Investigating the role of contraints from seismic, resistivity and boreholes in the inversion of Airborne EM data

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Summary

We present examples of integration of ancillary information to AEM data from Manitoba, Canada. The data enters the inversion as an a priori extra parameter, either from a grid, or from a point source. We use the spatially constrained inversion to migrate the a priori information across the dataset.

Introduction

There are a number of concurring factors that promote the use of a priori information in inversion of Geophysical data. The first one is probably the desire to cross check the geophysical derived model against ancillary information. The second is the inherent non uniqueness of the results of inversion of geophysical data, which is due to the fact that the problem is usually ill posed. The third is the ever higher level of accuracy of the output sought after by end users that, rightly so, demand results (either direct or derived) they can use directly for management. Last, but not least, is the drive to incorporate different physical parameters originating from different sources into one inversion problem, in order to derive directly, e.g., geological or hydrogeological models that fit all data sets at once.

In this paper we present some examples obtained adding information from seismic data to the inversion of Airborne EM data.

Theory and/or Method

In order to add a-priori information to the AEM data, and to have it migrate throughout the dataset, we use the framework of the Spatially Constrained Inversion (Viezzoli et al., 2008). In the SCI the resistivity model is constrained spatially to make use of the inherent geological spatial coherency present, in different degrees, in every environment. These constraints represent, per se, a priori information, that are fitted, together with the AEM data, during the inversion. However we now want to add also a-priori, from downhole resistivity logs, geological layers, seismic reflectors, hydrogeological units. The a-priori information is treated as nothing but an extra data set, carrying location, values, uncertainty, and expected lateral variability. The information it contains is carried by the spatial constraints to the location of the neighbouring AEM soundings. Constraints and uncertainties are usually different depending on data types and geology.

Examples

As example of the methodology, we present results from a SkyTEM survey in Denmark. Figure 1 shows the approach applied to a multilayers inversion. Notice how adding a priori allowed resolving the depth to Paleogene clay in areas where the AEM alone could not, as it was too deep.

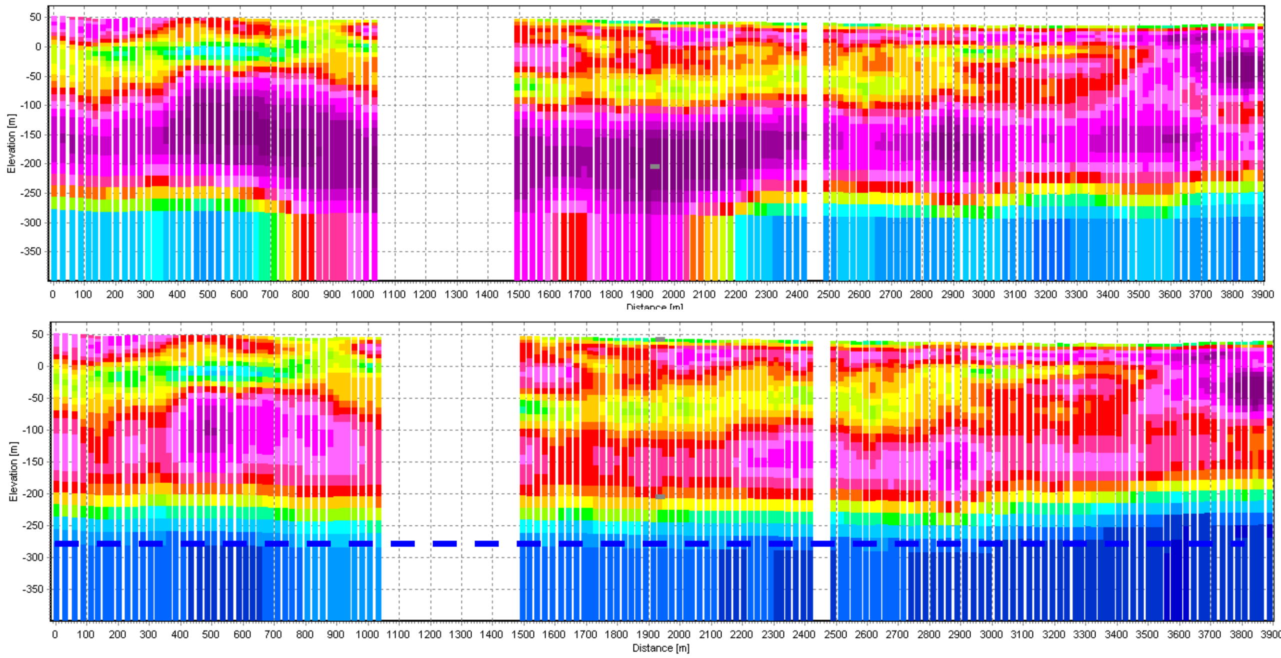

Figure 1. The effect of adding, as a –priori, seismic determined depth to Paleogene clay layer (dashed line) to inversion of SkyTEM data. Top no a-priori, bottom a –priori.

At the conference we will focus mainly on the results obtained from an AeroTEM III survey flown over the Spiritwood Valley Aquifer in Manitoba (See figure 2a for survey location). For this study, we apply a-priori information from seismic, boreholes and resistivity data. The high resolution seismic data is added to defining depth to layers. Seismic reflection data provide additional details of the subsurface geological architecture of the Spiritwood Valley in terms of the presence of a series of secondary incised valleys into the main valley (Oldenborger et al., 2010). In particular, data sections provide information about the depth of the incised valley and reveal approximately 60–100 m and 80–110 m depth to different investigated sectors (figure 2). Other ground based data exist in the survey area and make it possible to provide some additional information on subsurface resistivity values. Over 10 line-km of electrical resistivity data and resistivity downhole logs were collected and supply a simplified electrical model relative to the geological layers. Resistivity values obtained from surface geophysics and geological layers are also added to the AEM inversion. We will describe the effect of the different a-priori information on the AEM inversion performance and output.

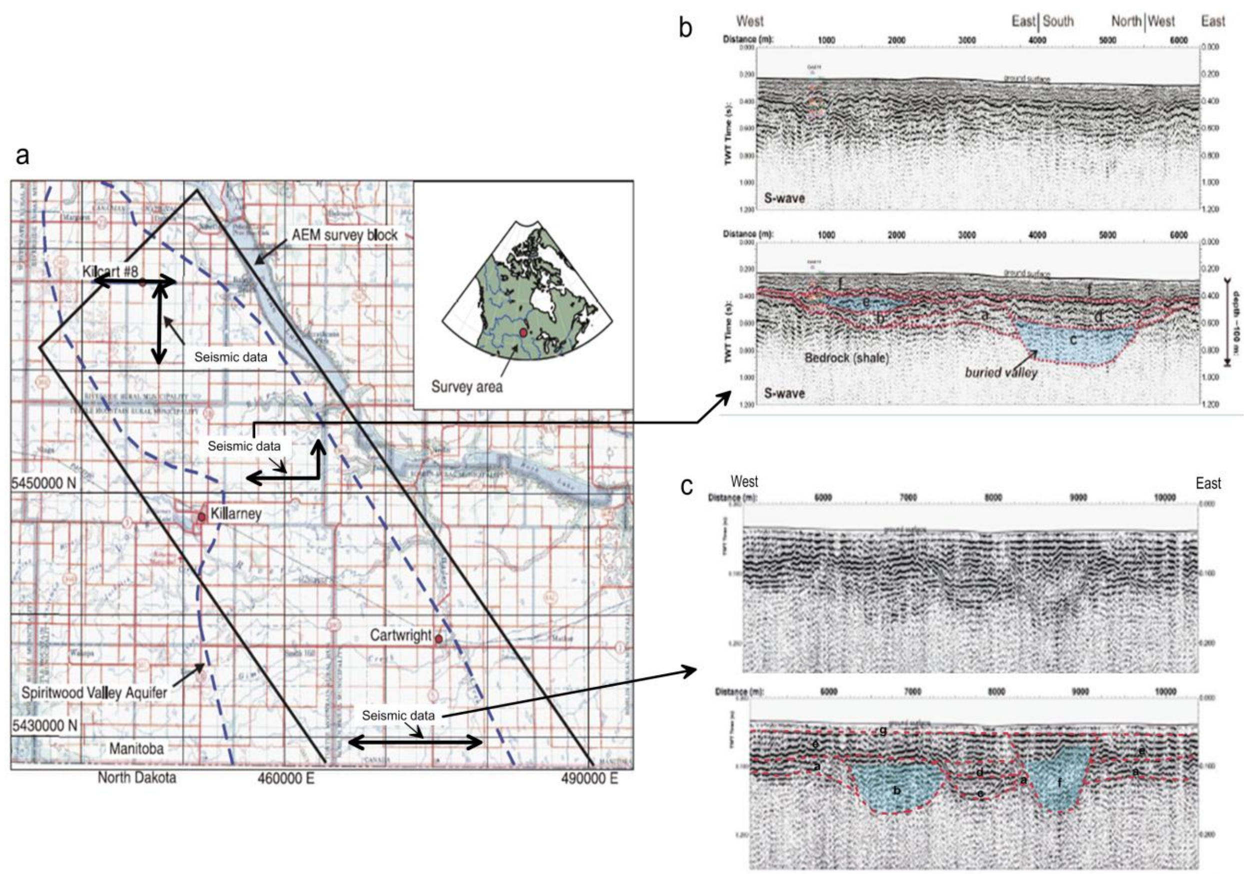

Figure 2. a) Map show the AEM survey area and the locations of seismic reflection surveys conducted in 2010; b) and c) show respectively S-wave and P-wave seismic sections; lower sections have been interpreted in terms of hydrogeological setting (adapted from Oldenborger et al., 2010 and 2011).

Conclusions

Adding a-priori to the inversion of AEM data in form of depth to layers, or resistivity values, can help refining the resolution of otherwise poorly determined parameters. In presence of issues with instrument calibration it also provides a chance to flag the problem, and possibly correct it.

References

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