Geophysical Research Abstracts
Vol. 16, EGU2014-9317, 2014
EGU General Assembly 2014

A comprehensive sensitivity analysis of central-loop MRS data

Ahmad Behroozmand, Esben Auken, Esben Dalgaard, and Simon Rejkjaer
Department of Geoscience, Aarhus University, Aarhus, Denmark (ahmad@geo.au.dk)

In this study we investigate the sensitivity analysis of separated-loop magnetic resonance sounding (MRS) data and, in light of deploying a separate MRS receiver system from the transmitter system, compare the parameter determination of the central-loop with the conventional coincident-loop MRS data.

MRS, also called surface NMR, has emerged as a promising surface-based geophysical technique for groundwater investigations, as it provides a direct estimate of the water content and, through empirical relations, is linked to hydraulic properties of the subsurface such as hydraulic conductivity. The method works based on the physical principle of NMR during which a large volume of protons of the water molecules in the subsurface is excited at the specific Larmor frequency. The measurement consists of a large wire loop deployed on the surface which typically acts as both a transmitter and a receiver, the so-called coincident-loop configuration. An alternating current is passed through the loop deployed and the superposition of signals from all precessing protons within the investigated volume is measured in a receiver loop; a decaying NMR signal called Free Induction Decay (FID). To provide depth information, the FID signal is measured for a series of pulse moments (Q; product of current amplitude and transmitting pulse length) during which different earth volumes are excited.

One of the main and inevitable limitations of MRS measurements is a relatively long measurement dead time, i.e. a non-zero time between the end of the energizing pulse and the beginning of the measurement, which makes it difficult, and in some places impossible, to record MRS signal from fine-grained geologic units and limits the application of advanced pulse sequences. Therefore, one of the current research activities is the idea of building separate receiver units, which will diminish the dead time. In light of that, the aims of this study are twofold: 1) Using a forward modeling approach, the sensitivity kernels of different separated-loop MRS soundings are studied and compared with that of the conventional coincident-loop sounding. As a result, an optimal S/N is achieved using central-loop configuration. 2) The posterior parameter determination of central-loop MRS data (both synthetic and field examples) is studied in a joint MRS and TEM data analysis scheme.

In the typical 1D earth parametrization, a complete MRS measurement forms the 1D MRS sensitivity kernels as a function of depth and pulse moment Q; here referred to as a 1D kernel structure. For the conventional coincident-loop configuration, the 1D kernel structure covers the excited earth's volume throughout the applied Qs. As a result, the shallower parts of the subsurface are mainly sampled using smaller Qs and the deeper parts are mainly sampled using higher Qs. For central-loop configuration, however, the 1D kernel structure represents a superior behavior compared to coincident loop configuration.

The results of this study highlight advantages of central-loop MRS data and suggest that it can be beneficial to develop MRS instrumentation where the receiver system is separated from the transmitter system.