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title: **Hydrogeological modeling as a tool to assess geothermal water resources of Lower Jurassic formation in the NW part of Poland**

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The paper presents part of PhD dissertation aiming at estimation of geothermal water and energy resources accumulated in Lower Jurassic formation in Szczecin Trough.

Geothermal resources were calculated in respective categories according to methodology accepted by European Union countries, but water resources were estimated by means of dynamic hydrogeological modeling. Visual MODFLOW 4.3 software was used as a tool to create hydrogeological model. As a result of dynamic modeling, water circulation system as well as water mass balance were established.

The foundations of the conceptual model were interpreted well log data, which enabled identification of water bearing formations within Lower Jurassic sediments together with their petrophysical parameters. The Lower Jurassic water-bearing formations are covered by younger Mesozoic formations. Only on a small fragment in the north part of analyzed area, Lower Jurassic sediments lies directly below Cenozoic formations. There is no Lower Jurassic outcrops on the area of research. Recharge area is situated on the Pomerania Anticlinorium, while drainage zones constitute Baltic Sea in the north and Odra valley in the south (Szklarczyk, Łapinkiewicz, 1995). Since model boundary and hydrodynamical boundary should be similar (Szczepański, 2008), analyzed area was widened to the boundary of underground water section.

Model consists of seven layers: six regional layers of Lower Jurassic formation and one Cenozoic layers only in areas where Lower Jurassic formation lies directly below Cenozoic sediments. The following structure of the model together with filtration coefficients were assumed:

- layer No 1 — Cenozoic — 1×10^{-5} m/s,
- layer No 2 — Lower Jurassic — kamienskie layers —2×10^{-6} m/s,
- layer No 3 — Lower Jurassic — gryfickie layers — 1×10^{-10} m/s,
- layer No 4 — Lower Jurassic — komorowskie layers — 1×10^{-5} m/s,
- layer No 5 — Lower Jurassic — lobeskie layers — 1×10^{-10} m/s,
- layer No 6 — Lower Jurassic — radowskie layers —2×10^{-5} m/s,
- layer No 7 — Lower Jurassic — mechowskie layers — 4×10^{-5} m/s.

Geothermal water accumulated in the Lower Jurassic formation in NW part of Poland is characterized by temperature range of 20–90°C and TDS ranges from 20 to 150 g/dm^3.

Distribution of reduced pressure was obtained as a result of the reduction of the actual pressure to fresh water with temperature of 20°C (Szklarczyk, Łapinkiewicz, 1995). Values of reduced water pressure of Lower Jurassic vary from below 344 atm. above the reference level in the northern area and exceed 349 atm. above the reference level in the western part of research area. Reference level has been adopted at a depth of 3,293 m which is a center of the deepest sampling interval (Szczepanski, Szklarczyk, 2006). The map showing reduced pressures was created as a result of calculations. Values of reduced pressure vary from 145 m above sea level in the northern part to more than 195 m above sea level in the western part of research area.

First-type boundary condition was applied for the first layer of the model in a regions where Quaternary sediments lie directly on Lower Jurassic formation and another layers at the boundary of the model (H = constans). Second-type boundary condition was applied for the first layer as an effective infiltration. Value of infiltration coefficient depended on Cenozoic formations' lithological type and varied from 0.08 to 0.25. The average annual rainfall was set as 600 mm (according to IMiGW). Rivers were allowed for third-type boundary condition. Calibration of the model were carried out through analyses of hydrodynamical accordance of computer simulation effects with empirical hydrogeological model. Filtration coefficient was the main property subjected to calibration. Filtration coefficient after model checking was established from 5×10^{-7} to 2×10^{-5} m/s.

In order to show amount of water circulation to individual layers, zones with particulars balance were created. At the beginning balance zones for whole model were calculated. Total inflow to the model equals 2 963 375.63 m^3/day and total outflow amount to 2 963 368.81 m^3/day. As the result, model calibration achieves balance divergence 6.82 m^3/day, what is an equivalent of 0.000227781%. In order to calculate water balance for the area of Szczecin Through additional zones were created. The results of calculations allow to asses water balance for the Szczecin Through area which was subject of interest. Total inflow to the zones of the Szczecin Through area equals 1 186.5 m^3/day and total outflow amount to 1 169 m^3/day. As the result of model verification balance divergence of 16.9 m^3/day was achieved, what is an equivalent of 1.4%. In the Szczecin Through area two main direction of water circulation are observed. In central and north part of this area water circulation runs from SE to NW direction, where Baltic Sea is drainage zone. In south part of the Szczecin Through water flow from NE to SW, where drainage zone are Odra valley in area of Lower Jurassic outcrops.

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