Contribution ID: **29** Type: **Poster**

Investigating the flow instabilities in soil by neutron imaging

Thursday, 15 September 2011 14:01 (2 minutes)

Instability of the quasi-steady flow unexpected by standard theory was detected in recurrent ponded infiltration experiment conducted on small undisturbed soil sample and was visualized by neutron imaging (NI). Series of NI tomography images taken during the first infiltration run showed air trapping in many of large pores and cavities in the sample. Furthermore, many of entrapped air bubbles increased in volume during the first infiltration run. Further entrapped air redistribution has been detected during the second infiltration run. The fraction of the NI visible entrapped air was calculated based on image segmentation. It was found that increase of volumetric fraction of entrapped air bubbles by only 0.005 was accompanied by decrease of quasi-saturated hydraulic conductivity to 50% of the initial value. The experimental results support the hypothesis that the effect of the gradual decrease of the flow rates is caused by entrapped air redistribution and gradual build-up of bubbles in preferential pathways. The air comes probably from the soil matrix where residual encapsulated air is being gradually replaced by water attracted to fine pores by capillary forces.

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Session Classification: Poster session I and lunch

Track Classification: Poster Session I (Thursday)