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Structures of Mid-Polish Trough in the light of regional magnetotelluric survey

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Introduction

The magnetotelluric survey at three long regional profiles crossing the Mid-Polish Trough in north-western part of Poland was made during 2005-2008 period. Two of the profiles pass across the Pomeranian section of the Trough and the third one cuts its Kujawy section. The task of the survey was to recognize the geological structure of the contact zone of Precambrian East European Craton and Paleozoic Platform of Western Europe. The profiles crossed major geological structures of central and north-western Poland, including the Variscan Externides and Varscian Foredeep, the Transeuropean Suture Zone and the marginal zone of the East European Craton.
The main objectives of the project included evaluation of resistivity distribution and identification of structures of sub-Zechstein sedimentary and metamorphic complexes.The screening of seismic energy by high reflective Zechstein evaporates is the main problem in identifying the sub-Zechstein complexes in the Polish Lowlands area. Since evaporates do not screen the electromagnetic waves, the magnetotelluric method can be advantageously applied. The sub-Zechstein complexes and structures are commonly considered as hydrocarbon prospective. A lot of gas deposits have been discovered in Rotliegend sediments in central and Western Europe. A number offshore and onshore oil fields were found in Cambrian sandstones in the Baltic Sea area.

Techniques and methodology of surveys

Magnetotelluric measurements were taken with the use of MT-1 system of Electromagnetic Instruments Incorporation (EMI), Richmond, California, USA and System 2000.net based on V8 receiver of Phoenix Geophysics Ltd., Ottawa, Canada. An average spacing of sounding sites was about 4 km. The components of natural electromagnetic field were recorded over a broad range of frequencies, ranging from 0.0003 Hz to 575 Hz (MT-1) and 0,0003 HZ to 10 000,0 HZ (System 2000.net). This frequency band allowed information on the geology from a depth range of a few dozen meters to approximately 100 km to be obtained. A remote reference site was located at a distance of over 100 km of the study area.

Data processing and interpretation

Processing of the recorded data included the estimation of the components of impedance tensor (Zxx, Zxy, Zyx and Zyy), with the use of robust procedures. The components of the impedance tensor enabled calculation of field curves for two orientations of the measurement system and additional parameters of the medium like skew, strike, pole diagrams etc. Recording of the vertical component of electromagnetic field (Hz) enabled the tipper parameter, T, to be calculated.
Geophysical interpretation of MT sounding data along profiles was based on 1D inversion and 2D inversion. The upper part of the geological section is built of relatively flat layers; hence a 1D interpretation model could be effectively applied. Starting models for 1D inversion were constructed based on results of electromagnetic well-logging data. Some well-documented seismic horizons were taken as constraints in 1D inversion. The first step in 2D MT inversion was the calculation of inverse model with stabilized parameters of the upper part of geological section over the top of Zechstein complex. The starting model was obtained with the use of available geological cross-sections interpreted based on borehole and reflection seismic data. Results of inversion for the lower part of the section with constrained its upper part made some misfits between calculated and post-processed magnetotelluric curves. The second step in geophysical interpretation was 2D inversion with no constraints, which

was finished when the misfit was small. Results of the first step of 2D inversion were applied as a starting model. Depending on inversion parameters, final resistivity distribution model along profiles was obtained.
Geological interpretation was made based on resistivity cross-sections and borehole and reflection seismic data. Of great interest is varied resistivity of the formation resting below the Zechstein evaporate complex. As a result of data interpretation geophysical and geological sections were constructed.

Conclusions
As a result of magnetotelluric data interpretation, a tectonic model along measurement profiles with fault zones was constructed and lithology differentiation of sub-Zechstein complex was determined. Deep magnetotelluric cross-sections with interpretation of sub-Zechstein structures across the Polish Lowlands help to understand geodynamic processes in the area.

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