Geophysical Research Abstracts
Vol. 16, EGU2014-12044-1, 2014
EGU General Assembly 2014

Optical Analyses of Flow in and Transformation of Deformable Porous Media

Fredrik Kvalheim Eriksen (1,2), Renaud Toussaint (1), Knut Jørgen Måløy (2), Semih Turkaya (1), and Eirik Flekkøy (2)

(1) Institut de Physique du Globe de Strasbourg, CNRS / University of Strasbourg, 5 rue René Descartes, 67084 Strasbourg Cedex, France (eriksen@unistra.fr), (2) Department of Physics, University of Oslo, P. O. Box 1048 Blindern, 0316 Oslo, Norway

ABSTRACT. This study focuses on the characterization of fluid flow through transforming porous media and the simultaneous transformation of the porous media itself. The motivation is to investigate how fluid flow and deformation of the porous media influence each other, which are complex feedback processes. As a source of data, we have performed controlled experiments of air injection into deformable porous media samples created in the lab. The samples are transparent, horizontal and quasi 2-dimensional, enabling us to visually observe fluid flow through a slice of deformable porous media. The experiments are recorded from above with a digital high-speed camera, providing the raw-data as image sequences with high framerates (250 - 1000 images/s).
Analyses on the fluid flow are based on the spatial properties of the observed flow patterns. The spatial properties are derived digitally after the raw-images are transformed into binary images of the flow patterns. Analyses on the transformation of the porous media are based on the frame-to-frame displacement fields of the particles. Such displacement fields are obtained by evaluating a sequence of raw images with a Particle Image Velocimetry software. We aim to show connections between flow observations and porous media observations.

Two different kinds of experiments are analyzed. The first is two-phase flow in deformable porous media, and the other is aerofracturing in dry, fine-grained granular packings.
The samples for the two-phase flow experiments are created in a circular Hele-Shaw cell with the inlet in the center and the outlet along its rim. Inside the cell, glass beads form a monolayer of deformable porous media saturated with a viscous glycerol-water solution. During an experiment, air is injected into the center of the sample with a constant overpressure, which will force the air to drain the sample radially outwards. This two-phase flow is an unstable event creating fingering patterns of air, while at the same time, flow of fluids deform the porous media and modifies the porosity. Two border conditions of this experiment are used, the first one is with a semi-permeable rim allowing fluids through but blocks beads, and the second one is with an open perimeter for both fluids and beads.
The samples for the aerofracture experiments are created in a rectangular Hele-Shaw cell with the inlet at one of the short edges and the outlet at the opposing edge. Three edges are sealed, while the outlet edge is allowing air to escape but not beads. A packing of fine grained beads occupies about 70-80% of the cell, leaving an empty volume at the injection side. The air-solid interface inside the cell is parallel to the outlet edge and represents a solid surface. During an experiment, the injection region is pressurized and kept at a constant overpressure. The only way to relax the overpressure is for the air to flow through the fine-grained packing. When the pressure is high enough, flowing air will open channels through the solid surface. The airflow into the channels becomes unstable, and fractures emerge. The fracturing in turn compacts the surrounding material, affecting porosity and further fracture growth.
In addition, acoustic emissions from the fracturing processes are captured for analyses in a related study, and we aim to relate visual observations to acoustic events.