COMPARISON OF HIGH-RESOLUTION AUDIO-MAGNETOTELLURIC AND TRANSIENT ELECTROMAGNETIC DATA VERUS INTERPRETATION OF SHALLOW 2D SEISMIC REFLECTION DATA. EXAMPLE FROM THE LUBLIN BASIN

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Introduction

As part of a geophysical experiment, several studies aimed at assessing the possibilities of improving the interpretation of Lower Paleozoic deposits variability were undertaken in the area of the Lublin Basin. The research was carried out as part of the Blue Gas project with the acronym GASŁUPSEJS. Among others, an analysis of the electromagnetic methods resolution was carried out, allowing for identification of Silurian and Mesozoic sediments, which will be mentioned further in this article. Additionally, possibility of using EM methods in order to recognize shallow geology was analyzed. Geophysical measurements were made along a profile line designed for seismic surveys using the reflection method. For the purposes of this article, two active and one passive electromagnetic method were selected for complex interpretation with seismic data. Results of reflection and refraction seismic data processing were then compared with geoelectric models developed based on the TEM (Transient Electromagnetics Method) measurements in the MulTEM (Multi Transient Electromagnetics Method) and LoTEM (Long Offset Transient Electromagnetics Method) versions as well as on the Audio Frequency Electromagnetics (AMT) measurements. The obtained results allowed to verify the possibility of using the applied individual geophysical methods in the interpretation of the geological substratum.

Methods

The geophysical study using the AMT method in the continuous sounding version (profiling) was carried out along the 2D seismic profile line number 1708 and in the vicinity of nearby boreholes located in the central part of the profile. Field work consisted of recording the time series for 5 EM components of the natural electric and magnetic fields in the AMT band, in four frequency ranges marked: .ts2 (10400-900 Hz), .ts3 (780-40 Hz), ts4 (33-5.6 Hz), with sampling frequencies: 24000 Hz, 2400 Hz, 150 Hz, respectively. The registration time at a single measurement point (sounding) was no less than one hour. In order to eliminate the electromagnetic interference (noise), the recordings were made synchronously at two points: the field point (located along the profile) and at the so-called "magnetic reference point" (Gamble et. al., 1979). Additional field measurements were carried out also in the LoTEM configuration using the TEM transient processes along the same profile. Calibration of the results included performance of parametric TEM soundings in the MulTEM version, located in the vicinity of the existing boreholes and using transmitter loop sized 1000x1000m (Klityński et. al., 2011). Additionally, soundings with this method were performed along a 2 km section of the profile located near borehole S-1. Seismic works were performed using a reflection method with vibroseis as the seismic source and with shot points and receiver points at every 20m (Figure 1).

Results

Interpretation of audio magnetotelluric data consisted of delineation of resistivity distribution within the geological substratum. The qualitative interpretation of the magnetotelluric data included analysis of the impedance tensor skewness and the impedance polar diagrams in order to determine the character of the geoelectric medium: in 1D, 2D and 3D space. The WinGLink software was used for this purpose. The quantitative interpretation was carried out using algorithms for 1D and 2D inversion of the magnetotelluric data. The 1D inversion was carried out using Occam's "smoothing" procedures (Constable et al., 1987). The 2D inversion was carried out according to the NLCG (Non-Linear Conjugate Gradient) algorithm (Rodi, Mackie 2001). The 1D model assumes no variability in the horizontal distribution of resistivity (adapting model of a horizontally layered half-space). This assumption makes it difficult to interpret deep geological structures along profile lines, as recorded low frequencies MT curves sometimes point to a 2D character of the subsurface and locally even to its 3D character. One-dimensional resistivity distribution models were therefore treated only as an input data for a more accurate 2D interpretation. Interpretation of 1D measurements obtained from the transient process method was carried out using the ZondTEM1D software. The resistivity distribution was delineated as a result of 1D interpretation of LoTEM curves for the following three frequencies: 25 Hz, 5 Hz and 1 Hz.

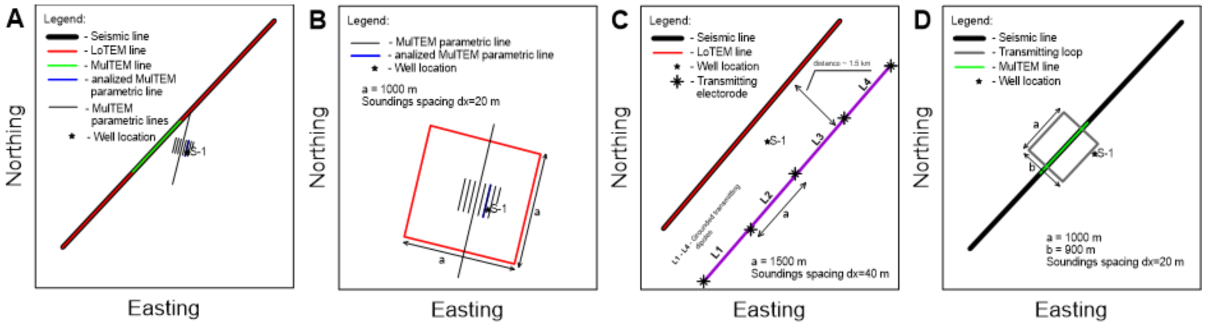

Figure 1. *A – Survey location map, B – scheme of LoTEM survey, C – scheme of MulTEM, D – scheme of MulTEM parametric survey (Cygal et.al, 2017). Not to scale.*

Conclusions

The results of the above described study allowed to evaluate the applicability of the obtained resistivity models for the purpose of the interpretation of the geological subsurface zone and to improve the quality of the interpreted seismic sections. The study was focused on verification of applied methodology in geological conditions that are not too complex. The conducted analyzes allowed to determine the potential applicability of the described methodology also in more tectonically complex conditions. Geophysical models were checked against the borehole data such as lithology and geophysical logging curves (velocity, resistivity, density, natural gamma) as well as against the regional geological and hydrogeological setting.

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