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Neutron imaging study of wetting dynamics and residual air distribution in heterogeneous porous sample.

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The dynamics of water infiltration into soil have a strong influence on the subsequent distribution of air trapped inside pores. Simultaneously, the presence of entrapped air affects water flow in soil or other porous media. We present results of two infiltration experiments conducted on an artificially prepared, heterogeneous sample, under ponding and constant flux boundary conditions, with concurrent neutron imaging of the sample during the infiltration. A cylindrical sample was packed with two grades of sand and disks of fine porous ceramic in an axially symmetrical geometry. The configuration of the sample provided a number of interfaces between regions of higher and lower hydraulic conductivity. Infiltration was started in dry media in both the ponded and constant-flux experiments, and water could flow freely through the bottom of the sample once it was saturated. Water was applied onto the sample surface during the constant-flux experiment at about one order of magnitude lower than the minimum flux reached during the ponding experiment. Despite this low application rate, ponding eventually occurred on the top of the sample, due to an unexpectedly low infiltration rate and unchanged application rate. Neutron tomographic imaging revealed massive air entrapment in the coarse sand regions of the sample during slow infiltration under constant flux conditions. This could explain the observed slow rate of infiltration. In contrast, during the ponded infiltration experiment the air was mostly flushed out from the coarse sand regions by gravity-driven water flow due to greater hydraulic head. Neutron imaging shows that the capillary barrier effect, air entrapment, and entrapped air redistribution were responsible for the observed low infiltration capacity of the sample during the slow–infiltration–dominated constant flux experiment. Despite the fact that the sample internal geometry was artificially designed in these experiments, it is reasonable to assume that similar phenomena can occur in natural soils having highly heterogeneous structures. The examples of natural and technogenic soils. Comparison of the internal structure of the sample under study and selected natural and technogenic soils was done.