USE OF GEOTHERMAL WATER FROM MESOZOIC FORMATIONS IN THE MOGILNO-LODZ TROUGH, POLAND

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ABSTRACT

In Poland geothermal energy uses are mostly direct uses like heating, balneotherapeutical and recreational purposes and the installed thermal capacity is lower than 500 MWt. The Mogilno – Lodz trough is located in Central Poland and is a synclinal structure filled with Triassic to Quaternary sediments. The Mogilno – Lodz trough is considered a potential area for geothermal uses, especially for heating purposes. The most favourable formations are Lower Jurassic and Lower Cretaceous. Currently, in the area of the trough 2 geothermal centres use geothermal water for multiple purposes in Uniejow and Poddebice.

Waters occurring in the area of the Mogilno – Lodz Trough in the Lower Cretaceous formations are mostly of Na – Cl type and Na – (Ca) – HCO3 type in the Lodz trough. Waters contain some specific elements (I, Br, Fe). There are several waters samples with mineralization lower than 1 g/L. The mineralization is variable The highest mineralization values exceed 90 g/L and are related probably to salt structures. Waters from the Lower Jurassic formations are, apart from few samples, of Na-Cl type and some I, Br and Fe elements are also present. The mineralization of waters differs from a few to even over 172 g/L. The lowest mineralization can be observed in the Lodz Trough. Chemical parameters of waters are given according to archival data.

This paper presents some possibilities of geothermal applications. According to hydrogeological and thermal conditions space heating, balneotherapy and balneorecreation, mineral extraction, geothermal source heat pumps and aquifer thermal energy storage (ATES) are considered, while electricity production in binary units has lower potential for application in the area of the Mogilno-Lodz trough.

1. INTRODUCTION

In Poland geothermal energy uses are mostly direct uses like heating, balneotherapeutical and recreational purposes and the installed thermal capacity is lower than 500 MWt (Lund and Boyd 2016) The Mogilno – Lodz trough is located in Central Poland and is a synclinal structure filled with Triassic to Quaternary sediments. The location of the Mogilno-Lodz trough and main salt structures are given in Fig. 1.

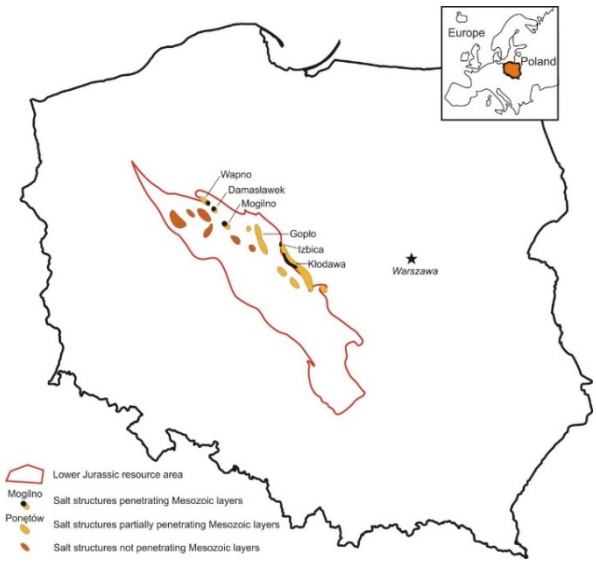

Fig. 1. Location of the Lower Jurassic resource area and the main salt structures within the Mogilno – Lodz Trough

The cross-section of the trough is given in Fig. 2. The Mogilno – Lodz trough is considered a potential area for geothermal uses, especially for heating purposes. Hydrogeological analysis and thermal data come mostly from archival data from deep drillings (mostly did in search for hydrocarbon). Archival data comes from National Geological Archives, the Archives of Department of Fossil Fuels, AGH University of Science of Technology and Archives of Geotermia Poddebice Sp. z o. o.

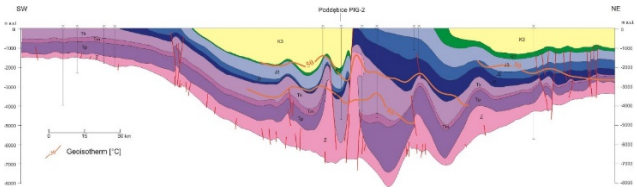

Fig. 2. Cross section of the Mogilno-Lodz trough according to Gorecki (2006)

The most favourable formations are Lower Jurassic and Lower Cretaceous. Waters from the Lower Cretaceous formations are used for heating and balneotherapeutical (Kepinska 2017) and recreational purposes (Halaj 2015). Currently, in the area of the trough 2 geothermal centres use geothermal water for multiple purposes in Uniejow and Poddebice.

In Uniejow, geothermal water of temperature of 68 °C is used for space heating and bathing purposes since 2001. The water comes from the depth of ca. 2,000 m and is Cl–Na type and its TDS varies from 6.8 to 8.8 g/L depending on the well (Sapinska-Sliwa and Kurpik 2011). The city has built the brand of a geothermal centre for recreation, spa and wellness and therapy. There is a well-known recreational centre with several geothermal swimming pools. In 2012 there were establish a health resort, which was named as the first geothermal health resort in Poland (actually, in Poland there are more health resorts, which used geothermal waters for therapy). Health resort treatment is conducted in the following directions: orthopedic and traumatic diseases; diseases of the nervous system; rheumatic diseases; peripheral vascular disease and skin diseases.

In the second centre in Poddebice (Fig. 3), the geothermal water is exploited from a depth of ca. 2,100 m is fresh water. It can be used as drinking water, while it's TDS is only 0.455 g/L. The water is a HCO3–Na–Ca type (Karska and Hajto 2009). The temperature of the water is high (72 °C). High enough to supply not only swimming pools but also heating plant. It is used for curing as well. And partially, water is supplied to the nearby ZOO Safari for animal husbandry. The use of geothermal water is wide. The centre was established in 2011 and since then more geothermal water use is considering, including spirulina growing.

Fig. 3. Thermal swimming pools in Poddebice (Kepinska 2017)

2. LOWER CRETACEOUS WATERS

The thickness of auriferous sandstones of Lower Cretaceous is on average approx. 50-150 m, not exceeding approx. 100 m in the south-eastern part and reaching over 200 m in the north-eastern part. At the outcrop of the Lower Cretaceous, the thickness does not exceed 25m. The depth of the Lower Cretaceous differs from 0 - 2300 m (the top of the Lower Cretaceous formations). All Mesozoic formations of the area are affected by saline tectonics. Salt structures also impact on the water's chemical composition and TDS.

Effective porosity of the aquifers is mostly ca. 15–25% (Gorecki 2006). Aquifers are interbedded with semipermeable and impermeable formations, which are discontinuous. A hydraulic conductivity ranging from 4 × 10 −4 to 200 × 10 −5 m2/s. Geothermal waters occurring in the Lower Cretaceous formations are under artesian formations. The open porosity of these rocks for the Polish Lowlands is respectively: 0.15-0.33 and <0.1. The filtration coefficients range from 10-5 - 10 -7 m / s for permeable rocks and 10 -7 - 10 -11 m / s for impermeable rocks

In the Lower Cretaceous formations in Mogilno–Lodz trough, waters are mostly of the Na–Cl type. Only waters from Lodz area are Na–(Ca)–HCO3 waters, and these are the waters with the lowest mineralization. In some samples with TDS not higher than 2 g/L there are waters of Na–(Ca)–(Cl)–HCO3 type. The TDS of all waters ranges from 0.2 to 100.8 g/L. The TDS of waters from the Lower Cretaceous formation is shown in Fig. 4. Waters with the highest mineralization (over 90 g/L) occur at the deepest depths exceeding ca. 2000 m. Generally, mineralization increases with depth, but numerous exceptions can be observed. One of them is the geothermal water in Podebice. Temperature of waters are given in Fig. 5. The temperature is mostly dependent from the depth.

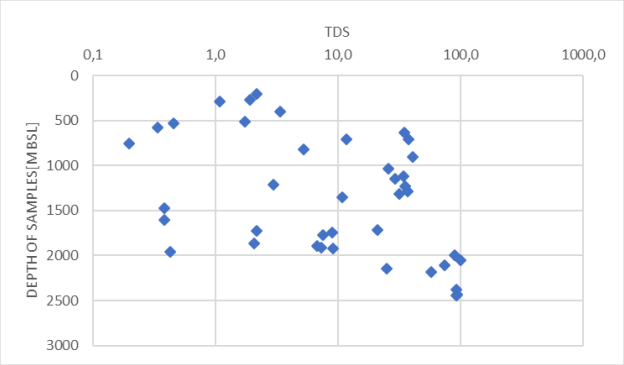

Fig. 4. TDS of waters from the Lower Cretaceous formations

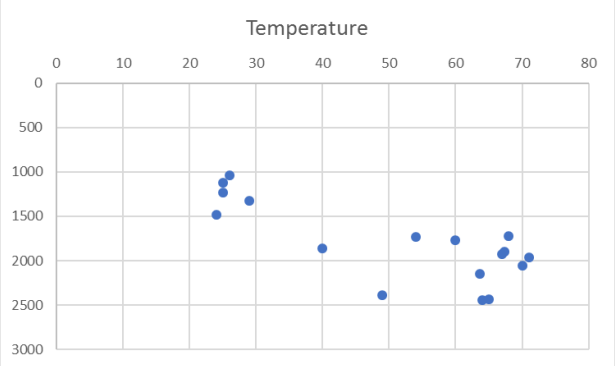

Fig. 5. Temperature of waters in the Lower Cretaceous formations

To use geothermal waters for heating purposes is desirable that the water has temperature of more than 65 °C. Such temperature is expected at depth of ca. 1,500 m in central and northern part of the trough. However, waters with high temperature and from greater depths can have higher mineralization (like in the northern part). The best conditions for heating purposes can be found in the central part, where waters of temperature > 65 °C have a lower mineralization level, in the range of 0.4–ca. 25 g/L.

Geothermal waters for bathing purposes must satisfy certain conditions relating to temperature, mineralization and contents of certain chemical elements (specific elements). Direct use of natural geothermal water with certain temperature and mineralization from the source for the balneotheraphy and recreation purpose can be expected in the northern and central part of the trough. In these areas I, Br and Fe ions occur in in quantities high enough to name same waters as healing waters. Even the waters are found in large depths and high values of mineralization for some waters is noticed, only in one sample suitable accumulation of minerals for industrial exploitation were found. In case of water sample from this well, K ions occurred in the amount of 350 mg/L. The sample is from the northern part of the trough. Even maximum temperature of ca. 70 °C can be found in the Lower Cretaceous formation it would be to small for effective production of electric power achieved even from a binary installations. Very preliminary analysis shown that the best conditions for ATES (aquifer thermal energy storage) in the Lower Cretaceous formations are located in the southern and marginal parts of the trough.

3. LOWER JURASSIC WATERS

Lower Jurassic waters

The Lower Jurassic profile is built mainly of sands and sandstones interbedded with semi-permeable or impermeable claystones and mudstones. The thickness of the Lower Jurassic formation may reach from 150 to 230 m on average. Permeable rocks fill 60–80% of the lithological profile. The top of the Lower Jurassic is trough-shaped, with the axis in the NW-SE direction and is at the depth of about 500 m in zones of the western trough boundary (minimum about 250 m in the southwestern zone, on the Trough edges) to more than 3,000 m along the axis extending NW-SE in the central-eastern part (Gorecki 2006).

The waters, apart from few samples, are of Na–Cl type. Sometimes waters include I, Br and Fe components. Sodium and chloride components are the main components of the waters. TDS of water ranges from 0.4 to even 172 g/L. T Salt structures also impact on the water’s chemical composition and TDS. TDS is shown in Fig. 6.

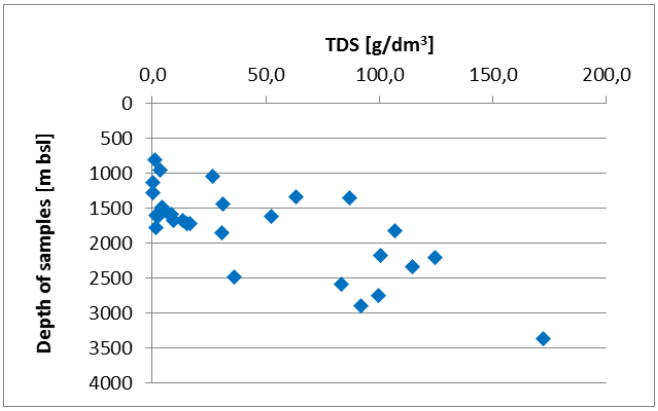

Fig. 6. TDS of waters from the Lower Jurassic formations

Temperature of waters are given in Fig. 7. The temperature is dependent from the depth.

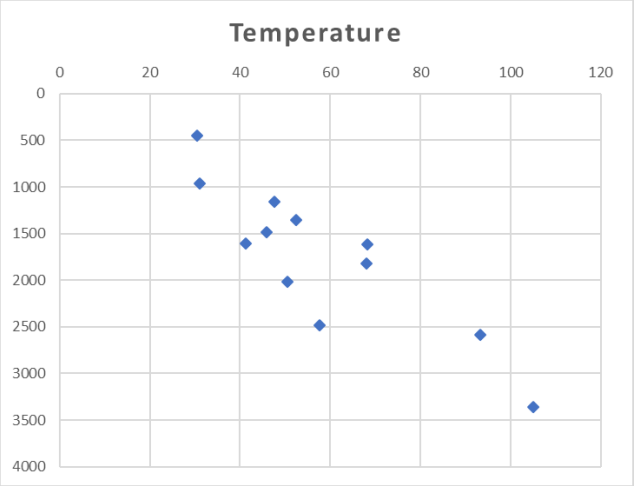

Fig. 7. Temperature of waters in the Lower Jurassic formations

Geothermal waters with temperature exceeding 65 °C is expected at depths lower than 1,600 m. Waters would have quite high TDS, which must be taking into consideration for technical problems that would occur during water exploitation. Potential use geothermal water for electricity production in binary plants is rather neglible, while electric power calculated for certain resources is still quite small. Geothermal waters from the Lower Jurassic can be used for balneotheraphy, while the waters consist of several ions helpful in curing like iodides, iron, bromine, etc. Highly mineralized waters can be used in mineral extraction, mostly like condensed salts for bathing. In some cases (3 wells) there is amount of K and Mg ions (1 well) high enough for industrial mineral extraction. ATES can be established only in very narrow, southern part of the trough, while the Lower Jurassic formations in the Mogilno–Lodz trough are located at great depths.

4. CONCLUSIONS

Geothermal waters from the Mogilno-Lodz trough should be used in sustainable way, which consists of several, preferable cascaded, uses of water.

REFERENCES

Gorecki W (ed) (2006) Atlas of geothermal resources of Mesozoic formations in the Polish Lowlands, Wyd. AGH, Kraków

Halaj E (2015) Geothermal bathing and recreation centres in Poland. Environ Earth Sci 74:7497–7509

Karska, A., Hajto, M.: Possibilities of utilization of geothermal waters in the area of Poddębice city. Exp. Geology. Geothermics. Sust. Dev., 2,(2009), 89-99

Kepinska B (2017) Energia geotermalna – podstawa niskoemisyjnego ciepłownictwa, poprawy warunków życia i zrównoważonego rozwoju – wstępne studia możliwości dla wybranych obszarów w Polsce (in Polish)

Lund JW, Boyd TL (2015) Direct utilization of geothermal energy. Worldw Rev Geotherm 60:66–93

Sapinska-Sliwa, A. & Kurpik, J.: Current management of water and geothermal heat in Uniejow. Exp.Geology. Geothermics. Sust. Dev., 1-2, (2011), 225-235