ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 2009
Seria: GÓRNICTWO z. 287 Nr kol. 1814

Ján PINKA, Gabriel WITTENBERGER, Marina SIDOROVÁ
Fakulta BERG, TU Košice, SR

EVALUATION OF GEOTHERMAL POTENTIAL IN THE SURROUNDINGS OF KOŠICE TOWN, SLOVAKIA

Summary. The utilization of geothermal energy brings important benefits in the fields of environment, recreation and economics. This paper describe about evaluation of geothermal potential for resource utilization of geothermal potential in the northern part of Košice town that presently serves as an urban recreation zone called Anička. The following paper shows analysis of geothermal conditions in a suburb of Košice town in Slovakia.

OCENA POTENCJAŁU GEOTERMALNEGO OKOLIC KOSZYC, SŁOWACJA

Streszczenie. Wykorzystanie energii geotermalnej jest bardzo korzystne ze względów środowiskowych i ekonomicznych, a także istotne dla rekreacji. W artykule dokonano waloryzacji potencjału źródeł geotermalnych w północnej części miasta Koszyce. Jest to obecnie strefa rekreacyjna Anička, służąca miastu Koszyce. Przedstawiono również warunki geotermalne okolic Koszyc na Słowacji.

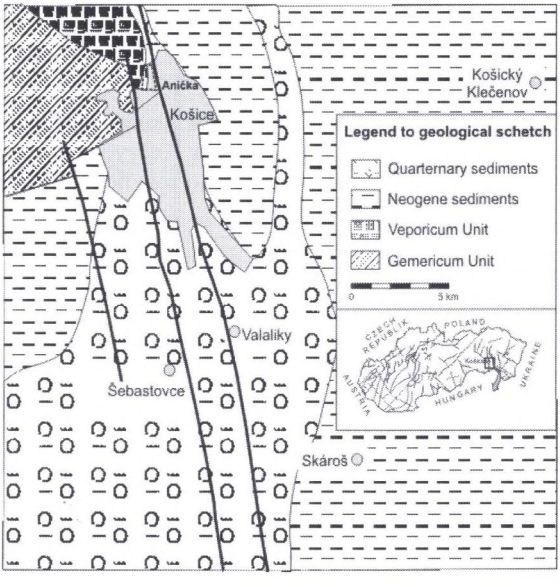
1. Introduction

Utilization of green energy is presently on the top of worldwide agenda. This strong movement is due to economic reasons mostly related to an efford to find substitution to fossil fuels as well as due to environmental reasons connected with global climatic changes. This movement is also observable in the Slovakia. One of the most advancing branch in the field of green energy in the Slovakia is utilization of geothermal energy. It is because of several reasons; the most important one is very good geothermal condition in the Slovakian part of the Western Carpathians. Several geothermal wells were performed during the last few years

and many wells are still planned. The utilization of geothermal energy brings important benefits in the fields of environment, recreation and economics.

Because investments for all works related to exploitation of geothermal energy are relatively high (costs for geophysics, drilling, engineering and other technical works), initial geological investigation with following feasibility study are necessary in order to lower the investment risk. The following paper shows analysis of geothermal conditions in a suburb of Košice town, Slovakia. The main aim of the study was complex evaluation of all geological (and geothermal) knowledge from the given locality and its close vicinity. This consists of an evaluation of surface and subsurface geologic structure, hydrogeological and geothermal conditions based on mapping and archive wells. The obtaned results are used for recommendation for localization of a planned geothermal well in this area [1] , [2].

The presented study area for evaluation of geothermal potential is located in the northern part of Košice town that presently serves as an urban recreation zone called Anička (Fig. 1). Košice town lies on the western margin of the East-Slovakian Basin and is situated on the junction of several geologic units importantly influencing geothermal potential in this area. It also belongs to the three geomorphologic units differing by relief. The Košice Depression is in this part typical by flat relief of flood plain belonging to the Hornád river.



The pre-Quaternary structure of the Depression is composed of Neogene sedimentary rocks. The Hornád river enters the depression from another geomorphologic unit – Čierna hora Mts. The Čierna hora Mts., formed by Paleozoic rocks and their Mesozoic cover (Veporicum Unit), has typical upland relief. The northwestern margin of Košice town is predominantly formed by geomorphological unit of Volovské vrchy Mts. mostly consisting paleozoic rocks of Gemericum Unit.

Fig.1. Location and geological map of study area
Rys.1. Loklaizacja i mapa geologiczna opisywanego obszaru

2. Geothermal conditions of Košice depression

Košice Depression has an important potential from the viewpoint of geothermal energy. In the wider area of Košice town several geothermal sources occurs that have high economic potential. Some of them represent unique sources of geothermal energy in the Central Europe.

The most perspective source of the geothermal energy occurs near Ďurkov village, some 20 km east of Košice. In this area three geothermal wells were drilled – GTD-1, 2 and 3 waiting for their commercial utilization. In the well GTD-1 water temperature is 125°C, the water discharge is 56 ls^{-1} with overflow. The mineralization is 30 gl^{-1} with 96% content of $C0_2$. The well GTD-2 well, localized west of the GTD-1, showed following data: the water temperature is 124°C and water discharge 70 ls^{-1}. The mineralization of thermal water is 28 g l^{-1} , the content of CO_2 is 98%. The reservoir rocks are represented by dolomites of the Veporicum envelope encountered in depth 2850 – 3150 m. The well GTD-3 has discharge 150 ls^{-1} and water temperature 126°C.

Further localities with indication of geothermal water in the surroundings of the study area are:

1. Locality Valaliky occurring in the southern margin of Košice town with the geothermal spring Koscelek. The spring has discharge 7.8 – 8.5 ls^{-1} and temperature 18.1°C. According to the long-term monitoring, the temperature is constant.
2. Locality Skároš occurs 12 km NE of Košice in the surroundings of Skároš village. In the hydrogeological well SHJ-1 the water discharge is 6 ls^{-1} and water temperature 21°C. The reservoir rocks is represented by andezite pyroclastics. The spring is utilized for drinking water.
3. Locality Šebastovce occurs 2 km south of Košice where areal spring has discharge 1.1 – 21.5 ls^{-1} with water temperature 18 – 19.5°C.
4. Locality Košický Klečenov occurs 15km east of Košice. Two wells were drilled here – KSJ-3 and KSB-3 with overflow discharge 4 ls^{-1} and water temperature 17.2°C to 23.1°C. The reservoir rocks area also represented by andezite pyroclastics.

3. Hydrogeologic conditions

The lithology of rocks forming the geological structure of the studied area as well as tectonic deformations are main factors influencing the type of water circulation in the area. Based on hydrogeologic investigation, realized in 1981, it is possible to state that crystalline and paleozoic rocks of Veporicum and Gemericum Units (Fig. 1) have low water-saturation. Their water-saturation is mostly restricted to the zone of surface fissures and weathering rind.

The Mesozoic rocks are mostly represented by Middle and Late Triassic carbonates. They have good conditions for infiltration of precipitation water and groundwater circulation.

The Neogene sediments are mostly represented by mudstones practically without accumulation and circulation of water and thus, the can be marked as barrier boundary.

The Quaternary fluvial sediments of Hornád river have a continuous relatively permeable rocks represented by sandy gravel. The permeability of gravel is high and the filtration coefficients are in orders of 10^{-4} to 10^{-3} m/s. The discharge of wells in the Košice Depression is from 7 to 12 ls^{-1} by lowering of water level in 2.5 – 3.0 m.

4. Data based on drilled wells in the studied area

There are relatively high amount of wells drilled in the Košice Depressions. In most cases the wells were drilled only for getting the water and there was no special well drilled in order to confirm the geothermal potential of the area. However, after drilling of the well G-5 Anička (Fig. 2) some interesting results were obtained that coresponds to the geothermal data from the wider surroundins of the Košice Depression.

4.1. Well G-5 (recreation area Košice – Anička)

The main aim of the well was to obtain a source of mineral water. The well is 30 m deep and its profile shows Qauternary, mainly fluvial sediments overlying Middle and Late Triassic dolomites of Veporicum. The mean discharge is 0.08 ls^{-1} e.g. 4.5 l/min. The total dissolvent solid is 3600 mgl^{-1}, the CO_2 content was 1200 mgl^{-1} and water temperature is 12.4°C.

The perforation and opening of the depth interval from 8.0 m to 10.0 m resulted in mixture of waters from Quaternary deposits with deep groundwaters and following lowering of mineralization to 655 mgl^{-1} and increased discharge 1.11 ls^{-1}.

Fig. 2. Košice – Anička, map of well distribution
Rys. 2. Koszyce – Anička, lokalizacja odwiertów

The water from the well is weakly mineralized (3.6955), weakly ACID (pH=6.42) and cold. The occurrence of HYDROSULHIDE (5.1 mg/l) classifies the water to the medium HYDROSULHIDE.

Based on PALMER's classification the groundwater is of calcium-magnesium-hydrogeneoxidcarbonate type. The HYDROCHEMICAL COEFFICIENT CL/Na+0.75 shows metamorphous infiltrated water with influence of Neogene sediments. The BACTERIOLOGICAL contents of the water is suitable.

Radiologic properties of mineral water showed slight increase, however, the admissible daily amount is 1.5 l water per day.

The main source rock for described mineral waters is Mesozoic dolomite belonging to the geologic unit of Čierna hora Mts. The dolomites are a part of envelope of crystalline and paleozoic rocks. They crop out on surface in the massif of Čierna hora Mts. where they probably represent the main infiltration zone. The mineral water ascends to the surface along the marginal Hornád faults system of N-S direction.

4.2. Well G-4 (recreation area Košice – Anička)

Well G-4 at locality Anička is deep 310 m. The uppermost part of the sedimentary succession penetrated by the well is composed of Quaternary fluvial deposits deposited by Hornád river. Beneath these sediments grey, palish-grey strongly fissured dolomites occur down to the base of the well representing the main resource rocks. The water discharge from the dolomites is 4 ls^{-1} and the temperature of water is 26°C. The water is weakly mineralized (4.497 gl^{-1}, see Tab. 1). The CO_2 content is1300 – 1780 mgl^{-1}. The H_2S content is from 11.1

to 23.94 gl^{-1}. According to the PALMER's classification it is of hydro-carbonate-chloride-natrium-carbonate-magmesium type. The water has slightly increased radioactivity 1.32 – 3.04 Bql^{-1}.

At the moment the water source is open and the water freely effluents on the surface.

Table 1

Chemical analysis of water from well G-4.

Cations			Anions		
M	mg/l	mmol/l	A	mg/l	mmol/l
Li	-	-	F	1,44	0,0758
Na	498,0	21,6616	Cl	553,02	15,5969
K	47,30	1,21	SO4	348,95	7,2648
NH4	1,30	0,0721	NO2	0,01	-
Ca	413,63	20,6400	NO3	0,50	0,0081
Mg	187,75	15,440	PO4	0,82	0,0006
Fe	0,20	0,0072	HCO3	2202,75	36,1000
Mn	0,45	0,0164	CO3	0,0	0,0000
Sr	-	-	OH	0,0	0,0000
Noble elements					
	mg/l		mg/l		mg/l
Ba	-	Ag	0,009	Cu	0,918
Zn	0,021	Cd	0,010	Pb	0,001
V	-	As	0,270	Se	0,003

4.3. Hydrogeological wells HPL (recreation area Košice – Anička)

Hydrogeological wells HPL-1, HPL-2, HPL-3 and HPL-7 were drilled with main aim to obtain waer for natural swimming pool „Ryba". Based on the wells the fluvial Quaternary sediments are underlain by quartzite sand and carbonates assigned to Middle and Upper Triassic unit of Čierna hora Mts.

HPL-1 well discharges strongly mineralized (1084 mgl^{-1}), slightly acid (pH=6.7) water with temperature 14.0°C by air temperature 20°C. According to PALMER's classification it belongs to calcium-magnesium-bicarbonate type.

HPL-2 well gives strongly mineralized water (962.32 mgl^{-1}) with pH=6.5 and temperature 14°C at the air temperature 20°C. According to PALMER's classification the water belongs to this same type as in the previous well.

HPL-3 well gives strongly mineralized water (1041 mgl^{-1}) with pH=6.5 and temperature 13.0°C at the air temperature 20°C. This is the same type as the water from HPL-1 and 2.

HPL-7 well gave water with 944.97 mgl^{-1} , pH=6.6 and temperature 14.0°C at the air temperature 20°C.

5. Geological structure in wider surroundings of recreation area Košice – Anička

The knowledge on geological structure in the wider area of Anička comes from surface geology and existing wells. The entire study area is covered by young, Quaternary fluvial sediments of Hornád river. According to existing wells the Quaternary sediments are underlain by Mesozoic dolomites (Fig. 1). These are the main relatively permeable rocks in the area due to their cavernous structures. Because small depth of this relatively permeable rocks, the circulating waters are considerably influenced by surface temperature. The extend of dolomites is assumed from the northern margin of Košice town southward to the central train station in the town. We assume that the dolomites are bounded by N-S and NE-SW faults. The most expressive fault system is N-S Hornád fault system. It represents the western boundary of the East-Slovakian Basin and strikes from Prešov in the north southward to Košice.

The second fault system of NE-SW direction is less striking, however, it had an important role for segmentation of rock blocks in this region. We assume that beneath the described dolomites Lower Triassic rocks belonging to the Veporicum envelope occur. They are probably represented by Lunz Beds, Ramsau Dolomites with thickness ca. 220 m and at the base by quartsoze sandstones of Lower Triassic. Beneath the Veporicum envelope we assume Brusno Formation consisting of greyish viollet wacke, shales with interlyers of sansdstone and conglomerates. These rocks represent a „normal" bed succession known from the emerged part of the Veporicum Unit in the Čierna hora Mts.. However, it is possible that a part of this succession may miss due to compression and removal of Veporicum Unit during its evolution. The thickness of this complex may be 400 – 200 m.

Beneath these envelope rocks Paleozoic phylites and amfibolites of Lodiná Complex belonging to Čierna hora Mts. occur.

6. Assumed geothermal potential in the recreation areal of Košice - Anička

The locality Košice - Anička is a part of geothermal structure of Košice Depression. It occurs in its marginal position influencing the smaller geothermal gradient. The position also influences the hydrogeological conditions: the main reservoir rocks, represented by Triassic dolomites, occur in shallow position. The underlying rocks have much smaller potential to be a good hydrogeological reservoir. Another complication represents tectonic contact between dolomites and underlying crystalline rocks that may cause complication during drilling. The expected geological profile in this area is as follows:

0 – 350 m	dolomite, dolomitic limestone
350 – 600 m	Permian and Lower – Midlle Triassic sediments
600 and deeper	crystalline rocks of Veporicum Unit.

Based on the data from the well G-4 as well as data from other wells in the vicinity of Košice town described above, assumed subsurface temperatures were calculated.

In 500 m depth we assume water temperature between 25- 28°C . The geological structure consists of rocks belonging to the Veporicum envelope. In these rocks we expect good discharge of water.

In depth 1000 m below surface we assume water temperature between 38- 42°C. The water discharge will be lower because the main rock types are crystalline rocks of Čierna hora Mts.

In 2000 m depth we expect water temperature 70 – 76°C. The lithology is probably this same like in the depth 1000.

Acknowledgement. The paper is a part of AV project Grant agency of Slovakia No. 4/2021/08.

BIBLIOGRAPHY

1. Pinka J., Janočko J., Jacko S.: Overenie a možnosti využitia geotermálnych vôd v okolí lokality prislúchajúcej spoločnosti Tatranský Permon a.s. na Podbanskom. Geocom, Košice 2006, p. 38.
2. Pinka J., Janočko J., Jacko S.: Možnosti využitia geotermálnych vôd v Košiciach a blízkom okolí. Geocom, Košice 2006, p. 39.

Recenzent: Prof. Ing. Petr Bujok, CSc. HGF, VŠB-TU OSTRAVA