Experimental investigation of Horizontal Redistribution of Two Fluid Phases in a Porous Medium

Project number: GQ11
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Models for (two-phase) flow through a porous medium are generally constructed from balance equations and constitutive relations. Although these models prove valuable they mostly lack the presence and influences of interfaces between the phases. Hassanizadeh and Niessner (2009) have constructed a horizontal redistribution model that includes interfacial area. This model was constructed using a similarity solution as introduced by Philip in 1991.

The aim of this research is to obtain experimental data on horizontal moisture redistribution in a two-phase flow system and to compare this data to mathematical models. The experimental setup consists of a Plexiglas flume (dimensions: 200 x 4 x 2.5 cm) that is placed within a metal construction (see figure 1). This metal construction holds a movable radioactive Cesium-137 source, which is used to measure the saturation within the flume. Pressure transducers are connected to the bottom of the flume to acquire either water pressure (wetting phase) or air pressure (nonwetting phase).

![Figure 9, experimental setup. The yellow hemisphere holds the radioactive source, while the pressure transducers are visible left of the flume.](image)

The flume is divided in two parts by a thin metal plate. The two parts are filled with sand with 0.8 and 0.2 saturations respectively. Once the metal plate is removed the dryer sand will imbibe and the wetter sand will drain. This process is made visible by directing gamma radiation through the flume, and recording the intensity at a detector, opposite to the source. Mass absorbs part of the radiation, so an increase in saturation will result in a decrease in intensity at the detector. Figure 2 shows two graphs of such saturation distribution over time, one at the wet side of the flume and one at the dry side respectively. It is clearly visible that
on the wet side of the flume less gamma radiation absorption takes place, thus moisture is draining, while the dry part of the flume is imbibing.

My part of this research consisted mostly of getting the system working and running. Tim Feuring will continue the experimental work where I have left off. Eventually it is desirable to have clear pressure and saturation data over time, where the system is according to models that include interfacial area to maintain a pressure gradient once the system reaches equilibrium. This can be an indication of the presence of interfacial forces within the system. Currently I am still working on this subject in Utrecht, so my thesis is not finished.

Figure 10, saturation data over time, plotted for two fixed points along the flume. The y-axis is expressed in mm Al, since a calibration was made using Al. Due to an error in the system this data is not converted to saturation.

References
