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Visualization and quantification of the entrapped air bubbles by neutron imaging

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Preferential flow in structured soils may be accompanied by a significant temporal variation of quasi saturated hydraulic conductivity. These effects, observed in number of experiments mainly on heterogeneous soil of Cambisol series, are sometimes attributed to a changing distribution of the entrapped air within the sample.

We have reproduced the variation of the quasi steady state flow during the constant head ponded infiltration experiment on the packed sample composed of three different grades of quartz sand, and visualized the water distribution during i) the initial stages of infiltration by neutron radiography and ii) during the steady state flow by neutron tomography. Provided that the hydraulic gradient is known, in the case of the experiment with ponding at the top and the seepage face at the bottom of the sample, the effective quasi-saturated (or satiated) hydraulic conductivity (K_{QS}) is known. Gradual decrease of the K_{QS} has been observed during first four hours of the infiltration event.

Series of neutron tomography images taken during the quasi-steady state stage have detected trapping of the air bubbles in coarser sand. Furthermore, the volume of a number of entrapped air bubbles increased during the infiltration event. The fraction of the entrapped air was calculated for a series of tomography images taken during each experiment. Similarly to previous experiments performed on natural Cambisols, experimental results support the hypothesis that the effect of the gradual K_{QS} decrease is caused by the entrapped air redistribution and the build-up of bubbles in preferential pathways. The trapped air thus restricts the preferential flow pathways and causes a lower hydraulic conductivity.