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Tracing the entrapped air in heterogeneous soil by MRI

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Magnetic resonance imaging (MRI) was employed to study the process of infiltration in an undisturbed core of coarse sandy loam during the course of repeated ponded experiment (RPI), in which the first infiltration was conducted in a naturally dry sample and the second infiltration into a sample with a water content after gravitational drainage. The aim of the present study was to assess the change in distribution of entrapped air (residual gas phase) in the sample and its influence on steady state flow rates. The RPI experiment was conducted on an undisturbed sample of 8.9 cm diameter and 8.4 cm height. Pressure heads and flux measurements were performed concurrently with the MRI monitoring. Multiple-slice maps of longitudinal relaxivity (T1), which is a parameter related to surface-to-volume ratio and proton density (M0), related to the water content, covered almost the entire volume of the sample. Mapping was conducted during the four stages of the experiment: steady state flow of first (I1) and second (I2) infiltration and the equilibrium after drainage of sample (D1 and D2). During I1 and I2 highest values of M0 and T1 were detected in the upper 3 cm of the sample, which agreed well with findings of computer tomography showing lower sample density/higher porosity in this region. The flow rate drop, which was observed between I1 and I2, accompanied the decline of T1 and M0 in the upper 40 mm. The decrease in T1 indicates replacing of the water in large pores with trapped air, while lower M0 signifies a general decrease of water content in the affected regions.
Preliminary results from additional experiments where bubbles of the entrapped were imaged by optical microscopy in the same soil, supports the findings done by MRI. This work has been supported by Czech Science Foundation project no. 103/08/1552 and by Ministry of the Environment of the Czech Republic project No. SP/2e7/229/07.