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Effects of salinity on multiphase flow using open soil columns under evaporation conditions.

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Knowledge of processes in the unsatured zone is important for understanding the behaviour of pollutants in the soil; this is the case of saline contamination or sulphide oxidation in desiccating mine tailings. In both cases, evaporation causes high ionic strength solutions, which affects the activity of water and, hence, phase changes of water. Moreover, under very dry conditions, water vapour fluxes become the main water flux mechanism. These phenomena have been studied in the past using closed columns, which represent poorly the actual field conditions. Therefore, the objective of this work is to study solute transport under evaporation condition using open columns, so as to understand the role of ionic strength and vapour fluxes.

We have built the columns using two different materials: sand and silt. High ionic strength has been simulated using two different salts: halite (NaCl, initial concentrations of 7g/kg and 20g/kg) and epsomite ($MgSO_4 \cdot 7H_2O$, 14g/kg and 40g/kg). The columns were initially saturated with these minerals. Evaporation was generated using an infrared lamp and proceeded until the overall saturation arrived at 0.32.

The resulting evaporation rates and processes depend on the material, the salt and the initial concentration. Evaporation is highest for silt, halite and low concentration. At the end of the experiment, water content of silt columns increases slightly downwards. Concentration decreases sharply from brine values at the top to values below initial concentration at the lower half of the column. In contrast, sand columns display more complex patterns. Sand is virtually dry at the top portion. An evaporation front, char-

acterized by a sharp increase to field capacity water content, is observed beneath. Further down, water content increases slowly with a shape similar to the retention curve. As in the silt columns, concentration in sand columns reaches brine values at the top and markedly smaller values than the initial concentration at the bottom. However, concentration now displays a minimum just beneath the evaporation front.

These results point to the qualitative importance of water vapour flux not only upwards above the evaporation front, but also downwards beneath this front. It is the subsequent condensation, especially near the front in the case of sand columns, what causes dilution of the solution below initial values. A preliminary modelling of the experiments has been performed with the program RETRASO. Simulation of the observed results required modifying the standard retention and relative permeability functions. A new model for these functions has been developed on the basis of existing formulations (Rossi-Nimo) that can reproduce the behaviour of the soil from full saturation to oven-dry conditions. The proposed retention and relative permeability functions account for the fact that residual water can only be extracted from the soil by means of evaporation. An accurate prediction of the water distribution in the sample obtained with the new model is crucial for the simulation of the transport of the solutes.