

**УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ“ – ШТИП
ФАКУЛТЕТ ЗА ПРИРОДНИ И ТЕХНИЧКИ НАУКИ**



**Природни ресурси и технологии
Natural resources and technology**

**декември 2017
December 2017**

**ГОДИНА 11
БРОЈ 11**

**VOLUME XI
NO 11**

**UNIVERSITY “GOCE DELCEV” – STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES**

ПРИРОДНИ РЕСУРСИ И ТЕХНОЛОГИИ
NATURAL RESOURCES AND TECHNOLOGY

За издавачот

Проф. д-р Зоран Десподов

Издавачки совет

Проф. д-р Блажо Боев

Проф. д-р Зоран Панов

Проф. д-р Борис Крстев

Проф. д-р Мирјана Голомеова

Проф. д-р Благој Голомеов

Проф. д-р Зоран Десподов

Доц. д-р Дејан Мираќовски

Проф. д-р Кимет Фетаху

Проф. д-р Ѓорѓи Радулов

Editorial board

Prof. Blazo Boev, Ph.D

Prof. Zoran Panov, Ph.D

Prof. Boris Krstev, Ph.D

Prof. Mirjana Golomeova, Ph.D

Prof. Blagoj Golomeov, Ph.D

Prof. Zoran Despodov, Ph.D

Ass. Prof. Dejan Mirakovski, Ph.D

Prof. Kimet Fetahu, Ph.D

Prof. Gorgi Radulov, Ph.D

Editorial staff

Prof. Zoran Panov, Ph.D

Prof. Boris Krstev, Ph.D

Prof. Mirjana Golomeova, Ph.D

Prof. Blagoj Golomeov, Ph.D

Prof. Zoran Despodov, Ph.D

Ass. Prof. Dejan Mirakovski, Ph.D

Редакциски одбор

Проф. д-р Зоран Панов

Проф. д-р Борис Крстев

Проф. д-р Мирјана Голомеова

Проф. д-р Благој Голомеов

Проф. д-р Зоран Десподов

Доц. д-р Дејан Мираќовски

Главен и одговорен уредник

Проф. д-р Мирјана Голомеова

Managing & Editor in chief

Prof. Mirjana Golomeova, Ph.D

Јазично уредување

Даница Гавриловска-Атанасовска

(македонски јазик)

Техничко уредување

Славе Димитров

Благој Михов

Language editor

Danica Gavrilovska-Atanasovska

(macedonian language)

Technical editor

Slave Dimitrov

Blagoj Mihov

Редакција и администрација

Универзитет „Гоце Делчев“ - Штип

Факултет за природни и технички науки

ул. „Гоце Делчев“ 89, Штип

P. Македонија

Address of the editorial office

Goce Delcev University - Stip

Faculty of Natural and Technical Sciences

Goce Delcev 89, Stip

R. Macedonia

Содржина

Стојанче Мијалковски, Зоран Десподов, Ванчо Ациски, Николинка Донева НАЧИНИ ЗА ИЗРАБОТКА НА ГЕОДЕТСКИ ПОДЛОГИ ЗА ПОТРЕБИ ВО РУДАРСТВОТО И ГЕОЛОГИЈАТА	5
Николинка Донева, Зоран Десподов, Дејан Мираковски, Марија Хаци-Николова, Дејан Ивановски УТВРДУВАЊЕ НА ЕФЕКТИТЕ ОД ИЗРАБОТКА НА ХОДНИК ВО РУДА И ЦИПОЛИН СО ПРИМЕНА НА РАЗЛИЧНИ СИСТЕМИ ЗА ИНИЦИРАЊЕ	17
Ванчо Ациски, Зоран Десподов, Дејан Мираковски, Стојанче Мијалковски МЕТОДОЛОГИЈА ЗА СИМУЛАЦИЈА НА КАМИОНСКИОТ ТРАНСПОРТ ВО РУДНИЦИТЕ ЗА ПОДЗЕМНА ЕКСПЛОАТАЦИЈА	25
Иван Боев, Блажко Боев СИЛИЦИСКИ ВУЛКАНИЗАМ НА КОЖУФ ПЛАНИНА ДОКАЖАН СО ПРИСУСТВОТО НА ТРИДИМИТ И ПЕРЛИТ ВО ВИСОКО-SiO₂ СЕДИМЕНТНИТЕ КАРПИ ВО КАЛДЕРАТА АЛШАР	33
Тена Шијакова-Иванова, Филип Јовановски, Виолета Стојанова, Виолета Стефанова, Крсто Блажев МИНЕРАЛОШКО-ПЕТРОГРАФСКИ КАРАКТЕРИСТИКИ НА ГРАНОДИОРИТИТЕ ВО БЛИЗИНА НА С.БОНЧЕ, ПРИЛЕП	43
Виолета Стојанова, Гошо Петров, Тена Шијакова-Иванова МИКРОФОСИЛИ И НИВНА ПРИМЕНА ВО ИСТРАЖУВАЊЕТО НА НАФТА И ГАС	51
Воjo Мирчовски, Горги Димов, Дарко Герасимов EXPLOITATION AND HYDROGEOLOGICAL PARAMETERS OF HYDROGEOTHERMAL SYSTEM SPA KEZHOVICA - STIP	57
Благица Донева, Марјан Делипетрев, Горги Димов, Крсто Блажев ГРАВИТАЦИСКО ПОЛЕ НА РЕПУБЛИКА МАКЕДОНИЈА	67
Крсто Наумовски, Борис Крстев, Горан Басовски, Тијана Тодева, Александар Крстев СОСТОЈБИ И ВЛИЈАНИЕ ОД ИНДУСТРИСКИ ПРОЦЕСИ И АТМОСФЕРСКИ ПРИЛИКИ НА АЕРОЗАГАДУВАЊЕТО ВО СКОПСКИОТ И ПОЛОШКИОТ РЕГИОН	75
B.Krstev, K. Naumovski, A. Krstev, B. Golomeov, M. Golomeova, A. Zendelska, T. Todeva AIR POLLUTION IN SURROUNDING ENVIRONMENT OF DOMESTI MINES – AMBIENT AIR AND PLANT DUST	83
Славица Михова, Марија Хаци-Николова, Дејан Мираковски, Николинка Донева ПЕРСОНАЛНА ИЗЛОЖЕНОСТ НА БУЧАВА НА РАБОТНИЦИТЕ ВО МЕТАЛНАТА ИНДУСТРИЈА.....	89

Иван Боев, Блажо Боев	
ХЛОРАРГИРИТ И АКАНТИТ ВО ПМ-10 ЧЕСТИЧКИТЕ ВО ОБЛАСТА ТИКВЕШ	95
Сања Симевска, Мирјана Голомеова, Афродита Зенделска	
КОНТРОЛА НА КВАЛИТЕТОТ НА ВОДАТА ВО ПСОВ - БЕРОВО	101
Зоран Стоилов, Борис Крстев, Мирјана Голомеова, Афродита Зенделска	
ИСПИТУВАЊЕ НА КВАЛИТЕТОТ НА ПОДЗЕМНИТЕ ВОДИ ВО	
ДЕЛ ОД ИСТОЧНА МАКЕДОНИЈА.....	113
Ацо Јаневски, Крсто Блажев, Киро Мојсов, Дарко Андроников	
ДОБИВАЊЕ НА СИЛИЦИУМ ДИОКСИДОТ ОД ОРИЗОВА ЛУШПИ	121
Марија Миленкоска, Зоран Десподов	
ЛОГИСТИЧКАТА ПОДГОТВЕНОСТ НА КЛУЧНИТЕ ИНСТИТУЦИИ ВО	
ОПШТИНА ШТИП ЗА УПРАВУВАЊЕ СО КРИЗНИ СОСТОЈБИ	127
Петар Намичев, Екатерина Намичева	
КОНСТРУКТИВНИ КАРАКТЕРИСТИКИ НА ТРАДИЦИОНАЛНАТА	
ГРАДСКА КУЌА ОД 19-ОТ ВЕК ВО ШТИП	139

EXPLOITATION AND HYDROGEOLOGICAL PARAMETERS OF HYDROGEOTHERMAL SYSTEM SPA KEŽHOVICA - STIP

Vojko Mircovski¹, Gorgi Dimov¹, Darko Gerasimov¹

¹ Faculty of Natural and Technical Sciences, Institute of Geology,
“Goce Delcev” University in Stip Blvd. Goce Delcev 89, Stip, Republic of Macedonia,
vojo.mircovski@ugd.edu.mk

Стручен труд УДК: 551.23

Abstract

This paper presents the exploitation and hydrogeological parameters of hydrogeothermal system of the spa Kežovica, which are calculated based on data obtained by the pump testing of the four exploitation wells that are located within this system, labeled as B-1, B-2, B-3 and S-3.

The individual exploitation capacity of the wells is for B-1 - 1,7 l/s; for B-2 - 12,5 l/s, B-3 - 8,9 l/s and for S-3 - 3,3 l/s, and the total capacity of exploitation of all wells is 26,4 l/s.

The coefficient of filtration of the aquifer medium is within ranges of 0,034 - 2,25 m/day, the transmissibility ratio is from the 3,3 to 38,29 m²/s, and the radius of the influence of the wells is in range from 49 to 155 m.

The temperature of the thermomineral is from 52 to 62 °C.

Key words: *exploitation wells, hydrogeothermal system, spa Kežovica, hydrogeological parameters, coefficient of filtration, radius of influence, coefficient of transmissibility*.

ЕКСПЛОАТАЦИОНИ И ХИДРОГЕОЛОШКИ ПАРАМЕТРИ НА ХИДРОГЕОТЕРМАЛНИОТ СИСТЕМ НА БАЊАТА КЕЖОВИЦА – ШТИП

Војко Мирчовски¹, Гоѓи Димов¹, Дарко Герасимов¹

¹Факултет за природни и технички науки, Институт за геологија, Универзитет „Гоце Делчев”, Штип
бул. Гоце Делчев 89, 2000 Штип, Република Македонија
vojo.mircovski@ugd.edu.mk

Апстракт

Во овој труд се презентирани експлоатационите и хидрогеолошките параметри на хидрогеотермалниот систем на бањата Кежовица, кои се пресметани врз основа на податоците добиени со тестирањето на четири експлоатациони бунари кои се наоѓаат во рамките на овој систем, означени како B-1, B-2, B-3 и S-3. Поединечниот експлоатационен капацитет за бунарите изнесува за B-1 1,7 l/s; B-2 12,5 l/s, B-3 8,9 l/s и за S-3, 3,3 l/s, а вкупниот експлоатационен капацитет за сите бунари изнесува 26,4 l/s. Кофициентот на филтрација за водоносната средина се движи во рамките од: 0,034 – 2,25 m/den, кофициентот на трансмисивност од 3,3 – 38,29 m²/s, а радиусот на влијание кај бунарите се движи од 49 – 155 m. Температурата во бунарите е во рамките од 52 – 62 °C.

Клучни зборови: *експлоатацијски бунари, хидрогеотермален систем, бања Кежовица, хидрогеолшки параметри, кофициент на филтрација, радиус на влијание, кофициент на трансмисивност.*

1. Introduction

Hydrogeothermal system of the spa Kežovica is located in the eastern part of Macedonia near Novo Selo about 2,5 km southwest of the city of Stip (Fig.1).

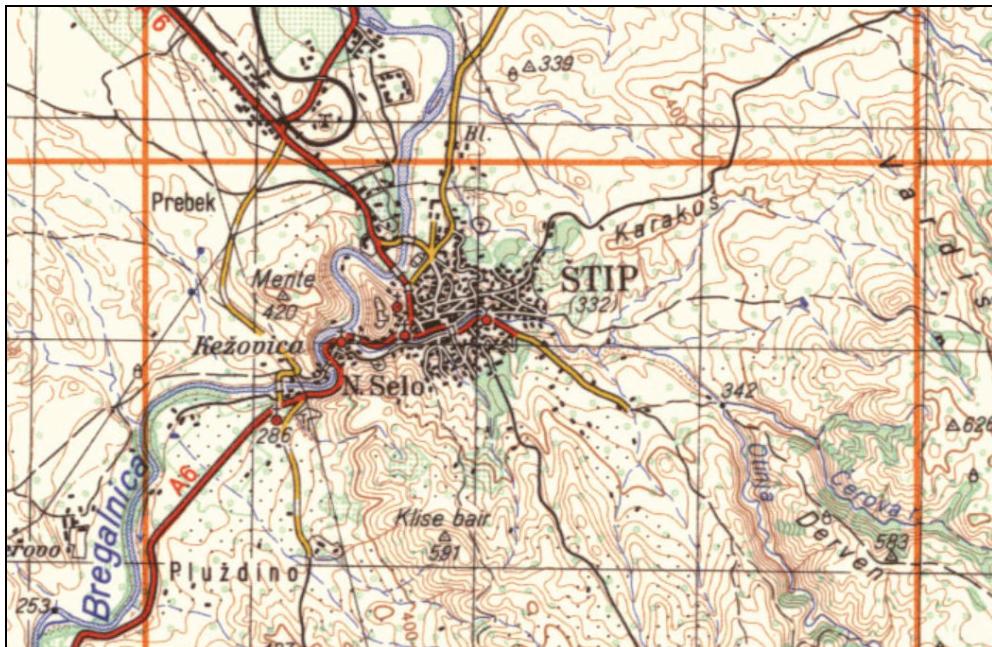


Figure 1. Geographical position of the hydrogeothermal system of the spa Kežovica

Within this hydrogeothermal system, there are four wells from which can be exploited thermalmineral water, labeled as B-1, B-2, B-3 and S3.

The wells B-1 and S-3 are located near the spa Kežovica Fig. 2 and thermomineral water are used for the spa and physical therapy. The other wells labeled as B-2 and B-3 are on site Ldzhi near the river Bregalnica (Fig.3). Thermomineral water from these two wells currently is not used. At this site near the well B-2 (Fig. 3) is located a spring with thermomineral water used by the local population of Novo Selo.



Fig.2. Exploitation wells B-1 and S-3 in the spa Kežovica yard.



Fig.3. Exploitation wells B-2 and B-3 at a site Ldzhi near the river Bregalnica.

In the past, a growing number of researchers have studied the thermaomineral waters from the spa Kežovica and locality Ldzhi: Miloevik (1953), Miholik (1953), Baik (1955), Netkov (1968), Nastic (1968), Gjuzelkovski and Strackov (1973), Kotevski (1974, 1983), Kekik and Mitev (1973-1978), Gjordjieva (1995): Mirchovski et. all. (2001-2002, 2016).

2. Exploitation wells

All four wells are made from Geological Institute in Ljubljana. Well S-3 was made in 1953 and wells B-1, B-2 and B-3 in the 1976/77 year. The depth of well B-1 is 30.7 m, B-2 is 101.1 m, B-3 is 44 m, and S-3 is 22.5 m. Yield of wells is B-1 is 1.3 l/s, B-2 is 11.5 l/s, B-3 is 6.5 l/s and S-3 is 2.7 l/s. The total capacity of all wells measured at that time was 22 l/s.

The static level in the well B-1 is of 1.7 m, B-2 is 2.3 m, B-3 is 2.5 m, and S-3 is 2.3 m, which indicates that it is for sub artesian aquifer located in the Jurassic cracked granites (Soprajanova 1967).

The temperature of the thermomineral water is in range between 52 - 62 °C.

The wells B-1 and S-3 are very close to each other at a distance only by 4 m, from the wells B-2 and B-3 are distant 300 m, while the wells B-2 and B-3 of one another are distant about 30 m.

Lithological - hydrogeological profiles of exploitation wells as their technical characteristics are shown in Fig. 4.

From lithological - hydrogeological profiles can be seen that to the aquifer is located in Jurassic, tectonic cracked, biotite granites. These granites occur on the surface of the ground until the drilling distance to the depth of 101 m, and drain water from the subartesian aquifer.

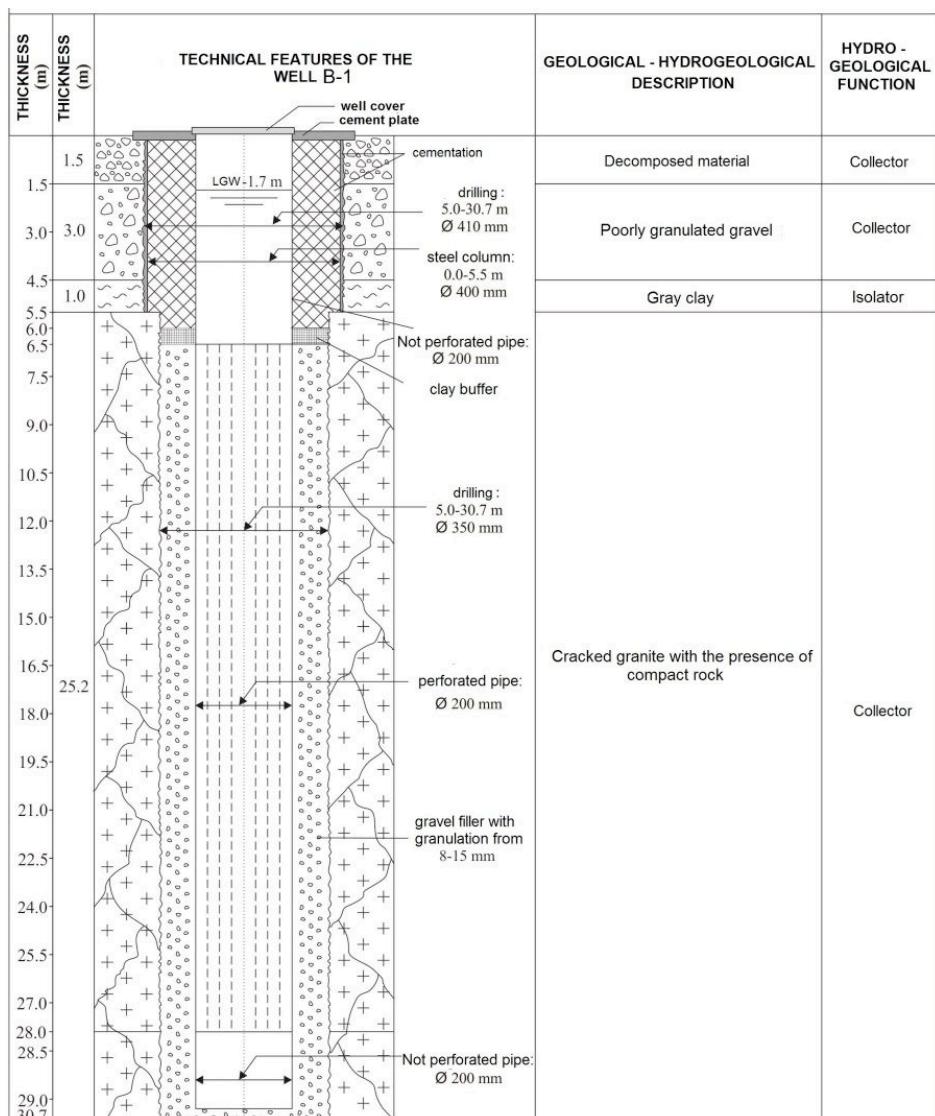


Figure 4. Lithological - hydrogeological profile and technical characteristics of the well B-1

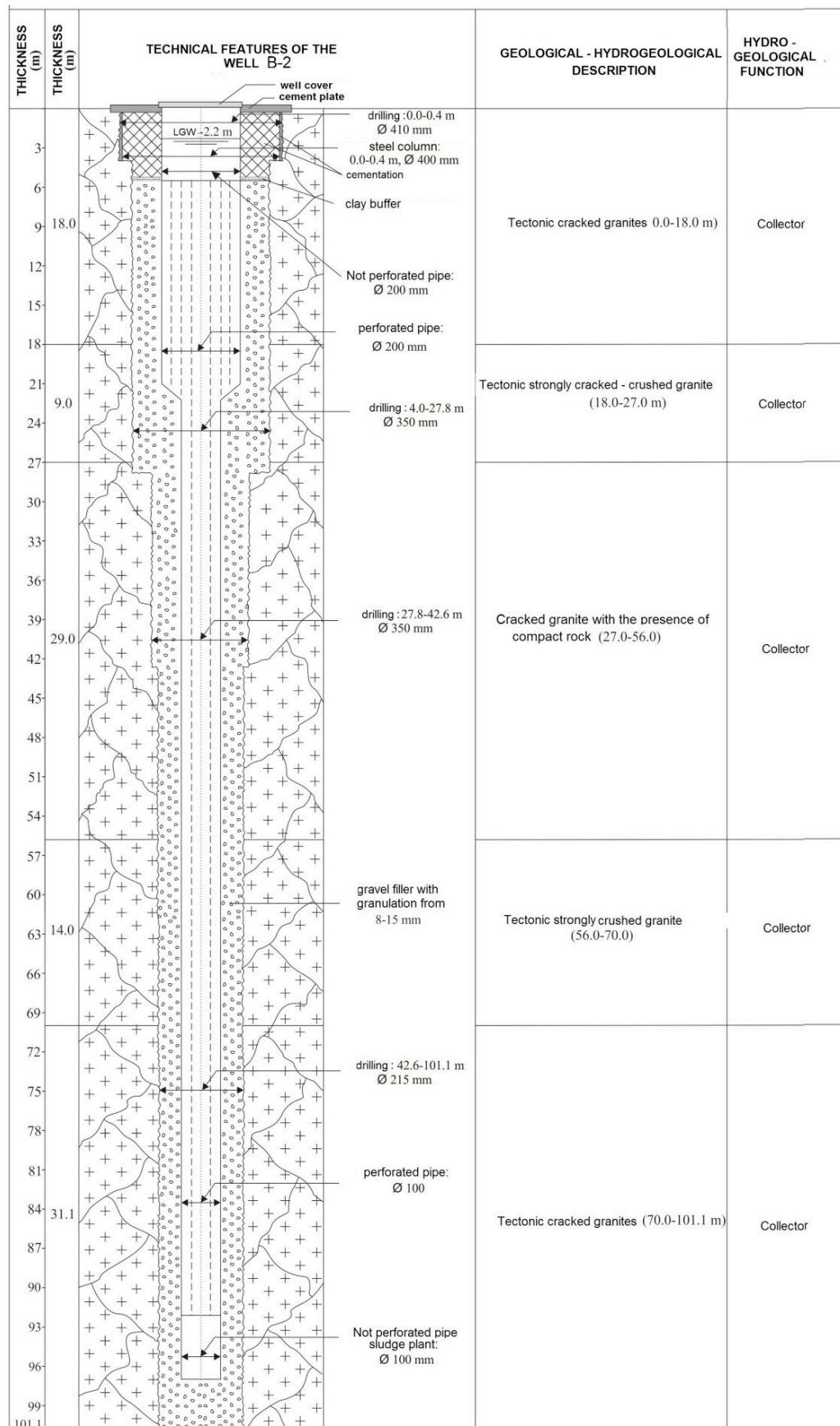


Figure 5. Lithological - hydrogeological profile and technical characteristics of the well B-2

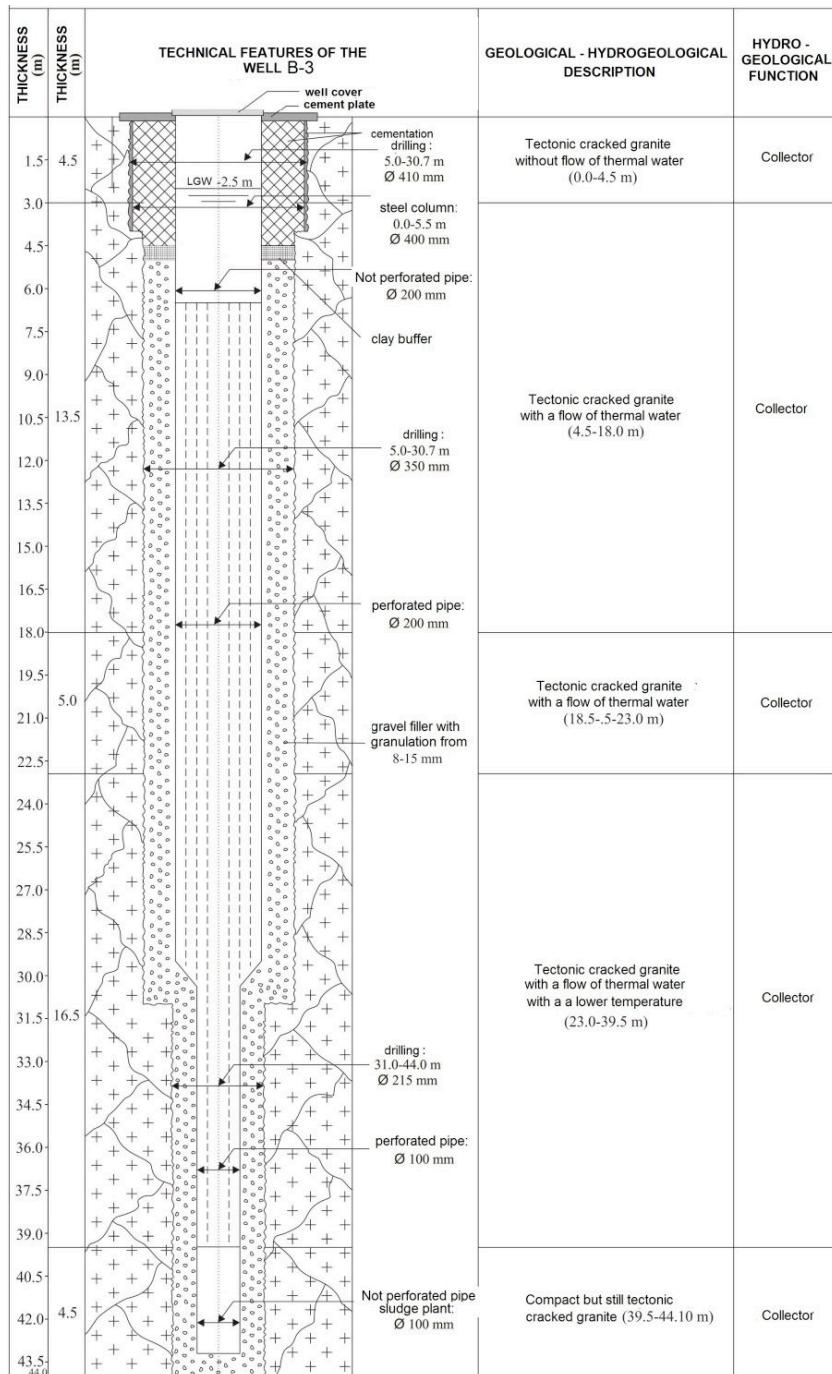


Figure 6. Lithological - hydrogeological profile and technical characteristics of the well B-3

THICKNESS (m)	THICKNESS (m)	TECHNICAL FEATURES OF THE WELL S-3	GEOLOGICAL - HYDROGEOLOGICAL DESCRIPTION	HYDRO - GEOLOGICAL FUNCTION
1.5	2.8	<p>well cover cement plate drilling : 0.0-2.8 m Ø 115 mm LGW -2.3 m perforated pipe: Ø 98 mm drilling : 2.8-22.5 m Ø 101 mm gravel filler Not perforated pipe Ø 98 mm</p>	Alluvium	Collector
15.0	26.0		Tectonic cracked granite (2.8-28.8)	Collector

Figure 7. Lithological - hydrogeological profile and technical characteristics of the well S-3

2. Pump testing of the wells

In order to determine the yield of exploitation wells B-1, B-2, B-3 and S-3 in October 2015 was performed pump testing process of the wells. It was made for each well individually and duration of pumping test was 24 hours, or total, three pump tests for a period of 72 hours. Also, pump testing was carried out by three capacities (Q), obtained at three dynamic levels of the lowering (S). During pump testing for pumping water, in the wells was descended pipe with diameter $\varphi 63$ mm to a depth of 7,5 m, with which was limited dynamic level in the wells.

Based on the data obtained from pump testing for all exploitation wells, we prepared a diagram $Q = f(S)$ and diagram $q = f(S)$, and hydrograms of extraction which is displayed $Q = f(t)$ and $S = f(t)$.

After completion of the pump test, it was also measured the recovery the level of the wells and from the received data are constructed diagrams $S = f(t)$. Summary data of pump testing are shown in Tables 1,2,3,4,5,6,7 and 8:

Table 1. Data from pump testing of well B-1

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
1,7	$Q_1 = 0,8$	4,95	$S_1=3,25$	24	0,246
	$Q_2 = 1$	5,9	$S_2=4,20$	24	0,238
	$Q_3=1,25$	7,1	$S_3=5,40$	24	0,231

Table 2. Data from pump testing of well S-3

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
2,30	$Q_1 = 1$	3,60	$S_1=1,30$	24	0,769
	$Q_2 = 2$	5,20	$S_2=2,90$	24	0,689
	$Q_3=2,8$	6,90	$S_3=4,60$	24	0,608

Table 3. Data from pump testing of well B-2

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
2,20	$Q_1 = 3$	3,00	$S_1=0,80$	24	3,75
	$Q_2 = 6$	3,85	$S_2=1,65$	24	3,63
	$Q_3=9$	4,80	$S_3=2,60$	24	3,46

Table 4. Data from pump testing of well B-3

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
2,50	$Q_1 = 2,5$	3,80	$S_1=1,30$	24	1,923
	$Q_2 = 4$	4,70	$S_2=2,20$	24	1,8181
	$Q_3=6,5$	7,00	$S_3=4,50$	24	1,444

Table 5. Data for pump testing well B-1 and measuring the level of decrease in well S-3

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
1,7	1,3	7,30	5,6	24	0,232

Table 6. Data for pump testing well S-3 and measuring the level of decrease in well B-1

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
2,30	3	7,10	4,8	24	0,625

Table 7. Data for pump testing well B-2 and measuring the level of decrease in well B-3

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
2,20	6,5	4,1	1,9	24	3,42

Table 8. Data for pump testing well B-3 and measuring the level of decrease in well B-2

LGW Static	Yield Q (l/s)	LGW Dynamic (m)	Lowering S (m)	Time T (h)	Specific yield q (l/s/m)
2,50	6,2	6,05	3,55	24	1,746

During the pump testing of the well B-1 was measured level of declining water in the well S-3 which is located at a distance of 4 m. In the well S-3 was measured a total decline in the level for 52 cm. During the pump testing of the well S-3, level in the well B-1 was dropped by 35 cm. This shows that there is a radius of influence between these two wells.

During the pump testing of the well B-2 which is located at a distance of 30 m from the B-3, was observed declining of the level in the well B-3, which was observed declining of the level in B-3 by 49 cm. During the pump testing of the well B-3 also was observed declining levels in the well B-2 and it was concluded declining of the level in the well B-2 from 45 cm. Based on these data it can conclude that there is a radius of influence between wells B-2 and B-3.

The static groundwater level is measured from the mouth of the wells. Because the type of pump that was used to the pump testing and lowered pipe in a wells with a length of 7,5 m limit the dynamic level in wells and prevented to perform the test with greater capacity and lowering the dynamic level deeper, optimum, maximum and exploitation capacity of the wells are certain grapho-analytical.

In the testing procedure of the wells in all three capacities, it is also measured water temperature for each well:

Wells	B-1	B-2	B-3	S-3
Temperature °C.	58 °C.	52 °C.	61 °C.	62 °C.

By increasing the capacity of the wells is not noticed an increase in water temperature, and the temperature of the water was constantly in the process of testing. The smaller water temperature in wells B-1 and B-2 compared to wells B-3 and S-3 is likely due to the mixing of these water with cold water from the upper parts of the aquifer.

3. Exploitation capacity of the wells

Based on the performed pump testing of the wells and graphoanalytical analysis, is determined exploitation (Q_{exp}), maximum (Q_{max}) and optimal (Q_{opt}) yield of wells.

To determine the exploitation (Q_{exp}), maximum (Q_{max}) and optimal (Q_{opt}) yield of wells has been used is a graphoanalytical method by applying diagrams $Q = f(S)$, which shows the functional relationship between yield of wells and lowering the level. During the determination of resource is used the principle that lowering in the exploitation wells should not be more than 1/3 of the thickness of the aquifer (H) and maximum lowering (S) in the wells should not be more than 2/3 of the thickness of the aquifer collector. The optimal capacity of the wells is calculated by formula $Q_{opt} = Q_{max} \times \alpha$ (where α is a coefficient which is 0.7), while the optimal lowering S_{opt} is specified graphoanalytical from diagrams $Q = f(S)$ by applying the optimal capacity Q_{opt} .

In the table 9 are given the capacity for exploration wells through values: Q_{exp} , Q_{opt} , Q_{max} , S_{exp} , S_{opt} and S_{max} .

Table 9. Capacities for the exploitation of wells B-1, B-2, B-3 and S-3

	B-1	B-2	B-3	S-3
Q_{exp} (l/s)	1,7	12,5	8,9	3,3
Q_{opt} (l/s)	1,99	9,6	6,8	2,9
Q_{max} (l/s)	2,85	13,8	9,8	4,15
S_{exp} (m)	8	33	13,6	6,56
S_{opt} (m)	9,6	3,52	5	4,92
S_{max} (m)	16	66	27,3	13,1

The total exploitation capacity (Q_{exp}) for all wells is as follows:

$$Q_{total} = 1,7 + 12,5 + 8,9 + 3,3 = 26,4 \text{ l/s.}$$

4. Hydrogeological parameters of aquifer environment

The main hydrogeological parameters of the aquifer environment: coefficient of filtration (K), the coefficient of transmissibility (T) and the radius of the depression (R) are calculated of conditions for stationary flow within the aquifer with level under pressure without the direct influence of surface water.

Coefficient of filtration is calculated according to the formula of Dupuit (1854, 1857) in case of wells, which drain groundwater aquifer under pressure:

$$k = 0.366 \frac{Q}{mS} \cdot \log \frac{\mathbf{R}}{r} \quad [\text{m/s}]$$

coefficient of filtration	K [m/s]
exploitation yield	Qexp (m ³ /s)
lowering	S (m)
radius of wells	r = (m)
thickness of the aquifers	m (m)
radius of depression	R (m)

The coefficient of transmissibility (T) is determined at the formula:

$$T = K \times m \quad [\text{m}^2/\text{s}]$$

Radius of the influence (R) of wells was determined for exploitation capacity Q(exp) and exploitation lowering S (exp), according to formula:

$$R = 3000 \times S \times \sqrt{K} \quad [\text{m}]$$

coefficient of filtration	K [m/s]
lowering	S (m)
radius of the influence	R (m)

The obtained data for hydrogeological parameters are shown in Table 10.

Table 10. Hydrogeological parameters of to the aquifer environment

	B-1	B-2	B-3	S-3
<i>Coefficient of filtration K_f (m/day)</i>	0,688.	0,034	1,25	2,25
<i>Coefficient of transmissibility T (m²/s)</i>	16,67.	3,3	51,36	38,29
<i>Radius of the influence R (m)</i>	68	62	155	49

The values of hydrogeological parameters as you can seen from the table is distinguish by well to well and show different values. That was due to the non homogenous cracking of the granites that is not homogeneous porosity in the aquifer environment.

The calculated values for the radius of influence show that there is a radius of influence between B-1 and S-3 and between the B-2 and B-3, because the distance between B-1 and S-3 is only 4 m, and between the B-2 and B-3 is 30 m.

While the radius of influence between wells B-1 and S-3 in terms of the wells B-2 and B-3 does not exist because the distance between B-1 and S-3 in terms of dupnatinite B-2 and B-3 exceeds 300 m.

The radius of influence of the wells, as previously stated, is registered with the simultaneous testing of the wells B-1 and S-3 and B-2 and B-3.

5. Conclusion

Based on the pump test of the wells and grafoanalytical analysis of the results of extraction are certain exploitation capacity by four wells located within the hydrogeothermal system of spa Kežovica. Individual wells capacities are: B-1 1,7 l/s; B-2 12,5 l/s; B-3 8,9 l/s and S-3 3,3 l/s, and the total exploitation capacity of the system amounted to 26,4 l/s.

The main hydrogeological parameters of the water supply environment: filtration coefficient (K), the coefficient of transmissibility (T) and the radius of the influence (R) are calculated for conditions of stationary flow within the aquifer with level under pressure without the direct influence of surface water.

The coefficient of filtration to the aquifer environment is within ranges of: 0,034 - 2,25 m/day, the coefficient of transmissibility is 3,3 - 38,29 m²/s, and the radius of the influence of the wells is between 49-155 m.

The difference of the values of hydrogeological parameters from well to well indicates the not homogenous porosity of the aquifer environment i.e. not homogenous cracking of the granite which carry the thermomineral water.

References

- [1] Baik, J.and others (1955);, Report. Expert archive of the spa Kezovica Stip .
- [2] Dupuit, J. (1854), Traite Theorique et Pratique de la Conduite et de la Distribution des Eaux, Carilian-Goeury et Dalmont, Paris.
- [3] Dupuit, J. (1857), Mouvement de l'eau a travers le terrains permeables, C. R. Hebd. Seances Acad. Sci., 45, 92 – 96.
- [4] Guzelkovski, D., and others. (1973): A brief overview of thermo-mineral and mineral water in the Federal Republic of Macedonia in relation to tectonic assembly. Technique no. 7, Belgrade
- [5] Kekik A., Mitev Ž. (1973-1978): Thermomineral water in Kežovica and Ldži near the town of Stip. Papers on geology institute in the Socialist Republic of Macedonia. Sv. 16. Skopje.
- [6] Kotevski G., (1974): Annual report for the regional hydrogeological Research carried out in the territory of the Federal Republic of Macedonia. sv.1, Fund on geology institute in the SRM, Skopje.
- [7] Kotevski G. (1987): Hydrogeology of mineral, thermal and thermo-mineral water on the territory of R. Macedonia. Self-management practices Skopje.
- [8] Kekic, A., Mircovski, V. (2001-2002),: Investigation carried out on the intake of the thermomineral water of the Kežovica spa near the town of Stip. Geologica Macedonica, vol. 15-16.
- [9] Mircovski V., Petrov G., Delipetrov T., (2001): Hydrogeological characteristics and new data on the chemical composition of thermal mineral water from spa Kežović and L'dži near the town Stip. First Counselling for geothermal energy in the Republic of Macedonia. Proceedings of papers, Bansko-Strumica..
- [10] Mircovski V., Gicevski B., Dimov G., (2016): Hydrochemical characteristics of the thermomineral water from the spa of Kežovica – Štip, Republic of Macedonia. Geologica Macedonica, 30 (1). pp. 79-87. ISSN 0352 -1206
- [11] Mircovski V., Dimov G., (2016) Hydrogeological features and assessment of temperature in primary collector of the thermomineral water from the hydrogeothermal system of the spa Kežovica and L'dži – Štip. Geologica Macedonica, 30 (2). pp. 173-182. ISSN 0352 -1206.
- [12] Miloevik N.(1953): Preview report of the terrain around Stip. Professional archive on spa Kezovica. Stip.
- [13] Miholik S. (1953): Test report about thermal water of Kežovića spa and mineral water Bogoslovska. Professional archive on spa Kezovica. Stip
- [14] Miholik S. (1953): Test report for thermal water from Štip spa (laundry Ldži). Professional archive on spa Kezovica. Stip
- [15] Nastik V. (1968): Geothermal Research in the Federal Republic of Macedonia in 1967. Fund on geology institute in the SRM. Skopje
- [16] Soprajanova G.(1967): Petrologic and geochronological features of some granitoides in Macedonia. Belgrade-Zurich (Doctoral dissertation).