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2D aquifer characterization and improved prediction of hydraulic conductivity using surface Nuclear Magnetic Resonance

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We present recent studies on the characterization of shallow aquifers using Nuclear Magnetic Resonance (NMR). NMR can help to gather detailed information about the water content and pore size related NMR relaxation time, of porous and water saturated material. The field application of surface NMR uses large wire loops placed at the surface of the Earth allows imaging the subsurface down to around hundred meters.

First, a sophisticated inversion scheme is presented to simultaneously determine the two-dimensional (2D) distribution of the water content and the NMR relaxation time (T2*) in the subsurface from a surface NMR survey. The outstanding features of the new inversion scheme are its robustness to noisy data and the potential to distinguish aquifers of different lithology due to their specific NMR relaxation time. The successful application of the inversion scheme is demonstrated on two field cases both characterized by channel structures in the glacial sediments of Northern Germany.

Second, we revise the prediction of hydraulic conductivity from NMR measurements for coarse-grained and unconsolidated sediments, commonly found in shallow aquifers. The presented Kozeny-Godefroy model replaces the empirical factors in known relations with physical, structural, and intrinsic NMR parameters. It additionally accounts for bulk water relaxation and is not limited to fast diffusion conditions. This improves the prediction of the hydraulic conductivity for clay-free sediments with grain sizes larger than medium sand. The model is validated by laboratory measurements on glass beads and sand samples.

Combining the new inversion scheme and petrophysical model allows 2D imaging of the hydraulic conductivity in the subsurface from a surface NMR survey.