Geothermal Energy in Uniejów - Characteristics

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Summary

The aim of the study is to present safety data sheet on geothermal energy in Uniejów.

Keywords: geothermal energy, geothermal processes, water

Introduction

In this paper we would like to bring information on renewable energy sources such as geothermal energy. The research carried out over the last several years suggests that geothermal energy is practically available throughout the country. However, not all deposits are worth exploitation. A number of conditions should be fulfilled, such as: sufficiently high water temperature and should be situated on a relatively small depth, additionally it should have low mineralization, were profitable. Most favorable mining conditions are for district heating in the region of Podhale. One of the oldest (more than 20 years old) geothermal installations in Poland are in Podhale. In this paper the authors investigate the geothermal water resources near Uniejów. In the commune and town, there are thermal baths using underground water, which works in the Polish lowland and comes from the lower Cretaceous. Rich renewable energy is used for therapeutic purposes, heating, tourist and leisure and recreation and balneology.

Characteristics of Uniejów

In the Lodz province geothermal water are situated in four areas:

- Sudety - St. Cross Mountains,
- Grudziądz-Warsaw,
- Szczecin-Lodz,
- Sudety Foothill – North St. Cross Mountains.

Uniejów is a town, with 2932 inhabitants. It is situated in the St. Cross-Sudety region on the right bank of the Warta River in north-western part of the Poddębicki County. It is located at the national road Lodz-Poznan, at a distance of approximately 51 km from Konin and 50 km from Lodz. It has good transport connections with the most popular tourist destination in the province (Poddębice - 15 km, Turek - 22 km and Dąbie - 12 km). Together with the town the municipality covers the area of 129 km^2 of the farmland (1500 agricultural holdings). One of the main advantages of the locality geothermal water is their temperature of 70°C, which are tourist attractions and constitute the basis of the development of municipality. Rich renewable energy is used for therapeutic purposes, heating, tourist and recreation as well as balneotherapy. The town is a source of services for the neighboring municipalities. It has water supply, sewerage and central heating systems as well as a modern sewage treatment station. Additionally there is a wellness complex there, as well as educational and tourist complex as well as sports and recreational center [1].

From geological point of view, Uniejów lies in the central part of the Polish lowland – Mogila-Lodz Syncline. The South-west borders are Sudety Foothill Monocline and the north-east border is the Pomerania-Kujawy Anticline (Figure 1) [5].

Geological characteristics of Uniejów

There are geothermal waters in the Uniejów sandstones of the Lower Cretaceous cliffs. In the geological structure of Uniejów there are formations of the Triassic, Permian-Zechstein, Cretaceous, Jurassic, Tertiary and Quaternary. Table 1 shows their characteristics.

Chemical composition of geothermal waters in Uniejów

In 1990s in the Town and Municipalitye of Unie-

jów two boreholes of a total output of 90m3/h, low mineralization (6.8-8.8 g/liter) and temperature of 70°C were exploited (Geotermia Uniejów). Thermal waters of the region, according to Altowski–Szwiec are chlorine-sodium waters (Figure 2). Depending on the borehole, their chemical composition can differ slightly. North-westwards the mineralization of the waters and the concentration of the chloride ions are growing. This, consequently, involves the decrease of hydro-carbonate ions.

Tables 2 and 3 present chemical composition and sensory properties of geothermal water from the borehole Uniejów PIG/AGH-2. Changes in chemical composition of thermal waters in subsequent boreholes depend on the depth. The difference in the depth of the roof of the water bearing horizon (60 m) and distance of 1950 meters between the boreholes of Uniejów PIG/AGH-2 and Uniejów IGH-1 and is not complementary to the difference in mineralization of about 23%. As-

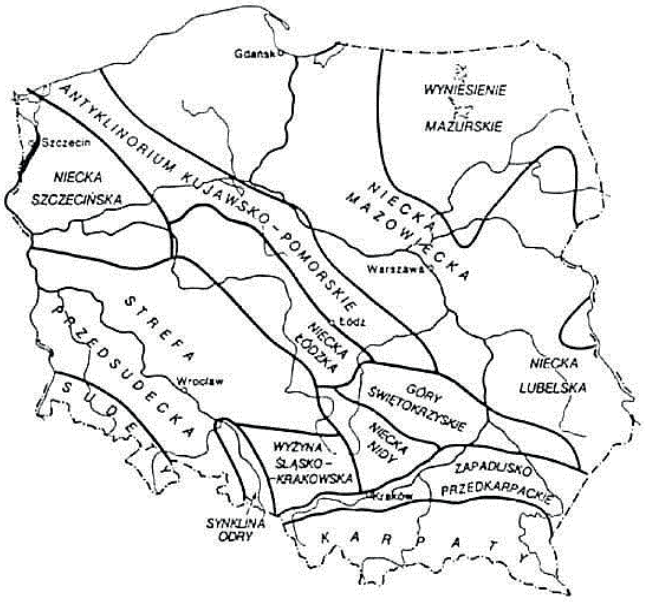

Fig. 1. Geological division of Poland [6]

Rys. 1. Geologicynz podział Polski [6]

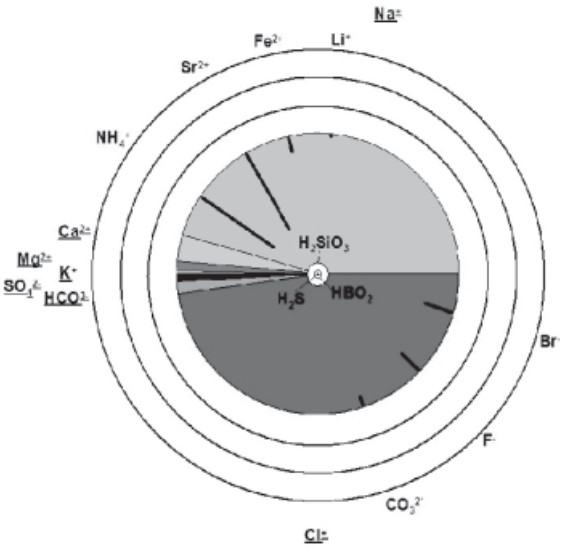

Fig. 2. Udluft circle diagram presenting the chemical composition of thermal waters exploited from the boreholes in Uniejów PIG/AGH-2 (based on the analysis of 10th March 2006), 1 mm^2 = 1 $mg*dm^{-3}$ general mineralization; the number of outer circles defines the range of the water temperature 1 – 20-40°C, 2 – 40-60°C, 3 – 60-80°C [3]

Rys. 2. Kołowy wykres Udlufta ukazujący chemiczny skład odpadów termalnych wydobytych przez otwory wiertnicze w Uniejowie PIG/AGH-2 (na podstawie analizy z dnia 10 marca 2006 r.), 1 mm^2 = 1$mg*dm^{-3}$ ogólna mineralizacja; liczba zewnętrznych kół określa zakres temperatury wody 1- 20-40°C, 2- 40-60°C, 3 – 60-80°C [3]

Tab. 1. Geological characteristics of Uniejów [3]

Tab. 1. Właściwości geologiczne Uniejowa [3]

The stratigraphic level	Geological (lithological) description
Permian-Zechstein	Zechstein formations in Mogiła-Lodz syncline are at depths of 4000-7000m. In the floor there are copper bearing shales, anhydrites and salts. Above there are shales of Z_2 cycle, followed by siltstone and mudstone level and dolomites, mudstones and anhydrites Z_3. In the roof there are salts and anhydrites.
Triassic	The floor of Triassic formations is on the depth of about 2000 m. The formations of the Lower Triassic of thickness up to 1000 m, are formed as mudstones, siltstones, sandstones, anhydrites and dolomites. Middle Triassic, of thickness about 200 m, are represented by limestones with the interlayers of siltstones and marls. The Upper Triassic formations have thickness of about 500 m and are formed as siltstones and silt and mudstone sediments.
Jura	The formations of the Lower Jurassic in the Mogiła-Łódź syncline are represented by sandstones, in the floor with the interlayers of silt mudstones and in the roof changing into silt formations. The thickness of the Liassic formations ranges from 1400 m in the Kujawy Trench to several hundred meters in its south-east part. In the north-east part of the syncline, sediments are very much reduced. The formations of the Lower Cretaceous are characterized with the deposit temperature ranging between 20 and 110 ^{o}C. Middle Jurassic occurs as silt formations, silt – mudstone and sand formations, with the interlayers of mudstones and dolomite sandstones, and in the roof – also sandy limestones. The thickness formations of Dogger varies from 100 m in the western part of the syncline, to 110 m in its eastern part. The formations of the Upper Jurassic are predominantly represented by sandy, rocky or marl limestones, marls, dolomite marls, siltstones, mudstones and – in the w north part of the syncline - gypsum and anhydrites. The thickness of the Malm formations ranges from about 600 to 1000 m in the east of the syncline. The oldest Jurassic formations recognized in Uniejów are the Upper Jurassic formations represented by dolomite limestones and limestones. In the roof there are interlayers of oolitic limestones.
Cretaceous	The formations of Lower Cretaceous are represented by sandstones of different granulation with the interlayers of mudstones and siltstones. The sandstones of Lower Cretaceous (Barremian – Middle Albian) in the whole Mogiła-Łódź Syncline make a good water-bearing horizon. The thickness ranges from several to 130 m. Win the region of Uniejów the thickness of the Lower Cretaceous formations (without the upper Albian) ranges from 117.9m in borehole PIG/AGH-2 to 124 m borehole IGH-1. The main formations include: sandstones, usually brown, fine grained, with the intrusions and interlayers of siltstones and mudstones as well as intrusions of siderites and pyrite. The Lower Cretaceous formations start from sandstones and go to the Gopło link „B". Above there is a monotonous series of sandstones, counted among the Kruszwica link „C". These are sandstones of various grain size with the intrusions of gravel stones, usually poorly compact. Among these sandstones there is a thermal water intake in Uniejów. In the region of the Kujawy Ridge, the thickness of the Lower Cretaceous formations is above 300m, on the north of the syncline the thickness is 600 m. The formations of the Upper Cretaceous are usually formed as marls, organogenic silica and limestones. Their thickness ranges from 2400 m in the central part of the syncline to about 200 m on its wings. In Uniejów the thickness of the Upper Cretaceous formations ranges from 1837.1 m in borehole Uniejów PIG/AGH-a to 1908.5 m in borehole Uniejów IGH-1. As floor formations of the Upper Cretaceous quartz-glauconitic sandstones with phosphorus concretions were taken. Upwards they change into sandy marls and marls with fauna. The Cenomanian formations are marl limestones with the intrusions of limestones and marls, The Turonian formation on the bottom have marl siltstones and above marl limestones with the intrusions of marls. In the roof there are interlayers of organogenic silica rocks.
Tertiary	In the area of the Mogiła-Łódź Syncline these formations are formed as silts and sands, in some places with the intrusions of lignite, of thickness from several to 120 m. In Uniejów the thickness of Tertiary deposits ranges from 18 m in borehole Uniejów IGH-1 to 35.5 m in borehole Uniejów PIG/AGH-1.
Quaternary	The Quaternary deposits occur in the whole area of the Mogiła-Łódź syncline and make the cover of thickness from several to above 300 m. In Uniejów the thickness of these formations ranges from 14 to 30 m, it is mainly made of deposit clays and sands.

Tab. 3. Chemical composition of geothermal water from borehole PIG/AGH-2 in Uniejów [2]

Tab. 3. Skład chemiczny wód geotermalnych z otworów wiertniczych PIG/AGH-2 w Uniejowie [2]

Cations	**mg/dm^3**	**mval**	**mval %**
Ammonium NH_4^+	0.05	0.00	0.00
Sodium Na^+	2300.00	100.04	94.09
Potassium K^+	21.00	0.54	0.51
Calcium Ca^{2+}	70.14	3.50	3.29
Magnesium Mg^{2+}	25.52	2.10	1.98
Strontium Sr^{2+}	3.92	0.09	0.08
Lithium Li^+	0.201	0.03	0.03
Iron Fe^{2+}	0.45	0.02	0.02
Manganese Mn^{2+}	0.05	0.00	0.00
Barium Ba^{2+}	0.115	0.00	0.00
Mercury Hg^{2+}	<0.001	-	-
Selenium Se^{2+}	<0.01	-	-
Cobalt Co^{2+}	<0.004	-	-
Arsenic As^{3+}	<0.015	-	-
Cadmium Cd^{2+}	<0.003	-	-
Chromium Cr^{3+}	<0.004	-	-
Copper Cu^{2+}	<0.004	-	-
Nickel Ni^{2+}	<0.004	-	-
Lead Pb^{2+}	<0.015	-	-
Antimony Sb^{2+}	<0.0072	-	-
Zinc Zn^{2+}	<0.004	0.00	0.00
Aluminum Al^{3+}	<0.005	-	-
Total	2421.45	106.32	100
Anions	**mg/dm^3**	**mval**	**mval %**
Fluorides F^-	0.65	0.03	0.04
Chlorides Cl^-	3686.80	104.00	97.68
Bromides Br^-	1.80	0.02	0.02
Iodides J^-	0.42	0.00	0.00
Hydro-carbonates HCO^{3-}	140.50	2.30	2.16
Sulfates SO_4^{2-}	5.18	0.11	0.10
Nitrites NO_2^-	<0.005	-	-
Nitrates NO_3^-	<0.20	-	-
Phosphates NO_4^{2-}	<0.05	-	-
Cyanides CN^-	<0.01	-	-
Total	3835.35	106.46	100

Non-dissociated components	**mg/dm^3**
Meta-boric acid HBO_2	<0.5
Meta-silicic acid h_2sio_3	6.10

Volatile components	**mg/dm^3**
Carbon dioxide CO_2	Not found
Sulfur compounds S(II) H_2S + HS	<0.05
Total of dissolved solid components	6262.90 mg/dm^3
Chlororganic pesticides	**ng/dm^3**
Lindane	<16
Heptachlor	<15
Aldrin	<15
Heptachlor epoxide	<15
Dieldrin	<11
Metoxichlor	<16
Polycyclic hydrocarbons	**ng/dm^3**
Aromatic	<2.5
Benzo(a)pyrene	<2.5
Benzo(b)fluoranthene	<2.5
Benzo(k)fluoranthene	<2.5
Benzo(ghi)perylene	<2.5
Other	**mg/dm^3**
Phenols	<0.01
Anion detergents reacting with the methylene blue	<0.01

Tab. 2. Sensory and physic-chemical properties of geothermal waters from borehole PIG/AGH-2 in Uniejów [2]

Tab. 2. Właściwości sensoryczne i fizykochemiczne wód geotermalnych z otworów wiertniczych PIG/AGH-2 w Uniejowie [2]

Color (mg Pt)	0
Taste	salty
Smell	Very weak kerosene-like
Reaction - pH	7.20 (22°C)
Water temperature (°C)	68°C
Redox potential E_h (mV)	-51.9 (22°C)
Electric conductivity (S/cm)	12.06×10^{-3}
Absorbance ë=254 (nm)	0.059
Absorbance ë=436 (nm)	0.005

cenization of deeper levels of the Lower Creataceous can cause mineralization in the north-west direction [2],[3],[4].

Temperature, mineralization and efficiency of a spontaneous outflow are parameters of thermal water deciding beneficial influence on the process of the exploitation of this deposit.

Conclusions

In the energy balance of Poland the increase of the participation of renewable energy should include geothermal energy. Due to the obligations within the European Union, until 2020 geothermal energy should play the same role in municipal heating systems as nowadays wind turbines play in power supply systems. Geothermal energy will be commonly used. All the resources of geothermal energy have been documented, in particular a lot of studies were carried out on the Polish Lowlands.

The commune Uniejów is situated on the water-bearing horizon of the Lower Cretaceous, with good geologic and deposit parameters. In this region the discovery of geothermal waters took place 36 years ago. With years, due to exceptional chemical composition of water and its physical properties, the use of geothermal waters is more and more divert. One of new products, which can be introduced to the market are cosmetics produced based on the Uniejów water. They can be the element supplementing its exploitation. Additionally selling of these products on the national scale can promote the region of Uniejów.

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Energia geotermalna w Uniejowie – właściwości

Celem badań jest zaprezentowanie arkuszu danych bezpieczeństwa w odniesieniu do energii geotermalnej w Uniejowie.

Słowa kluczowe: energia geotermalna, procesy geotermalne, woda