Spiritwood Valley

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Summary

With the recent changes in mining industry and increased rates of foreclosure of producing mines, there has been increased interest in environmental aspects related to mining activity, especially to groundwater applications in geophysics. Airborne EM methods remain the most cost-effective and preferred configuration, when it comes to assessing groundwater setting with high level of accuracy, which allows monitoring of mine tailings, finding any type of contaminate transport and modelling plumes. In our current study we present quantitative approach to hydrologic modelling, based on airborne interpretation ov VTEM data collected in Manitoba, Canada.

Introduction

The survey was flown in 2011 over Spiritwood valley in Manitoba using a VTEM system (Figure 1). The interpretation of the data was carried out by Aarhus Geophysics and the results highlight the importance of data quality and accuracy, availability of a-priori information and their consequences on derived hydrogeological models.

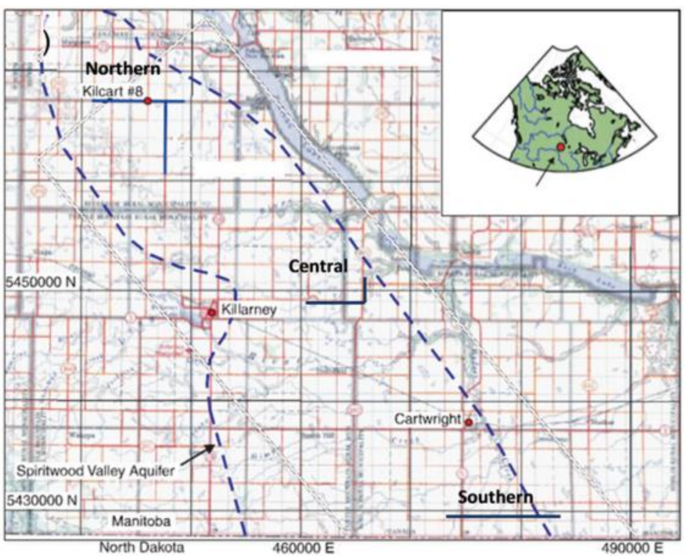

Figure 1. *Location of the VTEM survey (adapted from Oldenborger et al, 2010).*

Approach

The full waveform VTEM system was developed in late 2011 for improved early time data. The significant features of the full waveform technology are:

a) streamed half-cycle recording of transmitter and receiver waveform data, and, during the post-processing stage
b) continuous system response calibration
c) transmitter drift and parasitic noise correction
d) waveform deconvolution

Introduction of full waveform VTEM system allowed obtaining more accurate early-time data and as a result, improved shallow imaging.

During the fall of 2011full waveform system was tested over the Spiritwood Valley area. In particular, VTEM survey was flown in parallel with 2 seismic profiles, one of which was also overlapped by an electrical tomography profile. In addition to seismic data, there were downhole resistivity logs available, as well as electrical resistivity tomography (ERT) data.

Preliminary SCI inversion (Viezzoli et al., 2008) showed margin for improvement in the rendering of the shallowest layers. It was found that the description of the waveform originally used was not accurate. The modelling was therefore revisited redefining the waveform description of the VTEM data using the ERT as a reference model (Sapia et al., 2013). Further, a 3D voxel model of the VTEM inversion results was constructed. This model is compared with the original voxel model, constructed from original VTEM inversion results.

Results

As mentioned in the previous section, the VTEM waveform had to be recalibrated for the improved inversion. The results of recalibrated inversions were further matched with known seismic data and with downhole resistivity log (Figure 2).

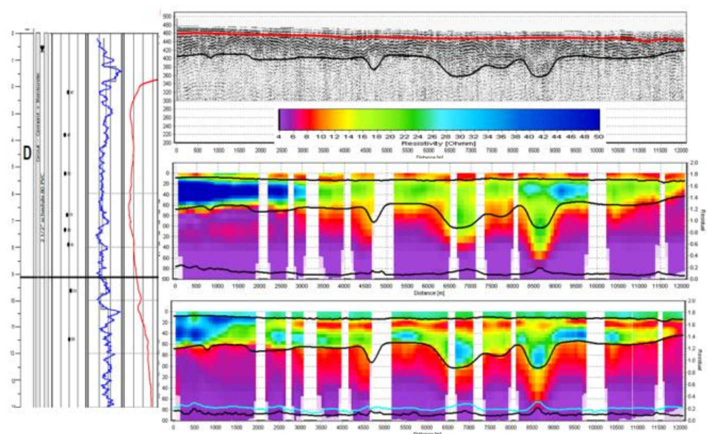

Figure 2. Top: Seismic section with interpretation; middle: original VTEM inversion; bottom: recalibrated VTEM inversion (Aarhus Geophysics); left: downhole resistivity log.

The original interpretation was based on grouping different pseudo-lithologies, based on their electrical resistivity values and resulted in a pseudo-lithology hydrogeological model with higher electrical resistivities corresponding to coarse-grained fractions and lower resistivities, corresponding to finer-grained material (Oldenborger et al, 2011). In Figure 2 (middle section) a conductive near-surface layer is suggested, which however is not supported by the downhole resistivity log.

After the recalibrated VTEM data were reinverted with a-priori constraints (based on the ERT data, the new model was matched with available seismic and downhole resistivity data showing much better correlation. The new model shown in Figure 6 (bottom section) on the other hand is suggesting a model, which is in better correlation with downhole log.

A voxel approach allows quantitative understanding of the hydrogeological setting of the area, and it can be further used to estimate the aquifers volumes (potential amount of groundwater resources) as well as hydrogeological flow model, including presence and transport of contaminants.

Two voxel models were constructed based on two inversions: original (Oldenborger et al, 2012) and with improved waveform (carried out by Aarhus Geophysics) incorporating the ERT a-priori information. The voxel discretization is 100 × 100 m in the X–Y direction and 5 m in the Z direction (Figure 3).

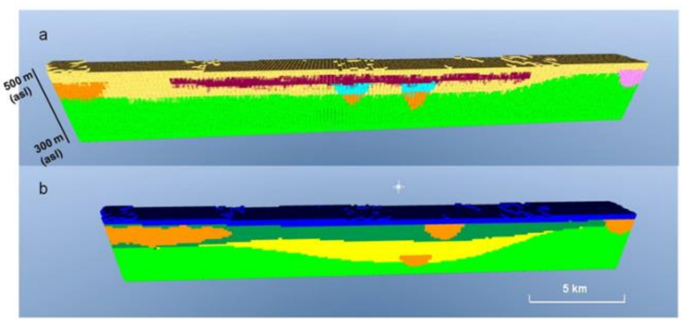

Figure 3. *(a): Voxel model constructed from updated waveform with a-priori (ERT) information incorporated; (b): voxel model based on original VTEM inversion results.*

It becomes evident from comparison of the two models, that if the interpretation is based on the original model, it is suggesting a fictitious shallow clay cap cover, which if existed in reality would prevent surficial recharge, while the updated model, based on inversion of recalibrated data set using a-priori information allows an adequate quantitative interpretation.

Conclusions

The shown examples shine light on innovative approaches, such as recalibration of AEM data and using a-priori information to constrain EM inversions.

Ongoing development within the AEM world is increasing the value, relevance and applicability of suggested methodology in groundwater and environmental applications. This methodology can become a very effective tool in quantitative assessments of groundwater potential of area of interest, and also help facilitate assessment of groundwater contamination and contaminant transport, as well as 3D mapping of contaminant plumes.

Acknowledgements

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