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?HYSICAL MODELLING OF LNAPL INFILTRATION IN A VARIABLY-SATURATED SAND

Terrance C. Neumann,[1] Arun J. Valsangkar,[2] Kerry T. B. MacQuarrie[2]

EXTENDED ABSTRACT

Numerical models have been developed by past researchers to simulate the migration of lighnonaqueous-phase liquids (LNAPL's) in porous media. The purpose of this research was to conduct physical experiments to provide quantitative data needed for validation of such numerical models.

The scenario modelled for this research was the infiltration of Soltrol-130 (LNAPL) into the vadose zone of a 30/50 silica sand. The physical modelling consisted of monitoring infiltration of LNAPL into a 1.2 m by 1.2m by 0.10 m tank filled with the sand. The sand tank was designed to represent a two-dimensional profile model. Water saturations and water and Soltrol-130 pressures were measured in the tank using resistivity probes and tensiometers, respectively. Physical properties such as capillary pressure-saturation curves, the soil saturation-resistivity relationship, and soil permeability were determined for the soil and fluids used.

A total of four experiments were conducted, with the LNAPL plume migration exhibiting similar behaviour for all experiments. An initially bulbous plume of 5 to 8 cm width formed in the upper vadose zone and progressed downward with little lateral spreading until increased water saturation was encountered at about 30 cm above the water table. The average downward velocity of the plume front before reaching the capillary fringe was approximately 2 cm/min. After about 40 min, the Soltrol compressed the capillary fringe and then migrated laterally forming a symmetrical lense and an LNAPL table at an average of 18.5 cm above the water table. After LNAPL infiltration ended, it reduced to residual saturation in the upper vadose zone and rebounded at the bottom of the lens as LNAPL mass redistributed laterally along the capillary fringe.

Generally there was little change in the water saturations at resistivity probes located in areas of the tank which remained near residual water saturation. Decreased water saturations were recorded at probes near the capillary fringe, where Soltrol accumulated as a lens, and also briefly at probes near the water table. After completion of each test, sand was excavated in lifts and samples were taken between resistivity probes and water contents were determined for the samples. The water saturations measured from the physical sampling were as much as 10% different (absolute difference) than the saturations determined from the resistivity probes. This difference is believed to be due to the radius of influence of the resistivity probes, which is probably less than the distance across the tank (10 cm). LNAPL saturations were not measured in sand samples.

Tensiometer response typically exhibited a sharp increased in pressure once the plume front came in contact with the tensiometer membrane, followed by more gradual pressure changes after cessation of Soltrol infiltration; however, the response of the tensiometers did not always correspond with the visually-observed time of arrival of the LNAPL front at the probe location.

The data obtained from these sand experiments, in conjunction with the capillary pressure-saturation data obtained for the soil and fluids used, should be sufficient to verify numerical models that describe two-phase flow.

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