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Influence of the electrical conductivity on Magnetic Resonance Sounding regarding 2D modelling and 1D inversion

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Magnetic Resonance Sounding (MRS, or Surface Nuclear Magnetic Resonance, SNMR) is used for groundwater exploration and aquifer characterization. The NMR experiment is conducted by a transmitter and receiver loop at the surface exciting the spin of protons of water molecules in the subsurface with the Larmor frequency of the earth's magnetic field. Successively increasing the excitation intensity (pulse moment) yields increasing penetration depths. Among other effects, an electrical conductive subsurface yields a complex valued sounding curve.

Investigations of 2D subsurface structures require also a 2D consideration of the electrical conductivity. We present the influence of the 2D electrical subsurface on the MRS signal compared to the calculated signal using an approximated 1D case. The excitation magnetic field is calculated with the finite element programme Comsol Multiphysics. The results show that a 1D approximation is valid, if the midpoint of the loop is at least one diameter away from the 2D structure.

Since the excitation magnetic field depends on the electrical conductivity of the subsurface, it has to be taken into account in the inversion: either as a priori information or as an inversion parameter during the inversion process. Studies with synthetic data with the layer thickness as a priori information show that water content and electrical conductivity can be resolved for a good electrical conductor as aquifer even using only the amplitude of the MRS signal. Having a resistive aquifer, the inversion result can be significantly improved using amplitude and phase of the MRS signal.