International Symposium

KARST 2018
Expect the Unexpected

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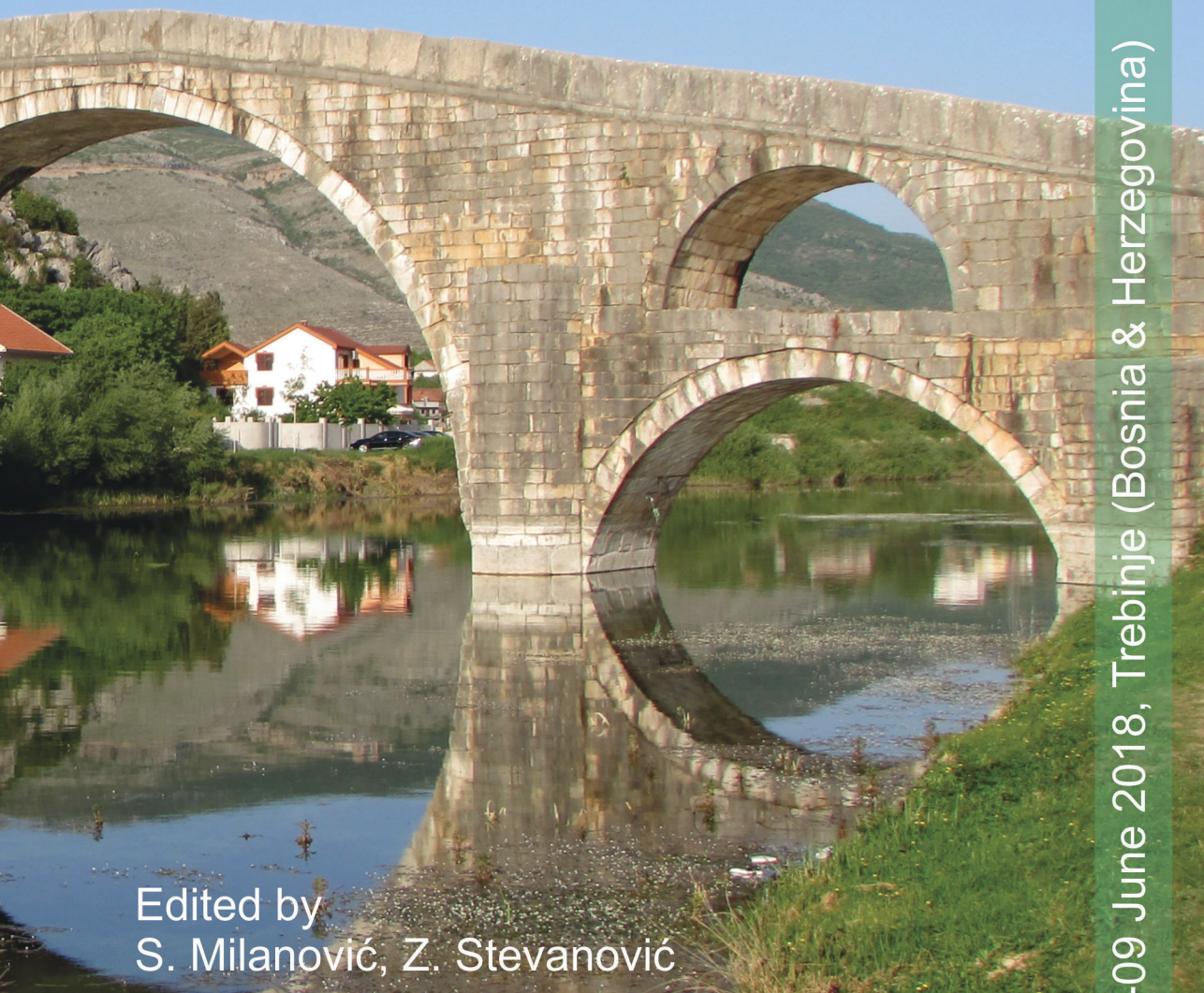

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Editors:

Saša Milanović and Zoran Stevanović

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HYDROGEOLOGICAL POTENTIAL OF MIOCENE LIMESTONES OF SOUTHERN PART OF THE KOLUBARA COAL BASIN

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Abstract: Kolubara-Tamnava coal basen is of the major importance for the economy of the Republic of Serbia and is insufficiently explored in terms of groundwater resources. This is primarily referred to the resources of potentially high-quality drinking groundwater as well as to the potential reserves of thermomineral groundwater. The previous studies conducted in the exploration area revealed the occurrence of the Sarmatian limestones, which due to their fabric, are considered as good aquifer. These data indicate that the Sarmatian limestones were discovered during drilling exploration in the southern part of the Kolubara-Tamnava coal basin, in the proximity of Vreoci village. The article deals with the spatial distribution of a limestone formation based on stratigraphic correlation of drill cores data as well as the possibility to estimate the spatial distribution of groundwater body.

Key words: Miocen limestone, coal basin

Introduction

Miocene limestones are known from earlier as suitable environment for the aquifer development. It has been found that many sources in the wider surroundings of Belgrade, both active and those that are no longer in function, derive or derived from Badenian (i.e. "Lajtovački krečnjak") or Sarmatian limestones. Within the Kolubara basin, as an important factor of the economy of the Republic of Serbia, geological research has been conducted for many years. Based on results of these explorations, stratigraphic differences of the northern and southern parts of the Kolubara basin were determined, as well as the kinematics of the neotectonic activity were performed based on morphostructural analysis of paleolandscape of the Badenian, Sarmatian, Pannonian, Pontian and Quaternary (Kezović, 2003). In the southeastern and eastern periphery of the Kolubara basin, the outcropping limestones of Miocene, predominantly Sarmatian age, were revealed; for example, surroundings of Ostružnica (Pećane), Sremčica, Barajevo, Sibnica, where these limestones are more or less karstified, while in the area of the southern productive (coal-

bearing) part of the Kolubara Basin, Miocene limestones are overlaid with sediments of late Miocene age (Pannonian and Pontian). In this work, the analysis of the distribution of Miocene limestones and their hydrogeological characteristics in the territory of the southern part of the Kolubara basin was performed through synthesis of the previous results of exploratory drilling and the analysis of sampled groundwater.

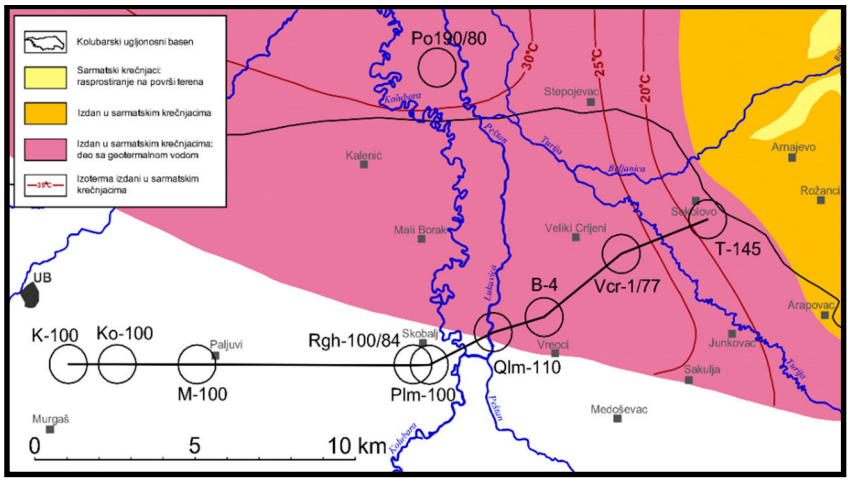


Figure 1 Modified map of distribution of Sarmatian limestone in the area of the Kolubara coal basin (taken from Milivojević, 2006) Black line is cross-section discussed in the text and part of it (between Qlm-110 and T-145) is given in Figure 2.

Results of previously performed geological exploration

In order to investigate the occurrence and spatial distribution of the Miocene limestones, the analysis of the results of previous geological exploration (i.e. exploratory drilling) was performed, whereby the presence of both the Badenian and Sarmatian limestones was singled out. The simplified hydrogeological map with the sites of drilling objects for which the processing of the available data has been made, is given in Figure 1, while the profile through the prospective area is given in Figure 2.

Badenian

Badenian limestones (i.e. Lajtovac) were revealed in the boreholes Vcr-1/77 (village of Veliki Crljeni) and T-145 (village of Arnajevo). In the Vcr-1/77 borehole, the Badenian limestone was determined in a depth range of 374-385 m (239-250 m of absolute height), interlayer with one meter thick marl. In the T-145 borehole, the Badenian limestones were recorded in an interval from 280m (164m absolute height) to the bottom of the well, i.e. depths of 294m.

Sarmatian

The Sarmatian limestones have a much larger distribution than Badenian ones and are found in boreholes M-100 (Paljuvi), Plm-100 (Skobalj), Qlm-110 (Vreoci), B-4 (Vreoci), Vcr-1/77 (Veliki Crljeni) and T-145 (Arnajevo). In the M-100 borehole, the Sarmatian limestone was found in the depth range of 232-327 m (239-201 m absolute height), in the Plm-100, in the depth range of 240-250 m (142-153 m absolute height), in Qlm-110 in depth range of 216-235 m (129-148 m absolute height), in the well B-4 in the depth range of 210-265 m (118-173 m absolute height), in Vcr-1/77 in the depth range of 318-362m (129-148 m absolute height) and in the borehole T-145 in the depth range of 206-266 m (90-150 m absolute height). The above facts indicate that the Sarmatian limestones are located in the central belt of the southern part of the Kolubara coal basin. The limestones occur in the altitude range of 205.9-362 m, where the shallowest one is ascertained in the borehole T-145. The largest thickness of these sediments was observed in the B-4 well, where they exceed 57 meters, and in the boreholeT-145 where limestones occur in two packages separated by marl, of which the shallows have a thickness of 20 meters, while deeper one of about 60 meters. The performed stratigraphic correlation of the cores shows great hypsometric differences in the spatial position of the Sarmatian limestones. Based on these observations, the large faulting is postulated to have occurred in the exploration area and there were strong differential movements of the separated blocks. They led to the creation of a complex structural fabric of Miocene deposits including Sarmatian limestones with the appearance of local tectonic trenches and horsts. For example, the terrain at which the Vcr-1/77 well is located is in a descending structure where the Sarmatian limestones are at about 70 meters deeper than those in the immediate surroundings.

By analyzing the profile of the wells, towards the west, it was found that the Sarmatian limestones pinch out and grade into other facies of the Sarmatian deposits (marls, alevrites). In addition, it has been noted that the thickness of the Sarmatian limestones decreases in that direction. The boreholes drilled southern of the analyzed profile are characterized by the lack of Sarmatian sediments as well as the Sarmatian limestones, since the sediments of the upper Miocene (Pannonian and Pontian) are deposited discordantly over Paleozoic-Mesozoic paleolandscape (e.g. Devonian shales). In this part of the southern periphery of the basin, Miocene transgression took place only in the upper Pannonian.

Hydrogeological characteristics of Sarmatian limestones

Aquifer in the Sarmatian limestones have relatively restricted distribution in the Kolubara coal basin, but its largest part lies in the eastern and southern parts (Figure 1). According to the hydrodynamic characteristics, an aquifer in the Sarmatian limestones in the area of the coal basin is under the pressure (i.e. confined aquifer) (Milivojević, 2006). The water of aquifer from this section, generally flows towards the west (Milivojević, 2006).

In the wider area of the Kolubara coal basin, that is, northeast of it, in the area of Barajevo-Manic-Sibnica, the Sarmatian limestones are directly exposed on the surface of the terrain, where the recharge of aquifer is mainly done by the infiltration of atmospheric waters. To the west, younger clay sediments prevent the recharging of aquifer. Discharging of water from the Sarmatian limestones is done in the valleys of the eastern tributaries of the Turija River, in the zones of contact of the Sarmatian limestone with Pannonian clay. In the southern part of the Kolubara coal basin, recharging of aquifer within the deeper Sarmatian limestones is not clear. However, the assumption is that its balance of water is well-balanced during the geological time that has passed since the time of its formation. The leakage from the confined aquifer is very little in natural conditions and is mostly carried out under the influence of the "thermolift", and to a lesser extent, under the influence of gravity or hydraulic gradient.

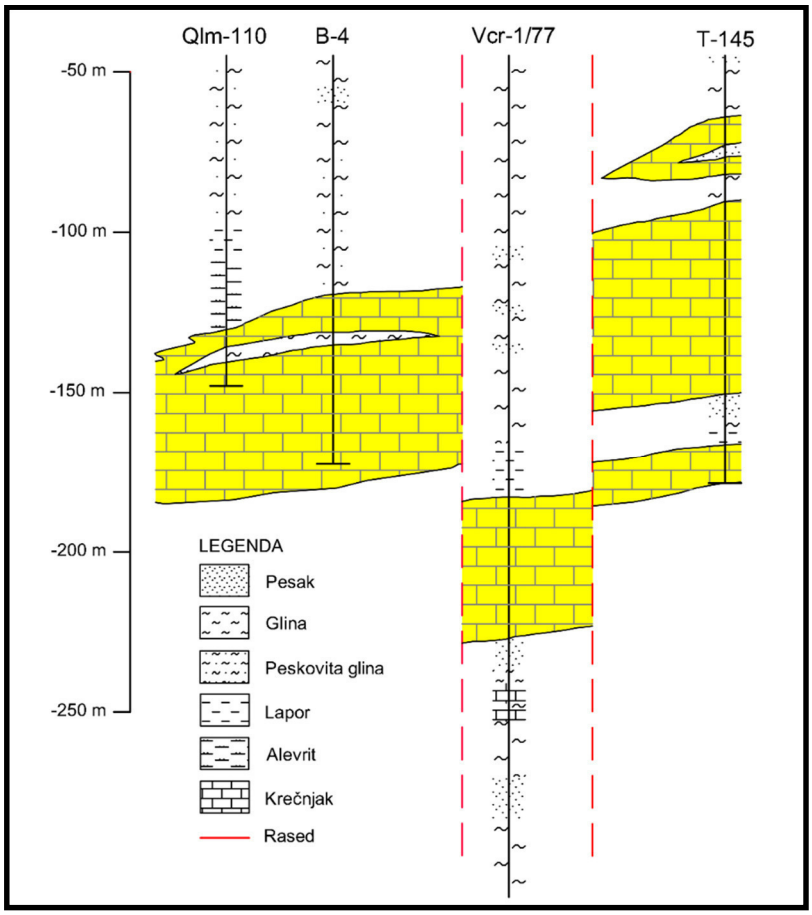
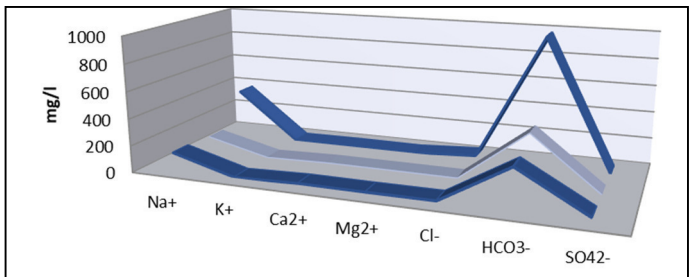


Figure 2 Cross-section through some drillholes as shown in Figure 1

Physical and chemical characteristics of ground waters in the Sarmatian limestone

The groundwater was sampled from the well B-4, from the borehole Qlm-110 (in the research area), and from the Po-190/80 borehole which is located north of study area but useful for data correlation. The water from these objects belongs to the hydrocarbonate-sodium group with temperatures up to 30.2 ° C, which is classified into water suitable for the exploitation of subgeothermal energy. This aquifer is characterized by chemical zonation, depending on the space, i.e. with departing from recharging zone, the mineralization gradually increases, as is the temperature. To the depth of about 250m, the quality of spring water is about the same as the quality of drinking water. The groundwater temperature measured in the Qlm-110 well is 28.2°C, the mineralization is 558 mg/l, while in the B-4 water temperature is 25°C and the mineralization is 550 mg/l.



	Na+	K+	Ca2+	Mg2+	Cl-	HCO3-	SO42-
B-4	132,3	1,8	15,5	13	13,50	305,00	30,00
Qlm-110	117,8	3	14	12,8	10,70	390,40	10,00
Po-190/80	370,00	2,50	5,50	2,30	29,60	972,00	0,20

Figure 3. Chemical composition of groundwater samples taken from well B-4 and borerhole Qlm-110 (Vreoci)

The measured water temperature sampled from the Po-190/80 well is 30.2°C, and the mineralization is 1.43 g/l. The groundwater from the well Po-190/80 belongs to the same type of water as the water from study area, but it is more mineralised and has higher temperature, which is probably the result of deeper burial of the Sarmatian limestones than at the investigative sites. This information is indicative and important due to the fact that in the research area in the tectonically lowered structure, drilled by the borehole Vcr-1/77 where the Sarmatian limestones are located at greater depth than in the surrounding (for about 70m from B-4), it can be assumed that the temperature of the underground water in them is probably higher than in B-4. The authors did not have the measured values of groundwater temperature for the other boreholes mentioned in this work. The water of the Sarmatian limestones were captured by the wells B-4 and B-5 at the location of Vreoci village, in the amount of approximately 8 l/s, the well Qlm-110 also has a yield of about 8 l/s, while the yield of the well Po-190/80 is 16,6 l /s. According to preliminary estimates (Milivojević, 2006) and

data synthesis, the assumption is that in the perspective location, the production of exploitation wells of depth 300-450m can yield 10-20 l/s with a temperature of 30-38 °C. Based on the analysis of water from wells Qlm-110 and well B-4, it can be concluded that the lithological composition have not affected the chemical composition of groundwater, given the extremely high content of Na and the extremely low content of Ca (Figure 3). According to internal data for the exploitation of geothermal water, regardless of its chemical composition and temperature, it is necessary to produce boreholes at given locations of depths of 300-450 m. From them it is possible to obtain a yield of 10-20 l/s with a temperature of 30-38 °C.

Conclusion

Based on the analysis of earlier research results, it can be concluded that in the central belt of the southern part of the Kolubara basin, the Miocene limestones occur and may be potential aquifers that can be used in the future as a source of drinking water. The occurrence of Badenian and Sarmatian limestones are determined. The limestones of Badenian stage have considerably lesser distribution and have been revealed only in one borehole (Vcr-1/77) with a thickness of 12 meters. However, these sediments can be collectors of groundwater of exceptional quality, and especially in terms of balneological properties. The Sarmatian limestones have much larger thickness as well as distribution in relation to Badenian limestones. As previously mentioned, based on the analysis of the core of the wells, their thickness is locally up to 60 meters. In the wider surroundings of the study area, i.e. going towards the central part of the Kolubara coal basin, the limestones pinch out and grade into other facies of Sarmatian sediments (i.e. marl, clay, sand). In the very southern area of the Kolubara basin, the Sarmatian limestones are absent, as it has been noted that the sediments of the upper Miocene (Pannonian and Pontian) lie discordantly over the Paleozoic-Mesozoic paleolandscape. It was also found that the structural fabric of Miocene deposits in this part of the Kolubara basin is much more complex than it was previously known. This primarily relates to newly identified local neo-structures that were formed through differential movements of faulted and separated blocks, which positioned Sarmatian limestones at different altitudes. The distribution, thickness and position of the Sarmatian limestones as well as the known hydrogeological characteristics of these deposits, it can be concluded that the Miocene limestones, especially the Sarmatian ones, represent the unused hydrogeological potential of Serbia, which is worth further research.

References

Kezović M, 2003: *Tektonska aktivnost i ugljonosnost Kolubarsko-tamnavskog basena, magistarska teza*, Rudarsko-Geološki fakultet, Institut za regionalnu geologiju i paleontologiju - Beograd

Milivojević M, 2006: *Groundwater resources of the wider area of Kolubara coal basin*, Faculty of Mining and Geology, Belgrade