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Exploration and Exploitation of Mineral Waters and their Influence on the Regional Development – Case Study of a Vrnjacka Spa (Serbia)

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Abstract. Geothermal energy, coal and hydropower are the major resources of Serbia. Serbia has more than 300 mineral and thermo mineral wells and more than 40 spas. Vrnjacka Spa is the most visited spa in Serbia. It is situated in the central Serbia, on the contact of the Goc Mountain and the West Morava valley, e.g. on the 43°37' of the northern latitude 20°53' of the eastern longitude. Using different literature sources, article provides an overview of the past and state of exploration of mineral and thermo mineral waters of Vrnjacka Spa. It explains their importance and influence on the development. The article analyzes the characteristics of thermo–mineral waters in Vrnjacka Spa and the condition and possibilities of their exploitation in different economic branches. Explorations are still contemporary trend in Vrnjacka Spa. There are few new springs. Particular attention is given on the results of questionnaire about future development of Vrnjacka Spa. Results show the following facts. Existence of Vrnjacka Spa and its region depend of wellbeing of mineral and thermo-mineral waters. There are different views of development perspectives. Generally they are differed on the positive and optimist views of young people and other, which belong to elder respondents.

Keywords: thermo-mineral waters; Central Serbia; Vrnjacka Spa.

Introduction

Geothermal energy is considered to be ecologically clean [Duffield, Sass, 2003; Kaygusuz, Kaygusuz, 2004]. It belongs to the group of renewable types of energy [Demirbas, Bakis 2004; Fridleifsson, 1996; 2001]. In exploitation, it is cheaper and multiple profitable in the long run compared to all the energies that have been conventionally used. Unlike the other natural renewable sources of energy, it does not depend upon the season, meteorological conditions and all

the other following influences of the nature. Until the consciousness of its importance and possibility of its exploitation have been risen, geothermal energy was often available to everyone and free [Aswathanarayana, 2010]. Clean drinking water has already become wealth. Besides the ordinary water Serbia is very rich in healing mineral and thermo-mineral waters. There are over 40 spas with therapeutic facilities, having adequate medical equipment, competent medical staff and reasonable accommodation. Some authors claim that there are over 300 locations with thermal and mineral springs although there are no precise data. On the territory of Serbia, the list of registered thermal and mineral waters is not complete. The estimates of the number of spas vary from 45 to 60 taking into consideration so-called 'people's' or 'wild' spas [Romelić, Ćurčić, 2001; Škrbić, 2009]. Mineral and thermo-mineral are, except for drinking, used also for other purposes [Fridleifsson, Freeston 1994; Gupta, Roy, 2007; Hepbasli, Ozgener 2004]. The results of the field research show insufficient use of this renewable energy source in Serbia. The work is focussed on the place in Serbia where this kind of energy, according to criteria of tourist turnover, physiognomy and function of villages, and also products that are based on exploitation of mentioned waters, and origin in it, is the most used. The work presents sources of mineral and thermo-mineral water of Vrnjacka Spa, chronologically, as they were discovered and talks about the ways of their exploitation and about their influence on the development of village. Then, it presents their physical and chemical features with the emphasis on illnesses which are successfully healed, controlled or facilitated by its use. Possibilities of use of this type of energy in future are perceived by consulting the local population through the interview. Special emphasis has been put on its importance in regional survival and development.

Study Area

Vrnjacka Spa is situated in the Central Serbia, on the contact of north slopes of Goc Mountain, which belongs to Kopaonik mountain system, and West Morava valley (Figure). According to geological zoning of the territory of Serbia, which is based on geo-tectonic units, Vrnjacka Spa belongs to Western part of Vardar Zones. Western part of Vardar Zone is composed of several blocks of a diverse composition, rich in ultramafites; then, of Santonian Ophiolitic Melange with metamorphism ranging up to the Cretaceous. This part also includes granitoids and volcanic rocks [Dimitrijević, 1994]. Different mineralogical composition of rocks, ration between non water permeable and water permeable formations, the existence of deep faults and other geological preconditions enabled the existence of significant accumulations of mineral and thermo-mineral waters [Petković, Anđelković, 1976]. Prolonged circulation of infiltration waters through the cracks of Palaeozoic marble in contact with other rocks enabled stronger mineralization and greater heating of ground water. When these waters come across the vertical faults, with their help they appear on the surface in the form of mineral and thermo-mineral sources [Miljković, Kovačević, 2003]. The analyses of mineral waters prove the direct dependence between the hydro-chemical composition of waters and complex geological properties in which the formation and movement of waters have been taking place, throughout the geological history [Petrović et al, 2010]. According to Kozoljev formula water in Vrnjacka Spa is 2.520.000 years old [Filipović, 1992].

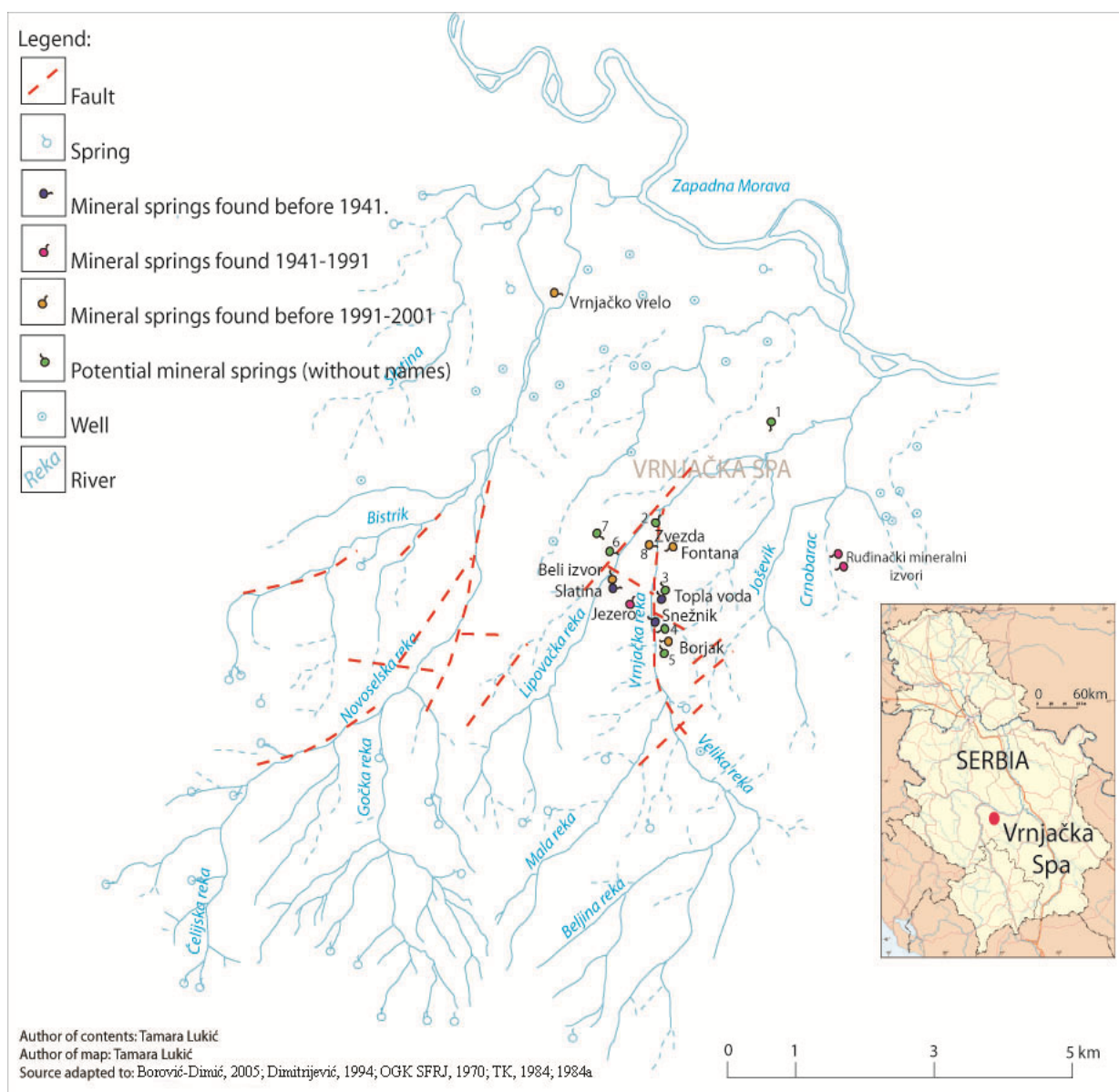


Figure 1. Geographic position of mineral and thermomineral wells of Vrnjačka Spa

Material and methods

In the process of drawing the map of geographical position of Vrnjačka Spa in Serbia and location of its mineral and thermo-mineral springs geographical and topographical maps have been used and also data gained from Real Estate Cadastre of the municipality Vrnjačka Spa [KNVB, 2009] and computer programmes Adobe Illustrator CS3 and Photoshop CS3. The problems of work have been approached critically. Part of the conclusion is the result of analysis of literary sources, synthesis and comparison of collected data.

The aim of the article is to find the answer on the following questions. What is the importance of mineral waters for the existence and survival of settlement? To what extent has the presence of this natural potential influenced the development of settlement? How much have they been used? How and to what extent are they being used in the present time? Do survival and development of settlement depend upon them? Answers to all these questions have been received using various literary resources and applying questionnaires, a form of an interview. A hundred respondents, who were between 20 and 65 years old and half of them were women, have been interviewed on the field. For that reason questions had open character, and answers to them were not predictable. Received data have been statistically analyzed and listed in the text, and some of them have been graphically presented.

Exploration and exploitation mineral and thermo-mineral waters in Vrnjacka Spa

Palaeozoic and Mesozoic formations on the territory of Vrnjacka Spa create waterproof of younger sediments of Neogene and alluvial deposits [Petković, Anđelković, 1976]. Within the complex of the oldest rocks of Palaeozoic schist and amphibolites, which are regarded as environment of low water permeability, arid environment, there occur lenses of marble which is 10 to 12 m thick, and within them large quantities of mineral waters circulate, not only in central but also in wider area of the Spa. Aquifer recharge is done by infiltration of falls and surface flows on the field, where marble appears on the surface, wherein the fissure structures represent directions. Prolonged circulation enables mineralization and heating of water, so in the area of Vrnjacka Spa it appears as mineral water with increased temperature [Milojević et al, 1974]. Serpentinities and igneous rocks build up low abundant water terrains to practically waterless terrain. In some places, in denser developed network of cracks, in serpentinities and serpentinised peridotites, then in granites, weaker aquifers are formed, which nourish the springs, whose bounty is 0.01 to 1 l/s of water [Petković, Anđelković, 1976]. Serpentinities, which are quite tectonized, are also characterized by fractured porosity within it is formed a fissure type of aquifer of medium abundance. Their breakage permits nourishing of aquifer by infiltration of water from rainfall and surface flows [Milojević et al, 1974]. Such assumption has been confirmed by dozens of surface drilling. All mineral and thermo-mineral springs of Vrnjacka Spa occur in fissure lines, they are permanent and quite abundant. Thermal springs are located in the Valley of Vrnjacka River, in the area of fault, which stretches in the direction north-south. Cold springs are located on faults in the direction northwest-southeast [Miljković, Kovačević, 2003].

1. Mineral spring found before 1941

The first exploitation of mineral and thermo-mineral springs had primitive forms. People learned about them from stories and material remains. The remains of the first known swimming pool which dates from the period at the end of the 1st century until the second half of the 4th century was adjacent to well from Roman period, at the depth of 2.4m [Kanic, 1892; Živadinović, 1925; Kovačević, 2010]. There is no material evidence about the use of mineral waters in Turkish times, but indirect sources say that the Turks came to several months of summer healing by bathing in warm mineral water in Vrnjacka Spa [Mutavdžić, 1884]. The first improvised bathroom was made in 1859, when the spring of mineral water was divided from the river water. This year is considered to be the year of the opening of Vrnjacka Spa. According to the written sources, the central part of the Spa was a swamp of warm mineral water, in which a barefooted villager would step in, and using his hoe dig a hole in the mud for bathing of the interested bather [Borović-Dimić, 2001]. During the eighties of the 19th century, the Spa looked like unregulated river full of willow trees and sandbank with corn all around the river. The houses were scattered over the plum orchards, there were also few facilities for a shop, cafe and primitive pool [Topalović, 2007].

The research of Vrnjacka waters began at the end of the 19th century. Performing the research of this area in 1872, engineer Zigmondi having seen Vrnjacka springs before the intervention of 'cultural hand', wrote in his report that springs which could not even be counted, appear at the depth of 40 to 50 feet. Describing the transverse cracks compared to the main which stretches in the direction of Orlovac hill, Crkveno hill, Brankova Glavica, the researcher Zujovic states that deposition of silicon caused blockage of springs, so the water was appearing in other place, so this place looked like a big boiler in which water was boiling. The confirmation to the long appearance of these springs is provided by a large mass of quartz rocks in Orlovac hill and Crkveno hill [Stevanović, 1939].

'The founder company of healing sparkling-hot water' was founded in 1868 in Vrnjacka Spa and it represents the first tourist organization on the Balkans. The number of visitors in 1869 amounted 538. In the year 1870 the first official spa season was opened. The status of state spa Vrnjacka Spa received in 1883, and in 1884 the spa region was marked and the first master plan was adopted. Around the ordered flow of the Vrnjacka River there are trees and landscaped park, which was planted in the beginning of 1888. From 1891 to 1905 important technical works were performed on arrangement of springs, i.e. baths were capped at three sites. The process of communal equipment of the Spa was followed by its development. So in 1905, the public lights were set and sewer of waste water which was until the year of 1938 extended up to the Western Morava River (Figure). Regulation plans for Spa have been passed on several occasions, but very

soon they have been changed [Borović-Dimić, 2005; Milinčić, 2001]. Before the World War I the modernization of traffic was performed, water and sewerage networks were extended, as it was required by 'Law on spas and mineral water' of Ministry of Construction, Public Health and Internal Affairs in 1914. In 1924 the Ministry of Health proclaimed Vrnjacka Spa for natural healing spa of the first-class [Grujić-Šarčević, 2005; Topalović, 2008]. In the period between the two World Wars tourist turnover increased, in 1924 tourist organization 'Goc' was founded and the first spa sanatorium 'Sveti Djordje' was built [Stanković, 2008]. Private hotels and villas in the style of 'modern' were built in Spa. Very hot mineral water was also used to wash household furniture and floors of rented rooms, after the departure of patients infected with tuberculosis, because the Committee of regular visitors considered hot alkaline water to be strong disinfectant against tuber bacilli. Similar examples of the use of mineral water in everyday life are present throughout the whole planet [Fridleifsson, Freeston, 1994; Hepbasli, Ozgener, 2004]. The water was even used for washing the streets 'in order not to spoil the air with the dust'. Treetops with leaves were washed, to prevent wind to spread the dust on walkers [Borović-Dimić, 2001; Kovačević, 2010]. There exist more springs which were found before 1941, but only two of them were put in use 'Topla voda' and 'Snežnik'.

1.1. Thermomineral spring 'Topla voda'

The first analysis of 'Topla voda' ('Hot water') was performed by Baron Herder in 1835, when by order of Duke Milos he was going through Serbia and searching for salt. Vrnjacka water is lukewarm and acid, such water rarely appear in nature, it can only be compared to water of Schlossbrunn and Carlsbad [Herder, 1846]. Accompanying Herder's description, after the visit and analysis of this water in 1856, the Chief of military medical department doctor Emerih Lindenmajer [1856], describes it as very good for drinking and bathing. The favourable evaluation in Lindenmajer's report influenced the decision to arrange the strongest, i.e. the most abundant spring which represents the first known post-Roman capping. In the time of the Foundation society, close to it the spring was dug up and hot bath was built. The first complete chemical analysis of this spring was performed in 1874 [Stevanović, 1939]. According to it was classified in alkali carbon-acid terms. The specific weight at the temperature of 22°C is 1.0029, and the temperature of water is 36°C [Borović-Dimić, 2001]. For the sake of caution for gaining large amounts of hot mineral water, for professional suggestion on the way of capping and supervision of works a geologist from Karlsbad, dr. Jozef Knet was asked to come. The works began in 1905, on the area of the old bath that covered two acres [Sotirović, 1991]. The spring rock was intersected by cracks up to 15 cm wide, which were partly filled with ochre, aragonite and pyrite. Doctor Knet distinguished at the time five such parallel cracks which were stretching in the direction southwest-northeast and falling towards southeast under the angle of 80°. According to his opinion, the mineralization of Vrnjacka thermo-mineral water occurs at greater depth (in granite or gneiss), while dolomite plays the role of only aquifers. From the number of springs at the time, three were chosen for hot bath, four for supplying of drinking fountain and the tank of newly built bath which was soon called cold [Borović-Dimić, 2001].

After the World War I the number of visitors to Spa soon increased, which lead to thinking about the increasing the available amount of mineral water. According to reports from 1922, the central springs that supplied the Hot bath gave 100 litres of water per minute, on drinking fountain 21.5 litres, and springs in Kursalon and Cold bath gave 62.5 l/min [Leko, Ščerbakov Joksimović, 1922]. Compared to the amount of water from the time of capping in 1905, because of the appearance of wild springs out of the capping zone, these springs gave four times less amount of water. New capping was performed along the water-bearing crack and it included all springs except the Roman spring, which was, because of its lower temperature and weaker mineralization, capped separately. When the capping was finished the total amount of water rose to 5-6 l/s, with the temperature of 36°C and with more carbon dioxide [Sotirović, 1991a]. The construction of great Thermo-mineral bath, increasing the number of visits to Spa and decreasing of abundance of hot springs for a half, induced the need for new amounts of water. The capacities of the new bath were due to the lack of water used partly. In the season only half of 43 tubs and two pools were in use [Sotirović, 1991b]. For that reason in August 1931, the director of Spa in Karlsbad, Prof. Dr. Robert Kampe explained the decrease of the abundance of spring as the system of mutually interwoven cracks, through which, because of the increased inner hydrostatic pressure, caused by too wide cracks on the place of capping, through wild springs, and flew mineral water [Filipović et al, 1992].

The first drillings in 1932 were performed twenty meters north of the line of the earlier capped thermal spring. At the depth of 45 metres hot water was found with the abundance of 16 l/s, and temperature of 35°C. This water with the abundance of 5.5 l/s supplied the baths and fountains until the October of 1933 when it stopped flowing [Nešić, 1936]. The other probe was set 39 m north of the line of the earlier capped thermal springs. The crack was cut at the depth of 140-144 m and capped with the abundance of 9.7 l/s with the temperature of 36.2°C. Its water supplied baths and drinking fountains from January 1934 until the end of July 1935 when the decrease of temperature to 33°C was noticed. In December of 1933 a thermal crack, 32.5 metres south, was examined in order to check Dr Knet's claim, it falls towards the southeast. The drill went through alluvium, serpentinite and schist. A small amount of hot water, of weak mineralization and lower temperature was obtained. It proved the assumption that Vrnjacka thermal crack falls towards the north. For that reason in the beginning of 1934, at the distance of 74.5 m north from the line of the old capping, next probe was set. After the alluvial deposits the drill went through magnesite, clays, and marls, sandstones of Cretaceous age, serpentinite with dolomite interbeds, thin layers of shale, pure serpentinite and schist [Stevanović, 1939]. Water was obtained with the temperature of 38°C, with slightly lower amounts of carbon dioxide and abundance of 8 l/s. Dr Kampe reduced diameter of the inlet pipe, the water temperature was reduced to 36.8°C, with increased amounts of carbon dioxide and abundance of 6 l/s. Except the water that was obtained from serpentinite, this probe obtained water also from schist with abundance of 0.36 l/s, and the temperature of 41.4°C and mineralization of 2.3 gram/l, which was separately capped and mixed with the water from serpentinite, until the end of 1936. Then because of the landslide of unprotected rocks at depths greater than 230 m, the probe got in mud, and collapsed material could not be pulled out. For that reason the probe was buried to depths of 230 m, and the water from schist was lost [Borović-Dimić, 2001]. With the repeated capping of the probe, from the depth of 300 m the main spring is supplied with water and also the Thermo-mineral bath; the main spring is settled east of the Thermo-mineral bath [Filipović, 2003]. The spring Topla voda (Hot waters) has the highest average abundance of 6.8 l/s. The minimal abundance of this spring was recorded on the 10th of August 1961, in the amount of 3.3 l/s. The maximal abundance of 20 l/s was recorded on the 1st of April 1938, and on the 11th of March 1940 [IHRGFB, 1992]. Hot mineral water has sodium hydrocarbon, it is slightly mineralized, according to pH values it is slightly acid, and the temperature is homeothermn (Table 1). In the decision of the Municipal Assembly of Vrnjacka Spa on the use of natural and medicinal factors it was specified that the most important spa resource, mineral water, would use the company 'Mercur'. The excess water that occurs after the use of Tople vode by 'Mercur', takes over the factory for bottling water 'Vrnjci' [Župac, 2005a].

Table 1. Physical properties of mineral and thermo mineral water of Vrnjacka Spa. Source adapted to: [Nešić, Balšić, 2007]

Spring	'Topla voda'	'Snežnik'	'Slatina'	'Jezero'	'Beli izvor'	'Borjak'	'Vrnjačko vrelo'	'Fontana'
Total mineralization (g/l)	2.76	2.21	3.64	3.27	3.73	1.35-2.14	-	-
Dry residue (g)	1.81	1.45	2.45	2.11	3.42	2.08	1.68	1.08
Specific gravity (g/l)	1.001675	1.001500	1.002000	1.002830	1.002300	-	-	-
Radioactivity U (µg/l)	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-
Rn (Bq/l)	0.5	1.2	6.2	0.7	2.4	-	-	-
Ra (Bq/l)	<0.05	<0.05	<0.05	<0.05	-	-	-	-

Water hardness	General	28.84	31.05	34.44	33.32	32.76	9.24	52.10	39.20
	Transient	28.84	31.05	34.44	33.32	32.76	9.24	52.10	39.20
(German degorees)	Perman ent	0	0	0	0	0	0	0	0
Electrical conductivity ($\mu\text{S}/\text{cm}$)		2.780	2.054	3.500	3.000	3.200	2.300	2.840	1.222
pH value		6.70	6.40	6.47	6.65	6.70	6.40	7.82	6.84

1.2. Mineral spring 'Snežnik'

The Commission of the Government of Kingdom of Serbia from 1896 noted that there existed cold mineral springs. One with the temperature of 14.2°C was located along the Vrnjacka River. Although people knew about the existence of springs, they were not used until one Austro-Hungarian officer, during the occupation in 1916, became interested for plateau close to Brdjovicka mill, where the snow melted away quickly. Several soldiers dug up the plateau and there at the depth of 1.5 m the water flew. At the end of the war, people started using this water for treatment. Grateful for the cure, a teacher in 1920 arranged the spring and built the fountain covered with wooden eaves [Borović-Dimić, 2001].

Next to the spring there is a borehole made in serpentinite rocks. The oldest rocks in the wider area are Paleozoic schist and amphibolites, with layers of marble through which considerable quantities of mineral waters circulate. The water circulates through serpentinites and gabbros, which are quite tectonically disturbed, implying very good filtration characteristics and also increased concentrations of Mg ions (55.4 mg/l) [Nikolić, 2009]. The presence of geochemical assemblage Cs, Rb, Si, Ge, indicates that granitoids influence water forming. There is granitoid located on the terrain surface 10 km to the South-East of Vrnjacka Spa (Zeljina Mountain and Crni Vrh).

With regulation of Vrnjacka River and Brdjovski stream the spring was protected from flooding and sediment [Stevanović, 1939]. The chemical analysis of the spring on the river bank was performed in 1920 in National chemical laboratory [Leko, Ščerbakov Joksimović, 1922]. The more complete analysis was performed by professor from Paris University, Bardet in 1924. It showed the traces of arsenic, and spectral analysis proved also the presence of silver, beryllium, potassium and titanium. Traces of aluminum and iron were determined in later analysis by National chemical laboratory. In the meantime guests and locals drank the water at the spring, bottled it and exported throughout the country unlicensed or under the supervision of spa management. In the year of 1937 the Ministry of social politics ordered the most urgent recapping of the spring 'Snežnik'. Analysis of the National chemical laboratory showed that all four springs belong to the special type of water, which contains less alkaline, and more natural-alkaline metals than 'Topla voda'. Since the factor F of cold waters of 'Snežnik' which amounts 7.8 1 does not agree with the factor F of 'Topla voda', ratio of dissolved solids is not the same. Also, it was determined that all springs belong to the same 'fumarol' cracks. The difference is in weight of dry residue, the amount of free carbonic acid and in the ratio of alkali and natural-alkali metals appears either because the samples were not taken at the same time or because of the bifurcation of mutual 'key' before the mineralization [Stevanović, 1939].

In the period between 1978-1980, for the needs of the new building, where there are drinking fountains, recapping and research drilling were performed, with three research drilling and the well Sz-1/79. The first two drill holes were positioned east, and one west of the Vrnjacka River. The drill hole B-1/78 went through alluvial-diluvial layer of clayey and gravel debris and through serpentinite to the depth of 30.4 m. Through the same soil composition went also the other drill hole to the depth of 51.5 m, while the third one located in the fissure zone of Paleozoic schist, to the depth of 67.8 m and mainly went through serpentinite [Filipović et al, 1992]. After the three exploration drill holes were carried out the exploitation well was constructed.

According to the Alekin classification [1970] the water of 'Snežnik' is sodium, calcium, magnesium hydro-carbonated, slightly mineralized, the pH is slightly acidic, and the temperature is cold (Table 1, 2). Higher content of Ni (9.12 $\mu\text{g}/\text{l}$) indicates the presence of ultra-basic rocks (gabbros and diabase) [IHRGFB, 1992]. The 'Snežnik' spring, which is used for balneo therapy, is

also used for water bottling under the name 'Voda Vrnjci' [Nikolić, 2009]. 'Voda Vrnjci' is characterized by an increased TDS up to 1174.80 mg/l and increased content of CO₂ (700–1044 mg/l). By self-flooding 'Snežnik' originally gave between 0.1 and 0.3 l/s. This abundance was increased to 0.9 l/s with capping the contact of phyllite and serpentinite at the depth of 216 and 220 m [IHRGFB, 1992].

Table 2. Review of basic indexes of some springs of Vrnjačka Spa. Source adapted to: [IHRGF, 1998; ZZZZ, 1999; ZZZK, 2001]

Components	'Topla voda'	'Snežnik'	'Slatina'	'Jezero'	'Beli izvor'	'Borjak'	'Vrnjačko vrelo'	'Fontana'	
Caped interval (in meters)	300	216-220	10-15	218-248	342	62-63	170-250	150-220	
Generosity (l/s)	6.8	0.9	2.0	1.5	0.6	0.1	2.5	0.5	
Water temperature (°C)	36.6	16.8	14.0	25.5	29.5	16.0	17.5	17.0	
Total mineralization (g/l)	2.76	2.21	3.64	3.27	3.73	1.35-2,14	-	-	
Content of therapeutic active components (mg/l)	Na ⁺ + K ⁺	621.23	393.76	903.21	701.96	942.77	639.63	-	-
	Ca ⁺⁺	58.11	105.41	147.89	142.28	116.23	12.02	12.02	14.42
	Mg ⁺⁺	83.66	76.97	59.94	57.51	63.84	32.85	32.85	178.97
	Na ⁺ (PF)	-	-	-	-	-	30.0	30.0	-
	K ⁺ (PF)	-	-	-	-	-	2.0	2.0	-
	Cl ⁻	39.70	31.90	46.08	35.45	48.21	2.89	2.89	55
	HCO ₃ ⁻	2176.10	1682.38	3060.98	2519.30	3088.43	274.5	274.5	-
	CO ₃ ⁻	1070.20	827.39	1505.38	1238.99	1518.88	1360.79	-	-
	SO ₄ ⁻	1.20	11.20	5.00	2.50	2.50	2.56	2.56	-
	NO ₃ ⁻	0.35	-	-	-	-	2	2	0.659
	CO ₂ free mg/l	972.0	686.4	1073.6	783.2	677.6	26.4	26.4	-
	Fe (total)	5.40	4.70	1.30	6.20	4.90	0.058	0.058	0.927
	Mn	0.01	0.01	0.00	0.01	0.01	0.008	0.008	0.0
	NH ₄	0.00	0.00	0.00	0.00	0.00	0.05	0.05	-
	NO ₂	0.00	0.00	0.00	0.00	0.00	0.003	0.003	0
Consumption KMnO ₄	1.44	2.08	0.64	2.40	2.24	3.79	3.79	6.32	
Type of water	Na – HCO ₃	Mg – HCO ₃	Na – HCO ₃	Na – HCO ₃	Ca – HCO ₃	Na – K – HCO ₃	Mg – HCO ₃	Mg – HCO ₃	

1.3. Mineral spring 'Slatina'

The Commission from 1896 noted the local 'Slatina' which had the temperature of 12.5°C [Filipović et al, 1992]. Researches around 'Slatina' continued in 1937. When the abundance was measured it amounted 400 grams per second. Regulating the Slatina stream neighboring swamps were drained, and the area was improved with stepped terraces, paths, trees, rose gardens and ornamental shrubs [Todorović, 1938]. In the year of 1978 four research drill holes were placed there. Thirty meters southwest of the natural spring 'Slatina' the first drill hole B-1/78 was set at the depth of 44.5 m. The second one, B-2/78 was set 20 m northwest of the spring, at the depth of 42 m. The third drill hole B-2/78, which was drilled 100 m east of the spring, went to the depth of 30 m and did not find aquifer, while B-4/78 was set next to it and drilled to the depth of 42 m [Filipović, 2003]. All drill holes went through Paleozoic schist, which were mixed in higher layers with quartz sand, and in lower with quartz. In the surface layer were detected higher amounts of

carbon dioxide and smaller amounts of mineral water, which supported by the gases through cracks, particularly in zones of quartz sand, infiltrates from the deeper parts. As the water temperature of drill holes and spring is the same it can be concluded that cracks in this zone are quite compressed. The water level at drill holes is 31 m, and at springs is 10 to 15 m. According to this data recapping of the spring 'Slatina' was performed in 1984 [Filipović et al, 1999]. 'Slatina' is located on the southwest side of Cajka hill, in a place between valleys of Vrnjacka and Lipovacka River that is called Terapija [Miljković, Kovačević, 2003]. Water from 'Slatina' is sodium hydro-carbonated, slightly mineralized; the pH is slightly acid, carbon-acidic of medium concentration, and the temperature is cold (Table 1). Its abundance amounts about 2 l/s [IHRGFB, 1992]. In the beginning of the 20th century the heated water from the spring 'Slatina' was used for hydrotherapeutic treatments. The stock company built the facility in 1911 and opened 'The Institute for hydro and electrical treatments' with about 20 rooms. In 'Terapija' during the World War I there was so called 'Berry's hospital', whose head was dr. James Berry, who together with other doctors and nurses treated the wounded Serbian soldiers, but also civil population of Vrnjacka area [Vuković, 1985].

2. Mineral springs found from 1941 to 1991

With the attention to arrange Vrnjacka Spa in the way it is suitable for spa centers, after the World War II the following actions were taken: electrification, organizing educational institutes (1950-1970), libraries, museum 'Belimarkovic', cinema and Cultural centre. By the end of the 70-ties of the 20th century the problem of sewerage system was solved [Kovačević, 2010]. The town receives the physiognomy of European balneological centre and the leading centre of continental tourism in Serbia. During the 70-ties of the 20th century hotels were built with capacity of several hundred rooms. To serve clientele local population is engaged, but the need for manpower attracted population both from the region, and outside [Kovačević et al, 2007]. It was planned to form secondary town cores in parts of Banja in which it widens spatially, and those are Dubrava and Piskavac. Vrnjacka Spa has grown together with suburbs, such as: Rudjinci, Lipova and Novo Selo. Works on capping until the middle of the 20th century as well as new geological, hydro-geological and hydro-chemical researches of the wider area of Vrnjacka Spa from the 70-ties gave detailed review of characteristics of this terrain as well as the possibilities of capping. For the purpose of research 14 capped bores were accomplished and the record of springs and wells which includes 65 natural phenomena and 165 drilled wells was made [Pešterac, Natević, 1970]. In this period, only mineral spring 'Jezero' has been arranged, and Rudjinacki mineral springs have been researched in more detail.

2.1. Mineral spring 'Jezero'

In the area between the two springs 'Snežnik' and 'Slatina', next to a small lake, in 1978 thermo-mineral water 'Jezero' was discovered (Figure). The research bore VBJ-1/78 was made up to the depth of 260 m, and the groundwater of thermo-mineral water was discovered at the depth of 218 to 248 m in the layer of marble. The work was continued in 1985 when about 10 m from the first drill, the new drill VBJ-2/85 was set [Filipović, 2003]. Water from Jezero is sodium hydro-carbonated, poorly mineralized; pH value is slightly acidic and weakly acidic hypothermal [IHRGF, 1998]. The water temperature is about 25°C, of the same basic type as the other Vrnjacka water, but of specific mineralization. By opening the aquifer of yield of 10 l/s, with the tendency of decreasing, it stabilized at 1.5 l/s [IHRGFB, 1992]. Water exploitation is performed by self-flow which is set on the level of the surface of the terrain, i.e. 7 meters below the hydrostatic level, using the effect of 'gas-lift' self-pumping [Belić, 1978; Geozavod, 1986].

2.2. 'Rudjinacki' mineral springs

In wider spa area, in village Rudjinci, in the region of stream Crnobarac, there are two springs of mineral water with increased content of carbon dioxide. According to the research of Leko et al [1922] Rudjinacki spring had temperature of 13°C, and in one liter it contained 0.5900 grams of dry residue. In 1988, research drills with two bores were performed. One of them was performed up to the depth of 360 m, because of the damages the drilling stopped. The other bore gave at the depth of 10 to 15 m self-flow of 0.5 liters per second, of mineral hydro-carbonated water, magnesium type, with mineralization of 0.5 g/l [Filipović et al, 1999].

According to results of research by Filipović [2003], Rudjinci groundwater belongs to dense and cracking. On the basis of two researched drills with the depth of 328 and 360 m, temperature of Rudjinci water is 14°C, and pH is 6.9. So, it is called and neutral. By field research it was determined that Rudjinci mineral springs are not presently exploited.

3. Mineral springs found from 1991 to 2002

In the last decade of the 20th century Yugoslavia experienced changes at all levels. Secession of most republics, Slovenia, Croatia, Bosnia and Herzegovina and Macedonia happened. Except in Macedonia, they were followed by civil war, great emigrational circulation, economical crisis, which was conditioned by embargo and inflation. In the observed decade started the process of transition, owner transformation, i.e. privatization [Bartlett, 2009]. The development of Vrnjacka Spa has constantly been disrupted by the problem of water supply. It manifested through often suspension of delivery of water. The problem was solved in 1992, when the central system of water supply from the spring on Goc was established [Milinčić, 2001]. The search for new springs continued. The idea was based, as competent sources claim, on the fact that in the moment of privatization of mineral and thermo-mineral springs bigger price could be achieved if another new spring was found. From the mentioned springs that were found after the year of 2002, the significant contribution to the development of Vrnjacka Spa has been given by 'Beli Izvor' and 'Vrnjačko vrelo'. 'Beli izvor' with its healing properties, i.e. soothing effect influenced the increase in the number of tourists, and 'Vrnjačko Vrelo' had more marketing role. Bottled 'Vrnjačko vrelo', placed on the market in Serbia, as well as the Balkan region, reminds the consumers of the healing quality of Vrnjacka waters.

3.1. Mineral spring 'Beli izvor'

In search of new quantities of water, during the year of 1992, researches were conducted in areas of upper course of Lipovacka River and Lipovacki stream. 'Beli izvor' is located about 150 m from mineral spring 'Slatina' and about 350 m from 'Jezero'. Geological and hydro-geological researches gave good reason for placing a drill at the place of this fissure zone. The drill IGB-1/92 and drilling through Paleozoic graphitic and gray-greenish schist partially cracked and filled with quartz and calcite, up to the depth of 506 m, it confirmed the presumption about the existence of more favorable conditions for catching hot springs in the area of Lipovacka River [Filipović, 2003]. The amount of water at self-flow was at first 2.5 l/s, and after two months it stabilized at 0.6 l/s. Discovered mineral water belongs to the category of sodium hydro-carbonated, carbon-acidic and radioactive hypo-terms with the temperature about 29.5°C at self-flow, while at the depth of 342.4 m, the temperature is 36.5°C similar to the one at the spring 'Topla voda'. According to chemical content a new, but mixed type of water was obtained, similar to other types of Vrnjacka water, but different from them [Lazić et al, 1995]. Competent institutions assessed that it could be used for balneo-therapeutic purposes, by drinking, as remedy and that it could have the best impact in the treatment of gastrointestinal tract, metabolic disorders, kidney and urinary tract disorders [Filipović et al, 1999]. This water is very good for rheumatic and skin diseases. For that reason next to this spring people can be seen washing their hands and faces, putting water compresses or their diseased limbs in water containers. Water from 'Beli izvor' is sodium, calcium hydro-carbonated, poorly mineralized, pH is slightly acidic and according to the amount of carbon-dioxide it is hypothermal.

3.2. Mineral spring 'Borjak'

The locality of Borjak is 700 m upstream of the mineral spring 'Snežnik' (Figure). Its appearance is explained with the fact that along the riverbed of the Vrnjacka River stretches cleft which causes, or enables the appearance of 'Snežnik' and 'Borjak'. Miljković and Kovačević [2003] wrote that on the third fumaroles crack, where 'Snežnik' is located, there is a covered spring of mineral water. Natural spring of mineral gas water with the abundance of 0.1 l/s and with carbon dioxide of 238 mg/l which was confirmed with later hydro-geological prospection of Vrnjacka territory. The research drilling started in 1992, to the depth of 150 m. At the depth of 62.5 m was caught mineral water containing carbon-dioxide of 1.3 g/l and pressure of 20 cm above the surface. Up to 40 m the drill went through serpentinites, gabbros and amphibolites. At the beginning of 1997, a new drill was set BLV-1/97, depth 175 m, at the depth of 41 to 61 m it recorded the presence of gabbros, which were not recorded until then in the Vrnjacka territory. The drill was converted into observational facility and regime observation of physical and chemical properties is in progress [Filipović et al, 1999]. Water from 'Borjak' spring is sodium, potassium hydro-carbonated, poorly mineralized; pH is slightly acidic, with cold temperature. The Company 'Voda Vrnjci' use water from the drill 'Borjak' [Župac, 2005a]. Water from spring 'Borjak' is bottled and distributed in the territory of Serbia and some countries in the region as 'Voda Vrnjci'.

3.3. Mineral spring 'Fontana'

On the right bank of Vrnjacka river, about 300 m below the mineral spring 'Topla voda', the Institute of hydrogeology of Faculty of Mining and Geology from Belgrade in 1999, during the procedure of hydro-geological research because of the rebuilding of part of the foundation of hotel 'Fontana', set research drill F-1. The goal was to determine with minimal research works hydro-geological characteristics of the terrain to prevent self-flow of water in the foundation and basement premises of the hotel 'Fontana'. In part of the terrain towards the Vrnjacka River, under almost 3 m of poured material, there is alluvial deposit whose thickness in the zone of the hotel 'Fontana' is 2-3 m and it grows in the river direction. Heterogeneous complex of sediments of Miocene Pliocene age built of clay, marl and conglomerate thickness from 3 to 30 m, are located in the basement of alluvium, and partly on the surface. Below this complex are flysch formations from Lower Cretaceous period registered by drill in the range of 8 to 15 meters, whose thickness increases to about 60 feet towards the 'Topla voda'. Based on earlier geophysical research and records from new drill in the yard of 'Fontana', it is assumed that the contact between the Cretaceous flysch and serpentinites is tectonic. As next layer of lithological profile serpentinites occur at 15 m depth and the depth drops to about 70 m in the area 'Tople vode'. It is assumed that this is a consequence of cross fault in part of the field between the Probe III 'Topli izvor' and Probe B-11 under the hotel 'Fontana'. The fault led to lowering of blocks of serpentinites and schist towards the 'Topla voda' with a jump fault of 60 m. On the northwestern and southwestern parts of the terrain serpentinites occur also on the surface very changed, altered, bleached, and very rotten and decayed, the color is light green. Deeper serpentinites are compact and dark green, sometimes intersected with veins of magnesite. On the contact with the schist are stronger silicified, solid and compact. The occurrence of serpentinites with calcite veins and quartzite show that in the geological past there was the zone where carbon-mineral water flew [Milojević, 1974; Filipović et al, 1992; 1999]. Below the serpentinites layer there are the oldest rocks of the Paleozoic age made of schist, calc schist and amphibolites that in the area of the hotel 'Fontana' occur at the depth of 150-220 m in the southwestern part of the surface. The temperature of obtained water is 17°C. Chemical analysis was performed in the laboratory of factory 'Voda Vrnjci'. Water in the hotel 'Fontana' is partly used as a supplement to drinking water, partly as a supplement to the pool, and partly as technical water. Its bottling has been an option. Water is a leading concern of Hotel-touristic company 'Fontana'.

3.4. Mineral spring 'Zvezda'

At the end of the year of 2000, Hotel-tourist company 'Fontana' was an investor for its needs of hydro-geological studies, performed on the left bank of Vrnjacka river, about 300 m below the spring 'Topla voda' in the yard of the hotel 'Zvezda'. The aim was to partly solve the problem of water supply of the hotel 'Zvezda'. The first exploration bore was performed to the depth of 29 m [Jocić, 2000]. Dynamic groundwater level of 2.5 l/s was stabilized at 5.0 m. Below the covered soil clay gravel composition of about 1.9 m thick, the Quaternary gravel coarse grain was found, which were brought by Vrnjacka river and settled across the older graphite rocks, and rare across chlorite schist that up to 19 m occur in the form of clayed inwards, and to 29 m are broken and decayed. Quaternary gravel and decayed graphitic and chlorite schist represent hydro-geological panels that allow the flow and accumulation of ground water. Water from upper gravel was through the filter granules next to conduit pipe indirectly introduced into the well. This water at the moment of abstraction was 19.5°C and pH value is 7.32. This spring is not exploited.

3.5. Mineral spring 'Vrnjačko vrelo'

In 1998, geo-electrical research confirmed that at depths below 100 m large quantities of groundwater can be expected. In the middle of 1999 the exploration well was turned into the exploration facility. Drilling by coring continued to 166.6 m, when by self-flow occurred water eruption. The exploitation is performed from the depth of 184 m and from depths between 170 and 250 m, and bottling is done at the spring, without any additional filtration. The water temperature is constant, of about 18.7°C. Hydrostatic pressure is stable, as is the regime of yield, which from 3.5 got stabilized at 2.5 l/s. The water is bacteriological sterile, indicating noninterference with the shallower aquifers. Still water 'Vrnjačko vrelo' falls into the category of low-mineral or oligo-mineral. According to its chemical and gas composition this water is genetically distinct from other Vrnjacka mineral water, indicating the existence of hydro-geologic barriers built of Paleozoic rocks which are weak aquifers. It is connected to the Neogene series of rocks and serpentinites, with the possibility that some of the water is abstracted from cracking peridotite mass. Weak mineralization, below 200 mg/l, as well as low content of hydrocarbons provides a daily

consummation without any restrictions. Favorable concentration of magnesium has a beneficial effect on digestion; protect blood vessels and reducing the reaction to stress inductors. In 2001, the construction of bottling plant and the exploitation of this water started. With dry rest of about 250 mg/l, with the optimum hardness of 9.5 d°H, and very low organic load, low content of sodium, chloride and nitrate, with the ratio of calcium and sodium that makes it drinkable, with a high percent of magnesium, it belongs to rare waters of high quality which are bottled in Europe, like the waters 'Perrier' or 'Evian' [Ferrier, 2001]. As magnesium water gains more importance in prevention, doctors recommend the water from this spring for everyday use. It is bottled up without any technological treatment and physical disinfection, as natural non-carbonated and carbonated with a maximum CO₂ concentration up to 5 grams per liter. The factory has its own chemical laboratory, which monitors daily the quality of water from spring to bottle, and also the constancy of declaration.

4. Potential mineral springs

Various studies indicate that there are good predispositions for discovery and exploitation of new springs and new quantities of thermo-mineral and mineral water. During these detailed geological, geophysical and hydro-geological researches on the narrower and wider Vrnjacka territory several potential zones were mapped. Deep drilling project of zones of 'Topli izvor' would provide the possibility of making research-exploration well, which would permanently ensure sufficient quantities of hot mineral water for development of Special hospital of 'Institute for prevention and treatment' and bottling plant 'Voda Vrnjci'. Areas around the mouth of the Lipovacka River to the Vrnjacka River, and also the area of Lipovacka River on the territory of Church Hill, opposite Topla voda, with the drill bores from 1000 to 2000 m, it would provide the opportunity for catching large quantities of warm water for multipurpose use. The next location would be exploration of mineral water in the factory for bottling mineral water 'Voda Vrnjci' where the probe is placed at 1020 m of depth, which is due to the appearance of methane and destruction, abandoned [Filipović et al, 1999]. On Branko top, hill above Vrnjacka Spa, there is a spring of mineral water, which was a few decades ago primitively capped by the residents. In 1999 they began to supervise it. New researches are inevitable. But during all these and future research certain precondition must be respected, and that is that the current springs, in both quality and quantity of water, must not be compromised. The support for that is the fact that the testing of some old wells, at already exploited springs has determined the mutual interconnection of cracks and pores in the broader territory of Vrnjacka Spa. Construction of buildings around the known springs, deterioration of water quality of Vrnjacka and Lipovacka River, pond in the park, and irregularity of wastewater and storm water basins can affect the quality and quantity of mineral water. Therefore, the overall future development of Vrnjacka Spa must be subordinated to the preservation of quality and quantity of water. In development projects the special responsibility is on companies and institutions whose work is based on drinking and mineral water: Special hospital for the prevention and treatment of digestive diseases and diabetes 'Vrnjacka Spa', the company 'Beli izvor' and factory 'Voda Vrnjci', as well as Assembly of municipality of Vrnjacka Banja. They have already, in cooperation with relevant professional institutions in Serbia, such as the Institute of Hydrogeology, Faculty of Mining and Geology, 'Geozavod', 'Geosonda', 'Hidrosonda', 'Naftagas - Novi Sad', 'Hidro-projekt', 'Kosovoprojekt' Belgrade and others were most responsible in relation to research projects, protection and exploitation, as well as ordinary mineral water.

Characteristics of Vrnjacka Spa mineral and thermo mineral waters

By analyzing of the results of research of six Vrnjacka waters and their comparing the following results were obtained. Thermo-mineral water from the site 'Topla voda' is connected by gaps to system fissure zone in the serpentinites, and from the site 'Jezero' to fractured karsts system of fissure zones in Paleozoic marbles. Mineral water, sites 'Snežnik' and 'Borjak' are connected to gaps in the system section fissure zones within serpentinites, and 'Slatina' and 'Beli izvor' are connected to the intersection of fissure zone in schist (phyllite and serite schist) [Milojević et al, 1974].

Physical properties

According to physical features, Vrnjacka waters are mutually different. According to color they are slightly yellow, only 'Slatina' is yellow, and 'Topla voda' is neutral. According to the

fuzziness, it can be said that they are transparent, except for 'Slatina' and Borjak who have little blurry. Vrnjacka waters have no smell. However, older visitors of Vrnjacka Spa remember that Snežnik gave the smell of 'rotten egg'. According to them, the smell is gone from 'moving' the spring in the local facilities. Vrnjacki mineral springs vary in temperature. According to the temperature of groundwater Petrović et al [2004] classify them as: 'Snežnik', 'Slatina' and 'Borjak' have cold water, 'Jezero' and 'Beli izvor' are hypothermal, while 'Topla voda' is homoeothermic. Considering the fact that the degree of mineralization of Vrnjacka water ranges from 1 to 5 g/l, Vrnjacka mineral water are poorly mineralized. Therefore, they are of pleasant organoleptic properties and well tolerated, so they are suitable for therapeutic use, especially for internal use. The specific gravity of Vrnjacki springs at a temperature of +4°C vary to a lesser degree, ranging from 1.001500 g/l in 'Snežnik' to 1.002830 g/l at the spring 'Jezero'. General hardness is consistent with the transient, resulting from the hydro-carbonated ions of natural-alkaline metal that are deposited by cooking. Considering the fact that the value of the permanent water hardness of Vrnjacka water equals zero, it means that other salts of natural-alkaline metals are not in it. Since the pH of the Vrnjacka water is mainly less than 6.8, it can be said that they are all weak acid. 'Fontana' is one of the neutral water, and 'Vrnjačko vrelo' is alkaline.

Chemical features

Chemical compositions of Vrnjacka water are similar, indicating the connection of these waters in a larger scale. The same mineral ingredients are found in different proportions [Petković, Anđelković, 1976]. Among them, the amount of carbon dioxide expressed in grams per liter, classifies Vrnjacka water into the category of slightly acidic water because in all waters it ranges from 0.5-1.4 g/l. Only 'Slatina' belongs to the category of carbon-acidic waters of medium concentration (Graph 1).

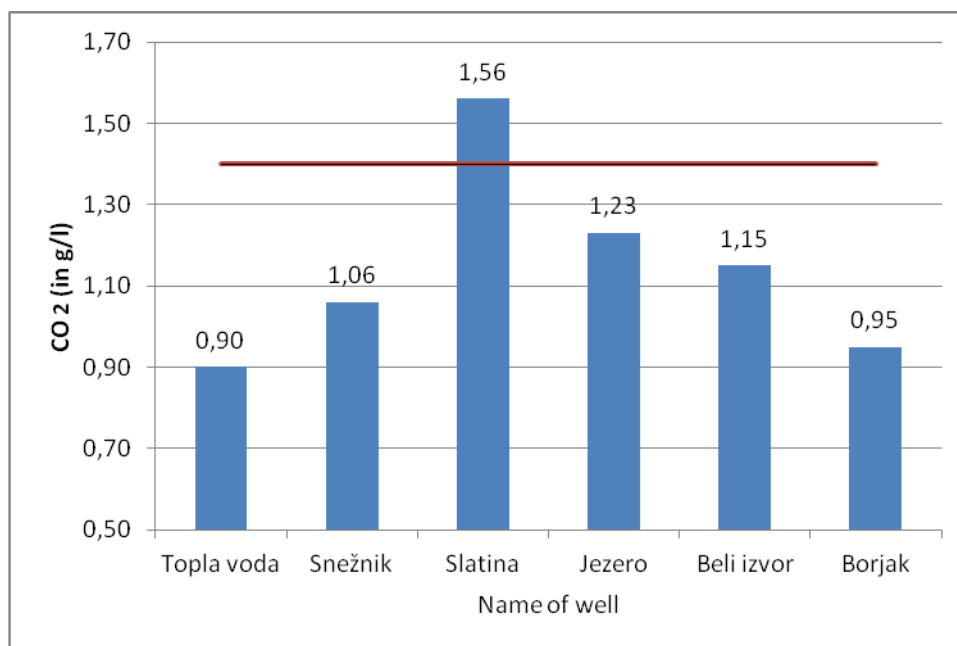


Figure 1. The amount of carbon-dioxide in mineral and thermo-mineral springs of Vrnjacka Spa Source adapted to: Ref. [IHRGF, 1998; ZZZZ, 1999; ZZZK, 2001]

Other differences in chemical composition are due to the characteristics of locations where they occur. Alkalinity, carbonic acid and the presence of different amounts of ions Na, Ca, K, Mg, Mn, Ni, Zn, Cu, Pb, Li, Ba, and then also Cl, Br, I, sulfates, etc. caused the healing effect of water on some diseases of human body. The healing effect caused the water to be noticed [Miljković, Kovačević, 2003]. Legend say that in the second half of the 18th century, one man from Vrnjci village gave this water to his sick horse, which after three weeks it regained strength. Their use by diverse types of therapies: hydro, balneological, physical, kinesis, electro, paraffin, drinking of

water, thermal, inhalation and others, can indicate a wide range of diseases – cardiovascular, gynecological, gastrointestinal diseases and pancreas, kidney, urinary tract etc.

State of the use of mineral and thermo mineral waters in Vrnjacka Spa

The first time that it was mentioned and recorded that Vrnjacka mineral water was taken and drunk outside the spring happened in 1870, in Program for raising mineral water in the village Vrnjci, which was sent by Funding Company to Chief of the district Kruševac [Mutavdžić, 1884]. According to the writing of Jugović [1970], even in the year of 1876, a pharmacist from Belgrade named Dilber carried the water in bottles and sold it in Belgrade. 'Wild' carrying of hot water had lasted until the discovery and capping of 'Snežnik', when exploitation and export of its water started. Bottling of mineral water from the spring 'Snežnik' was free, with no control and unhygienic [Borović-Dimić, 2001]. The World War II interrupted the organizing bottling and export of water outside Vrnjacka Spa by the state. Physic-chemical properties of then-known mineral water and their potential exploitation were explored during the sixties of the 20th century. It was ascertained that of the total capacity of mineral resources (220 million liters), Spa center 'Vrnjacka Spa' uses only 24 %, or 52 million liters of water [Pećinar, 1965]. Trial production began in 1970. By technological means, from natural mineral water the iron is removed, and carbon dioxide is added. The increase in demand caused the need for greater capacity, so in 1973 the construction of factory began, which started to exploit the spring of hot mineral water, with the capacity of 60 million liters per year. The standard and quality of table mineral water 'Vrnjci' has been recognized by the International Association of Manufacturers of Mineral Water in Europe. In the year of 1986, more than 27 million liters of table water was produced, which made up 4.9% of the total Yugoslav production with 19 filling stations and 14.4 % of production of mineral water in Serbia. Until 1992, water 'Vrnjci' was present in Germany, Great Britain, America, Japan and Australia and thus contributed to promotion of health and tourism values of the spa Vrnjacka Spa. In the year 2002, 'Vrnjci' became joint stock Company for exploitation of mineral water and production of soft drinks. Water has been pumped for years from the spring 'Topla voda' in Vrnjacka Spa, and now the spring 'Borjak' is used. Today, it is sold in Macedonia, Bosnia and Herzegovina, Germany and Canada [ID, 2008].

Water from mineral springs is used in healing and therapeutic purposes and is bottled and sold as such. The following facts illustrate to what extent it is developed. The most important health institution and developer of healing tourism is Institution of Prevention, Treatment and Rehabilitation of the digestive system and diabetes 'Vrnjacka Spa', which was established in 1976, on the grounds of the State clinic in which since 1948 the experimental and scientific research in the field of balneology was performed, and that has in the meantime been known as the 'Natural Spa' and 'Center for rehabilitation and treatment of digestive diseases and diabetes - Vrnjacka Spa'. Specialized institution for treatment and rehabilitation has gained high status and reputation in health care in the areas of prevention, treatment and balneological rehabilitation. Since 1998 it has the status of teaching base of the Medical Faculty in Belgrade in the field of balneology [Borović-Dimić, 2001]. Special hospital performs stationary and polyclinic health care activities, implementing health care programs and provides preventive diagnostic, therapeutic and rehabilitative health services in the field of digestive diseases, diabetes, chronic rheumatic and degenerative diseases and diseases of urinal-genital tract. It monitors and studies the health of the population, health culture, hygiene conditions and it proposes measures for their rehabilitation. It implements measures for health education on the formation of behavior that leads to promotion and preservation of health. In the field of prevention it investigates the causes and occurrence of disease spreading and suggests measures for their prevention, efficient and quality treatment and rehabilitation. It monitors and conducts professionally scientifically established methods for diagnosis, treatment and rehabilitation and establishes professionally methodological and doctrinal criteria for prevention, treatment and rehabilitation. It examines and implements new methods of preventive care, diagnosis, treatment and physical and balneological rehabilitation. It conducts professional training and specialization of sub-specialization of employees and associates. As a health facility owned by the state, by the decision of the Ministry of Health, Institute of Public Health and the Ministry of Mining and Energy, it is an institution that cares about control, exploration of mineral water, exploitation and use of thermo-mineral and mineral water for medical, therapeutic purposes. The institution is legally obliged to control regularly the physical properties of thermo-mineral and mineral water, microbiological, chemical composition,

spring protection and application in balneological purposes [Borović-Dimić, 2001]. Therapeutic balneotherapy cabinets are: underwater massages, baths, inhalations, vaginal spraying, duodenal tubing, electrotherapy, magnetic therapy and manual massage. Special hospital bears the name Special Hospital 'Mercur'. It gained its place on the market in the year of 2005, with opening of the Wellness center 'Fons Romanus'. However, since the interest of visitors exceeded center capabilities, the company introduced new facilities. It opened a new fitness center, sauna and tepidarium. It also opened the clinic for aesthetic and reconstructive surgery, a new mini-operating room that allows more demanding interventions in this field has been equipped.

The future status of the springs

Regarding the expectations of the future status of ownership of mineral and thermo-mineral waters and the influence on socio-economical development of Vrnjacka Spa, a questionnaire was conducted among local residents. Hundred of respondents have been selected according to the following criteria. All respondents live in spa Vrnjacka Spa. They were aged between 20 and 65. Half of the respondents were women. The subjects were of different degrees of education and economic power, and also of different business dependence of the mineral sources.

According to the Strategy of development of tourism in Serbia, there are three scenarios of the future use of mineral and thermo-mineral water of Vrnjacka Spa [VRS, 2006]. According to them, a common starting point is that defining the owner of the spring is imperative; otherwise it will continue to lose large amounts of water due to the difficulty of management of springs. Inadequate maintenance of water springs, which has been present until now, can only continue to have negative impact on their design and utilization. The first or 'the worst' scenario is that by which springs could be transferred or sold to entrepreneurs from abroad, which will only bottle the water and sell it. Interdict of access to visitors and citizens lose the sense of existence of the spa. In the second scenario, the water would be partially transferred, and access to springs would be available to everyone but for a fee. In the third scenario the mineral and thermo-mineral waters would remain the property of the state of Serbia, with unlimited access to mineral springs. In that case, its management must resort to reengineering and must, in function of sustainability, raise the level of responsibility in all aspects of the use of this natural treasure.

The following results were obtained from the survey. Mineral waters are very important for the existence and survival of the settlements to those respondents who are employed in health care facilities, restaurants, hotels, industrial buildings, which process and bottle the mineral water, institutions of culture and administration. Most (75 %) of the local population of Vrnjci thought that regional development depended on the mineral and thermo-mineral waters (Graph 2). About 23% of respondents did not achieve any income by working in jobs that directly or indirectly are associated with the presence of mineral and thermo-mineral waters in the Spa. They stressed that them it is not of crucial importance, but they are aware of its importance due to activities carried out by members of their families, neighbors and acquaintances, which depend on the mineral and thermo-mineral springs. Most of the respondents 86 % agrees that the presence of this natural resource in the past influenced a lot the development of settlements, i.e. micro-region, especially after the World War II. Most respondents (91 %) believe that the mineral and thermo-mineral waters were not used enough in the past. They note that even today in some springs the water flows out freely, and that it should be regulated as soon as possible. About 18 % of respondents believe that the problem can be solved in the way that Vrnjacka Spa springs should be privatized. However, the majority of population of Vrnjci (71 %) still believes that the springs in Vrnjci should not be privatized (Graph 3). Almost $\frac{3}{4}$ of respondents (73 %) says, if privatization is inevitable, they would like to privatize a minority of the springs. Most of the population of Vrnjci (68 %) thinks that the future of Vrnjacka Spa depends on the future owner of mineral springs (Graph 4). About half, the 56 %, prefers the future owner to be the citizen of Serbia. More than two-thirds, 62 % of respondents are afraid that the future owner of the spring could reduce the purpose of the spring, i.e. to use it only for bottling, which would jeopardize the benefits that they provide to tourists and citizens of the micro-region: 'Hotels would then remain empty, capacity in private facilities would remain empty, restaurants would be closed, medical facilities would be without patients, spa bath would be without its users, shops and other service industries would be reduced to the needs of residents of settlements, Secondary school of Tourism would be left without students, and teachers would lose their jobs and so on.' They admit they are not sufficiently informed about all the possibilities of exploiting these waters, and that even they themselves did not use enough, but are

aware of their healing effect. Development of micro-region largely depends on the way of exploitation and conservation, i.e. quality of mineral and thermo-mineral water of Vrnjacka Spa. There are different views of development perspectives. Generally they are differed on the positive and optimist views of young people and other, which belong to elder respondents.

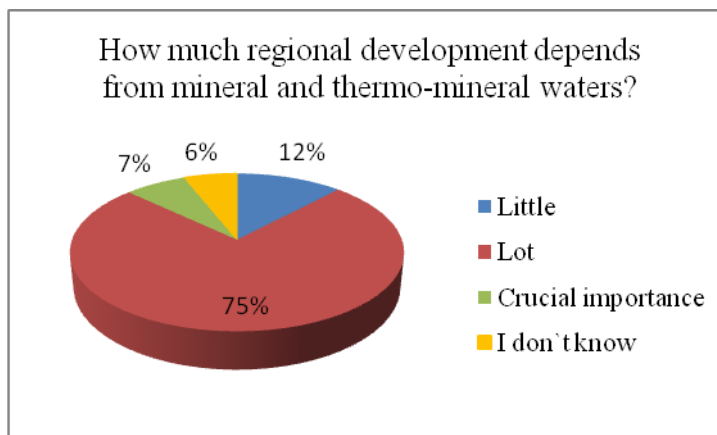


Figure 2. How much regional development depends from mineral and thermomineral waters?

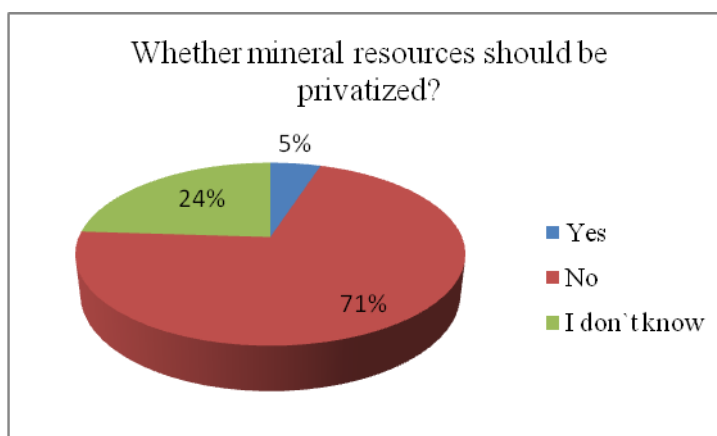


Figure 3. Whether mineral resources should be privatized?

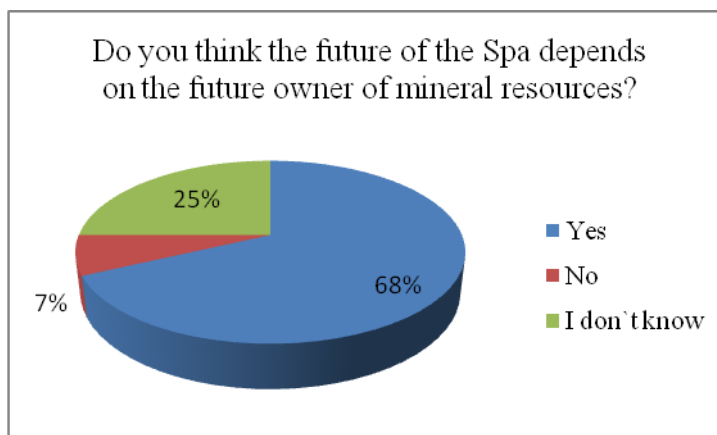


Figure 4. Do you think the future of the Spa depends on the future owner of mineral resources?

Conclusions

Exploration and exploitation of mineral and thermo-mineral springs in Vrnjacka Spa through the entire 20th century was of utmost importance for its development. Depending on the political situation and time, it depended in which direction the development would take place. Before the World War I 'the foundations of development were placed' in such way that researches and testing of mineral and thermo-mineral springs started. Between the two World Wars, researches continued, but their healing properties attracted a rich layer of Serbian population and by the construction of hotels and villas for holiday it positively affected the development of the physiognomy of the village. After the World War II, investments in the construction and equipping of health facilities and accommodation facilities were made. The state financially supported the construction of large hotels and entrepreneurial initiatives of the local population in terms of increasing the accommodation capacity and raising their quality. There was the support of the State also in the issue of water bottling and distribution, which was accompanied by considerable publicity support. Since the last decade of the 20th century, great energy has been directed into research and finding of new sources, which will bring new supplies of water, which is planned for multipurpose use. The richness of Vrnjacka Spa in geothermal energy is used for water supply and treatment. The problem of unused water of hot springs, which daily flows into the disappearance, can be solved if it is put in function of heating greenhouses, water supply of swimming pools in spa hotels and as technical water. Water from the spring Topla voda (36.6°C), spring with the highest temperature compared to other springs of Vrnjacka Spa, can be used for heating of residential and commercial, industrial, recreational, storage and similar facilities. Excess water of hypothermal springs could be used in process of production of healthy food and fish farming. Vrnjacka Spa has modest energy potential, but sufficient and very important for the sustainability of its local development. Preservation of springs, Vrnjacka Spa, and the other spas in Serbia, could in future be of great importance in solving water supply problems. For the actual question of ownership over the springs it is necessary to choose such a solution which will satisfy both the interests of local population and the state. Exploration and exploitation of mineral and thermo-mineral water of Vrnjacka Spa stays in the function of development, but its intensity will always be under the influence of various external factors, among which dominate political and economic situation.

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