propant beds; the process is also at the heart of carbon dioxide sequestration.

We use a bed of water-saturated glass beads confined within a Hele-Shaw cell as a model system to illuminate these processes. Depending on packing density, injection rate and other factors, air injected into this system may invade in a broad variety of patterns, including viscous fingering, capillary invasion, bubble formation and fracturing. Here we focus primarily on the latter case.

Fracturing is observed when air is injected into a loosely packed bed of unconsolidated granular material. Our approach allows us to image the complete fracture pattern as it forms, and as such to study both the topographical properties of the resulting pattern (fracture density, braching frequency etc) and the dynamics of its growth.

We present an overview of the fracturing phenomenon within the context of pattern formation in granular fluids as a whole. We discuss how fracturing arises from an interplay between frictional, capillary and viscous forces, and demonstrate the influence of various parameters on the result.