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Potential of the application of Magnetic Resonance Sounding to deep targets

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The geophysical technique of Magnetic Resonance Sounding (MRS) is nowadays an established tool for the investigation of shallow groundwater distributions. Its direct sensitivity to the Spin of hydrogen protons yields unique information about water content and pore structure. The method is based on the NMR phenomenon of hydrogen nuclei, exposed to the Earth's magnetic field what leads to a measurement frequency of around 2 kHz. Conventionally electromagnetic fields of current loops in the size of 50 to 150 m are used allowing investigation depths of up to 100 m. In the context of CO2 sequestration the method is assessed for its application to target depths up to 1000m and more.

In a first step we investigate the scalability of the conventional configuration of large surface loop to reach depths in the range of 1000m. Therefore, we study the pattern of magnetic field distributions of large loops on conductive ground and the resulting effects for the MRS kernel function. Using a SVD analysis, we derive quantitative measures for the penetration depth and the resolution depth of the method in dependency of loop diameter and ground resistivity.

Since the pure up-scaling of surface loops encounters strong physical limits in depth penetration due to increasing electromagnetic induction for large loops, we investigate the potential of new electromagnetic sources for transmitter and/or receiver. Based on a Finite Element Modelling (FEM), we investigate pattern of sources using galvanic coupling. Using steel-cased boreholes and surface grounded dipoles allow signal excitation and recording close to the target depth and with minimum grounding resistance, i.e. generator power. From the studies we conclude the potential of the new MRS configurations for both a large penetration depth and a high lateral resolution.