Inversion and Prediction-Focused Approach (PFA) imaging of multiple loops Surface Nuclear Magnetic Resonance (SNMR) data

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Academic year: 2017-2018

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Abstract:

Surface Nuclear Magnetic Resonance (SNMR) is a geophysical experiment that enables to retrieve hydrogeological parameters of the subsurface with surface-based measurements. However, the method suffers from a low signal-to-noise ratio. To overcome this impediment, a new experimental configuration, called the multiple loops (or multi-central) configuration, is introduced, benefiting from both an increased signal-to-noise ratio and an increased sensitivity to shallow subsurface. In order to take advantage of those improvements, an adaptation of the state-of-the-art QT inversion is proposed. On the other hand, a novel innovative approach to SNMR data interpretation is developed and tested. This approach, called Prediction-Focused Approach (PFA) imaging, is part of a broader alternative way to exploit geophysical data: Bayesian Evidential Learning (BEL). PFA enables a quantification of the uncertainty on model parameters issued from statistics-based relations between simulated models and data. In order to demonstrate the feasibility and accuracy of the implemented method, the PFA imaging process has been applied to both synthetic and real field data (Mont Rigi, Belgium). The obtained results have been compared with those obtained by the classical QT inversion, demonstrating the superiority of the PFA methodology. Finally, the QT inversion approach and the PFA imaging are tested on synthetic and real multiple loops experiments. The results have been compared with the classically used single-loop configurations, proving the usefulness of the multiple loops configuration in specific contexts, where the interest is mainly focused on shallow parts of the subsurface for instance.

Keywords: Hydrogeophysics, SNMR, QT inversion, Bayesian Evidential Learning (BEL), Prediction-Focused Approach (PFA), quantification of uncertainty, multiple loops configuration.