



GEOLOGICAL CONDITIONS OF GEOTHERMAL RESOURCES OCCURRENCE IN POLAND

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The occurrence of geothermal resources in Poland relates to four main hydrogeothermal provinces: the Polish Lowland, the Carpathians, the Carpathian Foredeep and the Sudetes, characterised by different geological conditions.. Recognition of Poland's geothermal potential on a regional scale is good, yet, in order to evaluate the capabilities of utilising geothermal waters taking into account specific local conditions, a detailed geological, hydrogeological and thermal analysis is required in each case. Sometimes, the results of this analysis bring a new look at the geological structure and hydrogeological conditions in the region of specific deposits, and indicate a slightly different approach to the question of resource evaluation of the researched deposits. Due to the location of natural resources in the subsurface, there is an appreciable amount of risk and uncertainty associated with exploration for such resources whether they are petroleum, mineral, groundwater or geothermal. There is a strong need in the geothermal sector to reduce risk and uncertainty, especially during the exploration stage.

Geothermal studies conducted in Poland since 1980's have enabled good regional recognition of Poland's geothermal potential. An important contribution to extending knowledge about geothermal resources was Geothermal Atlases published from 1990's until 2013 (Górecki (ed.) et al. 1990-2013), which enabled to recognise a geothermal potential of about 90% of Poland: the Polish Lowland, the Carpathians and the Carpathian Foredeep. Despite the fact that information on the occurrence of geothermal waters in the Sudeten region is dated to the twelfth century, the recognition of this region is point-like, and the Sudeten area has not yet received a monograph in the form of an atlas. In seven places, thermal waters have been found that flow out of the rocks of the crystalline substrate everywhere (granites, gneisses). Published set of monographs in the form of atlases constitute a perfect source of information about the occurrence of geothermal waters in different Polish regions and the basis for preparing further detailed studies at the local scale, particularly in areas predisposed for that.

One of the challenges of the geosciences is the inherent problem of incomplete knowledge of the geologic and engineering properties (geologic geometries, temperature distribution, permeability, etc.) of the subsurface (Witter et al., 2019). In areas with complex geological structure or in places with scarce availability of geological information determination of hydrogeothermal parameters is very difficult. In common practice, the geologic interpretation of an area of interest begins with the construction of a geological working model. Structural geology can play a key role in exploration for geothermal resources. As more data are obtained, the working model is added to and improved. This technique generates a geologic interpretation in an environment of high uncertainty and results in working models that are inherently non-unique. The obtained results are verified only after the geothermal reservoir has been made accessible by boreholes. In some cases, the so-called frolics of nature, i.e. situations, when the results of making a borehole can be unpredictable, may occur.

Unpredictability of hydrogeological and geothermal parameters, in various regions of Poland is confirmed by the results of works carried out at the AGH University of Science and Technology, aimed at recognising the geothermal potential in the area of Wiśniowa and in Poddębice.

The area of Wiśniowa is located in the Outer (flysch) Carpathians, characterised, on the regional scale, by a low geothermal potential, stemming from particularly low potential of water output on most of the area (Górecki et al., 2015). Complex geological structure of this region makes it additionally difficult to designation of hydrogeothermal parameters. However, analyses conducted on a local scale enable drawing of the conclusion that in some regions there is a chance of providing waters with a suitable temperature and



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output, the example of which may be the area of Wiśniowa, where during drilling behind hydrocarbons in years 1990-1991 a sudden brine outflow occurred with the output of 180 m³/h and the temperature of 85°C. The analysis conducted in the area of Wiśniowa does not give a clear answer with regard to a geothermal potential of the region. It indicates three different variants of geothermal reservoir management, dependent upon the acquired hydrogeothermal reservoir parameters. The correctness of the conducted analyzes will be confirmed in the near future when the geothermal borehole will be drilled. The results of drilling such a borehole will enable confirmation of hydrogeothermal parameters and legitimacy of the assumed solutions

In turn, in the area of Poddębice (the Polish Lowland) a geothermal heat plant has been in operation since 2010, which produces fresh waters with low mineralisation (0.4 g/L) (Posyniak, 2015). This phenomena of particularly low TDS become a subject of scientific research, due to proximity of Uniejów, where waters with much higher mineralisation have been exploited from the same reservoir for many years. The mineralisation value of the Lower Cretaceous waters increases precipitously in the north-west direction, i.e. in the area of Uniejów 1 well where it totals 21.9 g/L. This phenomenon may be related to the elevation of the Lower Cretaceous formation between Poddębice and the area of Uniejów 1 well, resulting in the accumulation of “heavy” waters high in TDS in the vicinity of the Uniejów 1 well, which due to the structural elevation (barrier) does not flow down towards Poddębice town. Moreover, the water does not flow down also towards Uniejów town as the mineralisation of exploited water varies between 6.7-8.8 g/L and water reveals on chloride-sodium type. Before the implementation of the Poddębice GT-2 well, it was impossible to predicted such value of geothermal water mineralization. In this case, the results were very positive, because the low mineralisation of geothermal water creates more opportunities for its use. However, geological risk means that geothermal parameters can also be overestimated.

In geothermal exploration, as in analogous subsurface industries, uncertainty is likely to have the most significant effect on the final interpretation of the most important geothermal factors, i.e., temperature and water flow rate.

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References

- Górecki W., (ed.) et al. 1990. Atlas of geothermal resources in the Polish Lowlands; AGH-UST, Kraków.
- Górecki W., (ed.), Hajto M., et al. 2006a. Atlas of geothermal resources of Mesozoic formations in the Polish Lowlands. AGH-UST, Kraków.
- Górecki W., (ed.), Hajto M., et al. 2006b. Atlas of geothermal resources of Paleozoic formations in the Polish Lowlands. AGH-UST, Kraków.
- Górecki W., (ed.), Hajto M., et al. 2011. Atlas of geothermal waters and energy resources in the Western Carpathians. AGH-UST, Kraków.
- Górecki W., (ed.), Hajto M., et al. 2013. Geothermal Atlas of the Eastern Carpathians. AGH KSE, Kraków
- Górecki W., (ed.), Sowizdzał A., et al. 2012. Geothermal atlas of the Carpathian Foredeep. AGH-UST, Kraków.
- Górecki W., Sowizdzał A., Hajto M., Kotyza J., 2015. Ocena możliwości pozyskania i wykorzystania wód termalnych w rejonie Wiśniowej, projekt zrealizowany na zlecenie Urzędu Gminy Wiśniowa.
- Górecki W., Sowizdzał A., Hajto M., Wachowicz-Pyzik A. 2015. Atlases of geothermal waters and energy resources in Poland/Environmental Earth Sciences SSN 1866-6280, 2015 vol. 74 iss. 12.
- Posyniak A., 2015. Annex no. 1 to Hydrogeological documentation establishing exploitation reserves of thermal water intake "Poddębice GT-2" from Lower Cretaceous formation in Poddębice. Warszawa. February 2015. Archives Geothermal Poddębice Sp. z o.o.. (in Polish).
- Witter J.B., Trainor-Guitton J. W., Siler D. L., 2019. Uncertainty and risk evaluation during the exploration stage of geothermal development: A review; Geothermics, Volume 78, March 2019, Pages 233-242.