Effects of wetting and drying cycles on autochthonous colloid mobilization in undisturbed soils

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Modelling 2-phase flow in DFM models with a linear FEM node-centered FVM hybrid method and a new treatment of jump discontinuities of the transport variable

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A number of recent publications have shown that multiphase flow in fractured rock can be realistically simulated using hybrid methods combining, for instance, the linear finite-element (LFEM) with the finite-volume method (FVM) to solve the pressure and phase transport equations in an implicit / semi-implicit timestepping framework, respectively. By centering finite volumes on finite-element nodes in a barycentric tessellation, we have previously shown that the finite-volume geometry does not even need to be stored because the assembly can be performed in parametric space in conjunction with Jacobian transformation performed by FVM stencils we developed for all common element types. We have verified this FEMFVM method in 2 and 3D, and in 3D using lower dimensional representations of the fractures. However, its remaining weakness is that node-centered finite volumes extended across material boundaries. This does not pose a problem with flux calculations because each finite-volume sector flux is computed individually, but in situations where intersectorial transfer should lead to a jump discontinuity of the transport variable such as during capillary transfer between domains with distinct relative permeability models, this effect is suppressed. Here we overcome this problem by enriching finite volumes located along material boundaries with additional degrees of freedom determined by how many materials contribute to them. While their overall functionality is retained, our new method adds functionality required to compute sector-to-sector fluxes and to retain higher-order accuracy. These subgrid finite-volume computations receive additional support from newly implemented FEM features for the pressure computation on the enriched mesh and an implicit calculation of diffusive transfer processes across discontinuous interfaces.

The enriched FEMFVM offers the advantages of discontinuous Galerkin methods, but is continuous where continuum mechanics applies. This will be illustrated with DFM computations that simultaneously consider viscous and capillary forces.

Effects of wetting and drying cycles on autochthonous colloid mobilization in undisturbed soils

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Understanding colloid mobilization and transport in soils is a major concern for environmental protection and water resources management: They can act as vectors for sorbing pollutants, transporting them farther and faster through the vadose zone towards the water table than pollutants simply dissolved in water. Additionally, the existence of preferential flow paths in the soil is known to lead to an even faster breakthrough of the colloid-sorbed pollutants. Among the already identified factors favouring/disfavouring particle mobilization, one factor has received little attention: the influence of the irrigation pattern undergone during the soil history. As a first step toward the study of this factor in undisturbed soils, I'll present a column-scale systematic investigation of the effects of rain interruption duration (pauses) on autochthonous colloid mobilization occurring during a
subsequent rainfall event. I'll then show how a new conceptual model of colloid mobilization can help understanding the experimental data.

**Use of soil surfactants to reduce preferential and unstable flow in soils**

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Flow and transport processes in soils are affected by, among other things, the wettability of the soil and surface vegetation. Accumulation of naturally occurring hydrophobic compounds at the surface and in the shallow region of the vadose zone reduces wettability as affected areas of the vegetative cover and soil become water repellent. These water repellent areas disrupt water infiltration and flow causing runoff, unstable wetting fronts and the formation of preferential flow paths. Even very low levels of soil water repellency, subcritical water repellency, can result in non-uniform wetting of the rootzone region. Preferential and unstable water flow in managed crop systems leads to waste, increased requirement for irrigation, and increased risk of environmental contamination. Since the 1950’s it has been recognized that certain surfactants can be used to reduce water repellency and restore wettability to soils. By reducing the surface tension of water and the contact angle of the air-water-soil system, surfactants influence the flow of water into and through soils. In recent years, there has been an increase in new surfactant technologies and research investigating the effect of these soil surfactants not only on improving soil wettability but also on water flow in the vadose zone. Results indicate that use of soil surfactants can be an effective means to significantly reduce preferential and unstable flow in this region of the soil. The objective of this presentation is to review the research, conducted under various conditions, as a contribution to the discussion of management strategies for certain naturally occurring cases of preferential and unstable water flow in soils.

**On the combined evaporation and salt precipitation process**

**YS-Contest**

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Evaporation is a major process in the global water cycle. Literature on micro-scale evaporation mechanisms and the influence of the resulting salt precipitation within pores on the evaporation processes is limited. Moreover, the role of porous media heterogeneity and salt type on the combined evaporation-salt precipitation processes is poorly understood. This research focuses on salt deposition occurring inside matrix pores during the evaporation process and its effect on evaporation rates for heterogeneous matrices and various salt types. Two methods are used: (1) X-ray CT scanning to quantify salt deposition within pores; and (2) long-term monitoring of evaporation and salt deposition in soil columns with different scales of heterogeneities for various salts (NaCl, KCl, NaI, Na\(_2\)SO\(_4\) and CaSO\(_4\)).

High correlation was found between the salt molecular weight and crystal volume and its effect on the evaporation rates. The larger the crystal volume of the salt precipitated from the evaporating solution, the larger the effect on evaporation rates. For large volume salt crystals low evaporation rates were recorded and vice versa. Results from column experiments indicate that the evaporation rates from