MRS noise investigations with focus on optimizing the measurement setup in the field

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By using multi-channel MRS equipment the opportunity to cancel harmonic noise from MRS data can be taken (Walsh, 2008). In addition to the MRS measurement loop, one or more reference loops are placed in an appropriate distance (remote reference) to measure the noise simultaneously. In the post-processing of the data, the electromagnetical (EM) transfer functions (TF) of the reference loop(s) to the measurement loop are calculated and used to predict the noise part in the MRS signal channel. Finally, the predicted noise trace is substracted from the measured signal, which leads to a significant cancellation of the harmonic noise.

The quality of the noise cancellation technique using remote references depends on the setup of the reference loops, i.e., on the quality of the harmonic noise signal and on the spatial coherence of the noise. Often, the same loop layout (size and number of turns) as the measurement loop is preferred, which multiplies time and effort in the field. Consequently, the working progress in the field slows down, which is, in particular, a serious problem when performing 2D measurements.

We have conducted systematic investigations to find a trade-off between minimizing time and effort in the field and applying the noise cancellation successfully. In doing so, we concentrate on three basic ideas. First, decreasing the size of the reference loop: A reference loop much smaller than the measurement loop is positioned much faster. The quality of the noise induction, which decreases with decreasing loop size, is maintained by a higher number of turns in the reference loop. This strategy can successfully be applied, unless the difference in loop size is not below approximately one tenth. In this case, the spatial coherence between the two loops gets lost.

Second, the use of very small and handy reference loops (1 sq m) to measure the x and y components of the EM field for the TF calculation. Following the EM theory, the z component (i.e., the measurement loop) is completely described by a linear combination of the x and y components, at least, for the far-field condition. Consequently, measuring the x and y components as remote references leads to a successful noise cancellation. However, it fails if the site of investigation is located in the near vicinity of a potential noise source.

Third, we investigated the spacial noise coherence in the presence of two potential noise sources. In doing so, we verified the necessity of using one remote reference loop for each noise source. Unfortunately, the attempt to gather the noise information from both sources with just one reference channel lead to unacceptable results.

Optimizing the noise cancellation technique is an ongoing research field. Further gathering and exchanging the experiences in that area helps the MRS community to improve and optimize their field experiments.

References

Walsh, D. O. (2008): Multi-channel surface NMR instrumentation and software for 1D/2D groundwater investigations. Journal of Applied Geophysics, 66, 140-150.