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Aerofractures in Confined Granular Media

Fredrik K. Eriksen (1,2), Semih Turkaya (1), Renaud Toussaint (1), Knut J. Måløy (2), and Eirik G. Flekkøy (2)
(1) IPGS CNRS UMR7516, University of Strasbourg, Strasbourg, France (eriksen@unistra.fr), (2) Department of Physics, University of Oslo, Oslo, Norway

We will present the optical analysis of experimental aerofractures in confined granular media. The study of this generic process may have applications in industries involving hydraulic fracturing of tight rocks, safe construction of dams, tunnels and mines, and in earth science where phenomena such as mud volcanoes and sand injectites are results of subsurface sediment displacements driven by fluid overpressure. It is also interesting to increase the understanding the flow instability itself, and how the fluid flow impacts the solid surrounding fractures and in the rest of the sample. Such processes where previously studied numerically [Niebling 2012a, Niebling 2012b] or in circular geometries. We will here explore experimentally linear geometries.

We study the fracturing patterns that form when air flows into a dense, non-cohesive porous medium confined in a Hele-Shaw cell - i.e. into a packing of dry 80 micron beads placed between two glass plates separated by $\sim$1mm. The cell is rectangular and fitted with a semi-permeable boundary to the atmosphere - blocking beads but not air - on one short edge, while the other three edges are impermeable. The porous medium is packed inside the cell between the semi-permeable boundary and an empty volume at the sealed side where the air pressure can be set and kept at a constant overpressure (1-2bar). Thus, for the air trapped inside the cell to release the overpressure it has to move through the solid. At high enough overpressures the air flow deforms the solid and increase permeability in some regions along the air-solid interface, which results in unstable flow and aerofracturing. Aerofractures are thought to be an analogue to hydrofractures, and an advantage of performing aerofracturing experiments in a Hele-Shaw cell is that the fracturing process can easily be observed in the lab. Our experiments are recorded with a high speed camera with a framerate of 1000 frames per second. In the analysis, by using various image processing techniques, we segment out and study the aerofractures over time looking at growth dynamics, fractal dimension and characteristics such as average finger thickness as function of depth into the solid. Also, by performing image correlation on two subsequent frames we estimate displacement fields and investigate the surrounding stress and strain fields in the solid around the fractures. Several experiments are performed with various overpressures and packing densities, and we compare the results. In a directly related project, acoustic emissions are recorded on a cell plate during experiments, and one of our goals is to correlate acoustic events and observations.
We will also compare the dependence of the patterns on the saturation of the initial deformable porous material, by comparing experiments performed by air injection in air saturated granular media, to some in liquid saturated granular media.

References:
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