RESULTS OF NUMERICAL MODELING OF THE LOWER JURASSIC GEOTHERMAL RESERVOIR PARAMETERS DISTRIBUTION IN THE CENTRAL PART OF POLISH LOWLANDS USING GEOPHYSICAL METHODS

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Abstract

The most important issue for any geothermal investment is properly characterization of the reservoir parameters distribution, which determine the location of wells to guarantee optimal hydrogeothermal parameters for the water intake. Currently geophysical methods, which for decades have been successfully used to recognition of geological structure and petrophysical parameters of rock formations, extended their applicability also to the geothermal aquifers. Based on reinterpreted data from deep wells located in the central part of Polish Lowlands, in the Mogilno-Łódź Trough, the 3D model of clay, porosity and permeability of Lower Jurassic aquifer, were presented. Taking into account results of numerical modelling the advantages of using geophysical method for selection of optimal areas for future geothermal investments, were discussed.

Introduction

The Mogilno Łódź Trough is located in the most prospective geothermal region of Poland, in Polish Lowlands (Fig. 1), which was confirmed in many research project in recent years (see e.g. Górecki, (Ed.) et al., 2006a;b; Wójcicki, Sowiżdżał, Bujakowski (Eds.) et al., 2013; Bujakowski, Tomaszewska (Ed.) et al., 2014; Górecki et al., 2015; Sowiżdżał et al., 2017; Kępińska et al., 2017). From tectonic point of view research area is located at the boundary between the Fore-sudetic Monocline and the Mogilno-Łódź Trough, between the recharge zone of the Jurassic groundwater horizons and the zone of strong salinary tectonics.

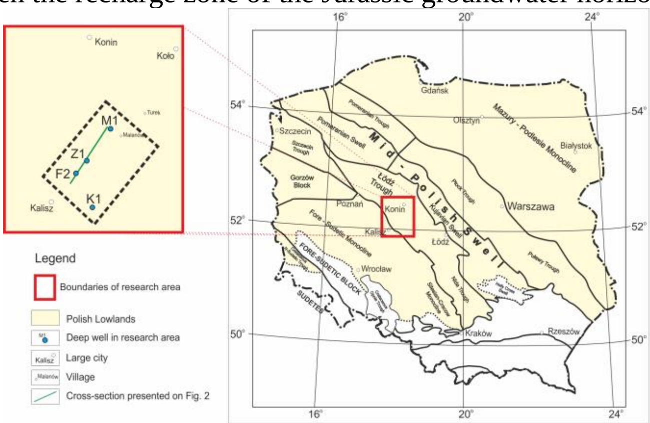

Figure 1. The research area projected against the regional structural division of Poland (after Narkiewicz, Dadlez, 2008, modified).

The greatest impact on the current form of Zechstein-Mesozoic complex in research area, were vertical movements in the sub-Zechstein basement (Dadlez, Marek, 1969) and salt tectonics, which resulted in stratigraphic gaps (Górecki (Ed.) et al., 2006a). Depth of the top of Lower Jurassic aquifer range in border of research area between 100 m b.s.l. in the SW part to beneath 2 000 m b.s.l. in the NE part. The most promising reservoir horizons are: Sinemurian, Pliensbachian and Lower Toarcian sediments covered by sealing overburden of Middle Jurassic claystones. For characterization of the reservoir parameters distribution the archival seismic and geophysical data from deep wells located in research area were reinterpreted and used in numerical modeling process.

Methodology

Archival seismic data were crucial for determination of geothermal aquifer geometry. The data were applied to recognize the depth of the Lower Jurassic horizons and to construct the 2D structural model. The interpretation of well logs from deep wells located in the research area allowed to construct the 2D distribution models of porosity and clay content. Permeability was calculated based on results from clay content and porosity after Nowak and Zawisza (2012) formula for Lower Jurassic sediments of Mogilno-Łódź Trough. Models were based upon the stochastic algorithms provided by the PETREL software.

3D models of geothermal parameters

Based on results of clay content model the sealing character (clay content up to 0.8) of Toarcian sediments was confirmed. In the Pliensbachian and Silurian sediments, clay contents were much lower (usually below 0.4) and allowed to recognition two groundwater horizons (upper and lower), with low value of clay (approx. 0.2) (Fig. 2A). The values of the clay content correlate with the porosity whit the highest values (up to 20%) and permeability (up to 500 mD) are easily visible near F2 well and in NE part of the area (Fig. 2B, 2C).

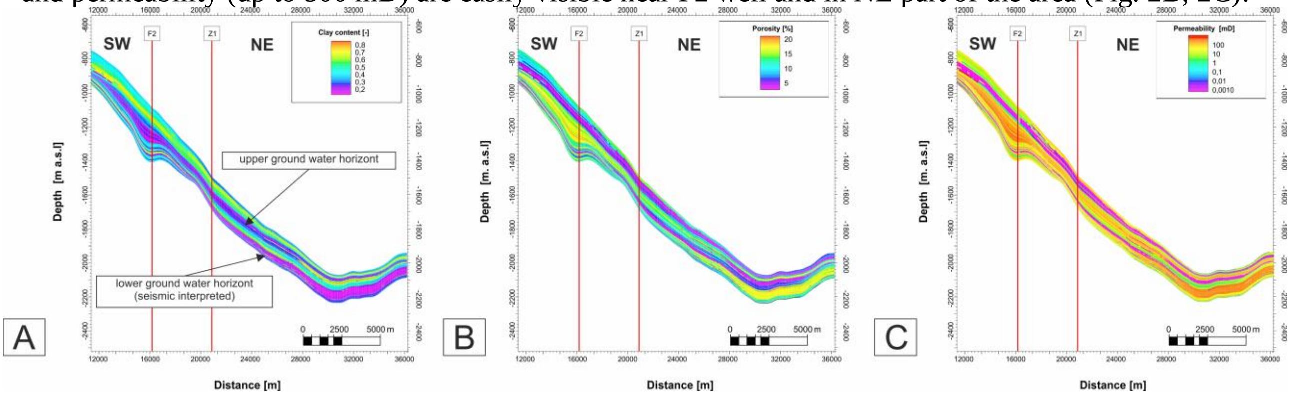

Figure 2. *Cross-sections (from Fig. 1) through models of: A – clay content, B – porosity, C – permeability in Lower Jurassic formation.*

Conclusion

Seismic and geophysical data can be successfully used for analyze the differentiation of reservoirs parameters and can be applied to recognize geometry of geothermal aquifer. Taking into account the results two groundwater horizons can be identified. Based on numerical modeling, the most favorable location of geothermal investment can be obtained.

Acknowledgements

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References

Górecki, (Ed.) et al., 2006a - Atlas of geothermal resources of Mesozoic formations in the Polish Lowlands. Ministry of Environment, ZSE AGH, Kraków.
Górecki, (Ed.) et al., 2006b - Atlas of geothermal resources of Paleozoic formations in the Polish Lowlands. Ministry of Environment, ZSE AGH, Kraków.
Wójcicki A, Sowiżdżał, A, Bujakowski W., et al. (red.) i in., 2013 - Ocena potencjału, bilansu cieplnego i perspektywicznych struktur geologicznych dla potrzeb zamkniętych systemów geotermicznych (Hot Dry Rocks) w Polsce Ministerstwo Środowiska, Warszawa, 246.
Bujakowski W., Tomaszewska B. (red.), 2014 – Atlas wykorzystania wód termalnych do skojarzonej produkcji energii elektrycznej i cieplnej przy zastosowaniu układów binarnych w Polsce. Wyd. IGSMiE PAN. Kraków.
Górecki W., Sowiżdżał A., Hajto M., Wachowicz-Pyzik A., 2015 - Atlases of geothermal waters and energy resources in Poland, Environmental Earth Sciences, vol. 74, no. 12, pp. 7487–7495, 2015.
Sowiżdżał A., Hajto M., Papiernik B., Mitan K., Hałaj E., 2017 - Possibilities of geothermal sector development in central Poland in reference to extended structural and parametrical analysis of Mogilno-Łódź Trough, Geological Exploration Technology, Geothermal Energy, Sustainable Development, vol. 56, no. 2, pp. 17–31, 2017.
Kępińska B., Pająk L., Bujakowski W., Kasztelewicz A., Hajto M., Sowiżdżał A., Pétursson B., Tulinius H., Thorgilsson G., Einarsson Ó. P., Karska A., Peraj A., 2017 - Geothermal utilization potential in Poland – the town of Poddębice, Technika Poszukiwań Geologicznych Geotermia, Zrównoważony Rozwój nr 1/2017.
Dadlez R., Marek S., 1969 – Styl strukturalny kompleksu cechsztyńsko-mezozoicznego na niektórych obszarach Niżu Polskiego. Ibidem nr 3.
Narkiewicz, Dadlez, 2008 – Geologiczna regionalizacja Polski – zasady ogólne i schemat podziału w planie podkenozoicznym i podpermskim. Przegląd Geologiczny. Vol. 56, nr 5, s. 391 – 397.
Nowak J. and Zawisza L., 2012 – Metodyka określania parametrów filtracyjnych skał nap odstawie kompleksowej analizy danych geofizyki otworowej Wydawnictwo AGH, Kraków.