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Mercury porosimetry for comparing piece-wise hydraulic properties with full range pore characteristics of soil aggregates and porous rocks

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Unsaturated hydraulic properties are essential in the modeling of water and solute movement in the vadose zone. Since standard hydraulic techniques are limited to specific moisture ranges, maybe affected by air entrapment, wettability problems, limitations due to water vapor pressure, and are depending on the initial saturation, the continuous maximal drying curves of the complete hydraulic functions can mostly not reflect the basic pore size distribution. The aim of this work was to compare the water retention curves of soil aggregates and porous rocks with their porosity characteristics. Soil aggregates of Haplic Luvisols from Loess L (Hneveceves, Czech Republic) and glacial Till T (Holzendorf, Germany) and two lithotypes of porous rock C (Canosa) and M (Massafra), Italy, were analyzed using, suction table, evaporation, psychrometry methods, and the adopted Quasi-Steady Centrifuge method for determination of unsaturated hydraulic conductivity.

These various water-based techniques were applied to determine the piece-wise retention and the unsaturated hydraulic conductivity functions in the range of pore water saturations. The pore-size distribution was determined with the mercury intrusion porosimetry (MIP). MIP results allowed assessing the volumetric mercury content at applied pressures up to 420000 kPa. Greater intrusion and porosity values were found for the porous rocks than for the soil aggregates. Except for the aggregate samples from glacial till, maximum liquid contents were always smaller than porosity. Multimodal porosities and retention curves were observed for both porous rocks and aggregate soils. Two pore-size peaks with pore diameters of 0.135 and 27.5 μm, 1.847 and 19.7 μm, and 0.75 and 232 μm were found for C, M and T, respectively, while three peaks of 0.005, 0.392 and 222 μm were identified for L. The MIP data allowed describing the retention curve in the entire mercury saturation range as compared to water retention curves that required combining several methods for limited suction ranges. Although the soil aggregates and porous rocks differed in pore geometries and pore size distributions, MIP provided additional information for characterizing the relation between pore structure and hydraulic properties for both.