PNEUMATIC FRACTURES IN CONFINED GRANULAR MEDIA

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We will present our ongoing study of the patterns formed when air flows into a dry, non-cohesive porous medium confined in a horizontal Hele-Shaw cell. This is an optically transparent system consisting of two glass plates separated by 0.5 to 1 mm, containing a packing of dry 80 micron beads in between. The cell is rectangular and has an air-permeable boundary (blocking beads) at one short edge, while the other three edges are completely sealed. The granular medium is loosely packed against the semi-permeable boundary and fills about 80 % of the cell volume. This leaves an empty region at the sealed side, where an inlet allows us to set and maintain the air at a constant overpressure (0.1 - 2 bar). For the air trapped inside the cell to relax its overpressure it has to move through the deformable granular medium. Depending on the applied overpressure and initial density of the medium, we observe a range of different behaviors such as seepage through the pore-network with or without an initial compaction of the solid, formation of low density bubbles with rearrangement of particles, granular fingering/fracturing, and erosion inside formed channels/fractures. The experiments are recorded with a high-speed camera at a framerate of 1000 images/s and a resolution of 1024×1024 pixels. We use various image processing techniques to characterize the evolution of the air invasion patterns and the deformations in the surrounding material. The experiments are similar to deformation processes in porous media which are driven by pore fluid overpressure, such as mud volcanoes and hydraulic or pneumatic (gas-induced) fracturing, and the motivation is to increase the understanding of such processes by optical observations. In addition, this setup is an experimental version of the numerical models analyzed by Niebling et al. [1, 2], and is useful for comparison with their results. In a directly related project [3], acoustic emissions from the cell plate are recorded during experiments, where we aim to localize acoustic events and correlate them with the optical observations.

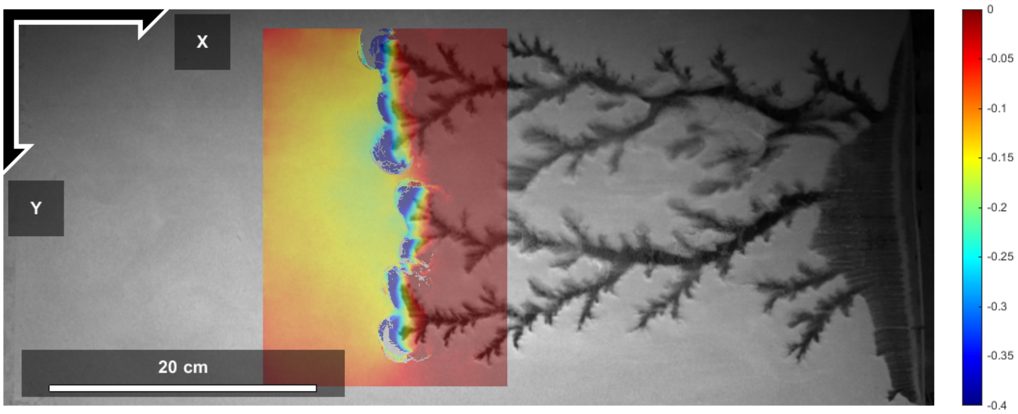

Figure 1. Air invades the granular medium from right to left forming granular fingering channels. One of the techniques we use is digital image correlation to analyze particle displacements. In this example, the color map shows x-component displacements in cm, outside fingers on a 100 ms interval

References

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