UDC 55 CODEN – GEOME 2 ISSN 0352 – 1206

GEOLOGICA MACEDONICA

Geologica Macedonica	Год.	15–16	стр.	1–70	Штип	2001–2002
Geologica Macedonica	Vol.		pp.		Štip	

GEOME 2
Manuscript received: June 18, 2001
Accepted: November 20, 2001

Geologica Macedonica, Vol. **15–16**, p. 51–59 (2001–2002)
ISSN 0352 – 1206
UDC: 628.11 (497.7–21)

Original scientific paper

HYDROGEOLOGICAL CHARACTERISTICS OF THE AREA IN THE VICINITY OF THE SPRINGS FOR WATER SUPPLY OF THE MUNICIPALITY OF KAVADARCI WITH REGARD TO THE DETERMINATION OF PROTECTION ZONES

Vojo Mirčovski, Blažo Boev

Faculty of Mining and Geology, "Ss. Cyril and Methodius" University,
ul. Goce Delčev 89, MK-2000 Štip, Republic of Macedonia

A b s t r a c t: Several protection zones have been distinguished in the vicinity of the Lukar 1, Lukar 2, Kosmatec karst springs and the surface intake of the Stara River: closest, wide as well as wider protection zones around each spring. The zones were distinguished based on results obtained from the hydrogeological investigations and studies carried out consistent with the legal requirements in the Republic of Macedonia.

Key words: protection zones; springs; Lukar-1; Lukar-2; Kosmatec; Stara River

INTRODUCTION

The municipalities of Kavadarci and Negotino and the villages connected with the regional water supply Lukar–Kavadarci–Negotino with the population of 60 000 receive the drinking water from Lukar 1, Lukar 2, Kosmatec and the surface intake of the Stara River which drains the water of the karst aquifer. The water supply of Lukar 1 ranges from 253 to 105 l/s, of Lukar 2 from 51 to 22 and that of Kosmatec from 72 to 40 l/s. The supply of the Stara River intake is within 208 – 200 l/s.

Investigations carried out in order to find out the quality and cleanliness of the drinking water indicated that the water from these intakes was bacteriologically and physico-chemically good for use. In order to protect the quality of water in these sources it is necessary to establish hydrogeological criteria, which will determine protection zones (belts), around the springs and prevent the area from possible contaminants.

GEOGRAPHIC, HYDROGRAPHIC AND GEOMORPHOLOGIC CHARACTERISTICS

The area under investigation is located in the south part of the Republic of Macedonia and occupies the central parts of Mount Kožuf (Fig. 1). It stretches from the estuary of the Zarnica River to the Stara River downstream to the Macedonian-Greek border. The area is a mountainous relief with numerous high and steep peaks and deep canyons separated by rivers and streams the most striking being those along the Stara River valley. The highest peak in the area is Dudica at an altitude of 2138 meters, then Porta at 2104 meters, Papas at 1999 meters as well as some at lower altitudes amounting to 1545 meters. Strong epirogenetic movements that took place over the history and the erosion processes in some parts of the terrain had an impact on the geomorphology of the terrain.

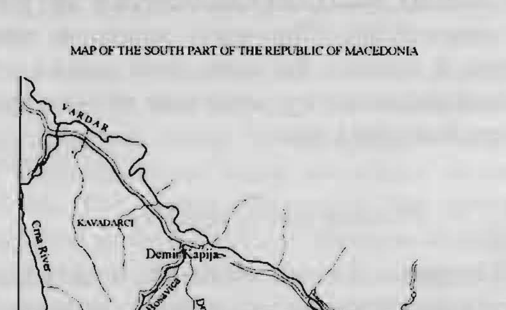

Fig. 1. Location of the area

The Stara River is the major artery and together with the Zarnica River comprises the spring of the Bošava River.

GEOLOGY

The geological composition of the area is shown using the data of: Ракичевиќ, Пенџерковски, 1963; Стојанов, Петровиќ, 1957; Boev, 1982, 1990a, 1990b, 1990c; Boev, Lepitkova, 1994; Иванов, 1962. It consists of: Old Paleozoic present as phyllites, argiloschists and sandstones, marbelized limestones interbedded with phyllites as well as metamorphozed quartzporphyries. The Upper Cretaceous is present as massive grey-white limestones.

Neogene is present as volcanic rocks such as propillitized hydrothermally altered andesites, amphibolite andesines as well as agglomerative and brecciated tuffs. Alluvial river sediments can also be found.

The area is part of the Vardar zone in which tectonic processes were fairly intense (Арсовски, 1997). Block tectonics is very common and folded structures, particularly in Paleozoic schists, are also present. The structures are of NE-SW extension dipping towards NW.

HYDROGEOLOGICAL CHARACTERISTICS

The hydrogeological characteristics in the area have been explored by a number of investigators: Кекиќ, 1973, 1974; Kekić, 1976; Котевски et al., 1968; Котевски, 1971; Старова, Кировски, 1973.

Three types of aquifers were determined based on the porosity of rocks boundary (Phreatic), fracture and karst types.

Boundary type of aquifers

This type is separated from the Stara River valley and extends downstream the estuary of the Zarnica River to the mouth of the canyon in Upper Cretaceous sediments. It is located in large-grained gravel alluvial sediments characterized by good water permeability. The water source is quite abundant. It receives the water from natural precipitations and mostly by penetration of water from the rivers Stara and Lukar.

Fracture type of aquifers

This type is formed within phyllites, argiloschists, metasandstones, marbelized limestones, propilitized and hydrothermaly altered andesites, metamorphozed quartz porphyries, amphibole andesites as well as agglomeratic breccia tuffs. They are the most widespread in the area. However, the rocks there are water impermeable because they are new geological formations in which tectonic processes were not intense. Nevertheless, the deeper and wider fractures of the type owe their porosity to tectonic processes. Shallower fractures, developed due to exogene factors, are confined to shallow layers and are also filled with eroded material developed through weathering processes. The oldest geological formations in which tectonic processes had great effect are more porous. This can also be said of the younger rocks such as propillitized and hydrothermally altered andesites.

Based on the permeability the rocks of this type can be divided into:

- rocks of good permeability,
- poorly permeable rocks,
- impermeable rocks.

Rocks of good permeability

These rocks include phyllites, argiloschists, sandstones; marbelized limestones interbedded by phyllites and other schists, propillitized and hydrothermally altered andesites.

The permeability of phyllites, argiloschists and sandstones is due to the presence of numerous fractures. They are short and oriented to schistosity in the surface parts but seldom transverse to it. They are very common but occur rarely when wider than 1 cm in size. They can be found in the right sleeve of the Stara River. In marbelized limestones interbedded with phyllites and other schists permeability is more pronounced due to hard limestone masses in which fractures are longer, wider in size and karstified. This is also similar to propillitized and hydrothermally altered andesites except that fractures in them are very rare since they are younger rocks and tectonically less disturbed.

Poorly permeable rocks

The type is present as metamorphosed quartz-porphyries and amphibolite andesites. System of fractures in them is poorly pronounced, particularly in andesites which results in their poor permeability and the small number of springs found.

Water impermeable rocks

Water impermeable rocks are present as agglomerative breccia tuffs in which fractures are very rare because they are young geologic formations in which tectonic processes are poorly developed.

Water abundance in rocks of fracture spring

Rocks of fracture porosity are poor in water, particularly agglomerative breccia tuffs, metamorphosed quartzporphyry inclusive of amphibolite andesites. Springs in these rocks are very rare and their abundance rarely exceeds 0.050 l/s. Only in the uppermost course of the Stara River in the slopes of Dudica and Porta a number of springs of some 0.1 – 1 l/s have been found. The part of the terrain is made up mainly of Paleozoic phillites, argiloschists and sandstones, propilitized and hydrothermally altered andesites, in part, amphibolitic andesites as well.

Physical properties of the water of fracture aquifers

The water of fracture aquifers is clean, transparent and good for drinking. It is mountainous water with temperatures amounting from 6 to 8 °C during the summer time. In some springs the water temperature amounts to 3.5 – 4°C. Water temperature in all springs does not exceed 10°C. Fracture springs are fairly shallow, so the outside temperatures have an effect on the temperature of underground water. Seasonal changes of temperatures are higher than changes of temperatures between day and night.

Karst type of aquifers

Karts type of aquifers formed in karstified Upper Cretaceous limestones that are characterized by fracture cavernous porosity and rarely sponge porosity. The type is characterized by their significant quantity of underground water. The Lukar 1, Lukar 2, Kosmatec karst springs and the Stara River are drained from these underground waters. Cretaceous limestones in the upper course of the Bošava River were separated into smaller or larger masses by tectonic processes and eruption intrusions and covered by agglomerative breccia tuffs and andesite outflows. The largest limestone mass can be found in the middle part of the terrain near Stara River and Čardak – Gladnica.

Three caves and 4 waterwheels also occur in the limestones as surface karst forms. In the slopes of the Stara River occurrences of clints as parallel and deep furrows with openings from 10 to 20 cm wide can be found. The occurrence of karst shapes and limestone fissures and the lack of surface flows in the upper parts of the terrain during the whole year are indicators of good water permeability of the rocks. This is also true of the flows that sink in the left sleeve of the Stara River right after penetration into the Upper Cretaceous limestones or partial sinking of the Zarnica River when part of the flow enters karstified Upper Cretaceous limestones.

This made it possible to classify the rocks as very permeable with the coefficient >Þ1 cm/s. The karstification process in the Upper Cretaceous limestones towards the impermeable foundation has not been completed. It can be clearly seen from the springs occurring at heights from 1 to 15 meters in the riverbed of Stara River .

Regional setting of karst aquifers according to water abundance

The regional setting was carried out based on water abundance of springs found in various parts of the Upper Cretaceous karst. Since abundance is within 10 l/s, the karts aquifer was classified as very abundant, except for the spring in the vicinity of Gladnica whose water abundance amounts to 3.5 l/s. The terrain surrounding the spring was classified as very abundant, the most abundant being Lukar 1. Based on the data obtained by the Hydrometeorological Institute in Skopje the water abundance ranges from 166 to 253 l/s (1972) and 105 l/s (2000). The abundance of Lukar 2 during the same time period amounted from 33 to 51 l/s and 22 l/s. It can be concluded that the system of water supply is not the same although they belong to the same karst aquifer although they are located 250 m from one another.

Regional setting of karst aquifers according to depth

Based on the depth of the karts the following zones have been distinguished: a zone of shallow aquifer confined to a narrow zone along the valley of the rivers Stara and Zarnica, a zone in the area of the springs of Lukar 1 and 2 along the valley of Lukarska River and a zone in the immediate surrounding of the spring at Gladnica. Deep karts aquifer can also be found in the other parts.

Physical properties of the water of the karst aquifer

The water obtained from these aquifers is clean and transparent. They are fairly shallow mountainous springs with temperatures that do not exceed 10°C during the summer. The water temperature at Gladnica is 4 °C, and that along the Zarnica River does not exceed 6°C.

CHEMICAL COMPOSITION OF UNDERGROUND AND SURFACE WATERS

Examinations carried out on the chemical composition show that the lithological composition of the terrain in which underground waters are formed and the time period they remain underground had a great effect on the chemical composition of underground waters. The hydrochemical characteristics of Lukar 1, Lukar 2 and the surface waters of the Stara River are shown in the hydrochemical map as a cyclogram indicating water types according to anions and cations, total mineralization, hardness and pH values (Fig. 2).

They are classified as a group of hydrocarbonate-calcic waters (Кекиќ, 1974), because of the chemical composition the waters of the Stara River and Lukar 2. The spring of Lukar 1 is of a more complex composition since it belongs to hydrocarbonate-sulphate-chloride type (Кекиќ, 1974). This chemical composition indicates that the waters of this spring mixed with underground and surface waters of non-karst terrain prior to their entry into the limestone rocks.

Micro- and macro-components of 9 analyses were carried out on samples taken from Lukar 1, Lukar 2, Kosmatec and Stara River in order to determine the quality of the water. The results obtained are given in Tables 1, 2, 3 and 4. It can be seen that no analyses yielded high concentration of harmful components. This is an indicator that these are good quality waters that can be used for sanitation and technological purposes.

Table 1

Chemical composition of waters from Lukar 1 (ppm)

	1	2	3	4	5	6	7	8	9
Ca	34.92	36.94	34.28	34.97	34.66	34.83	34.67	34.88	34.91
Mg	1.567	1.461	1.155	1.145	1.686	1.705	1.656	1.359	1.739
K	1.089	1.197	1.064	1.190	1.423	1.355	1.342	1.373	1.356
Na	1.690	1.460	1.518	1.599	1.578	1.624	1.586	1.761	1.710
Al	0.023	0.022	0.031	0.020	0.010	0.012	0.002	0.015	0.030
P	0.065	0.081	0.062	0.064	0.061	0.079	0.039	0.072	0.077
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pb	0.018	0.042	0.026	0.022	0.043	0.027	0.074	0.016	0.013
Cd	< 0.010	0.002	0.003	0.001	0.001	0.003	0.001	0.001	0.001
Zn	0.008	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.002
Co	0.002	0.004	0.004	0.008	0.001	0.001	0.067	0.006	0.014
Ni	0.001	0.012	0.001	0.001	0.007	0.001	0.005	0.001	0.001
Cr	0.001	0.001	0.001	0.002	0.001	0.000	0.003	0.000	0.000
Ag	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fe	0.002	0.000	0.000	0.048	0.000	0.005	0.001	0.001	0.001
Mn	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000

ICP method

Table 2

Chemical composition of waters from Lukar 2 (ppm)

	1	2	3	4	5	6	7	8	9
Ca	36.90	34.22	37.37	35.12	36.66	39.03	37.23	37.34	39.14
Mg	1.640	1.517	1.673	1.370	1.712	1.713	1.671	1.400	1.430
K	1.057	1.086	1.030	1.095	1.657	1.590	1.052	1.324	1.232
Na	1.550	1.618	1.430	1.630	1.440	1.451	1.445	1.731	1.600
Al	0.023	0.020	0.027	0.020	0.031	0.035	0.016	0.031	0.016
P	0.081	0.032	0.060	0.087	0.057	0.057	0.060	0.069	0.070
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pb	0.019	0.021	0.044	0.043	0.053	0.041	0.017	0.010	0.013
Cd	< 0.001	0.002	0.001	0.002	0.004	0.003	0.001	0.001	0.001
Zn	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.002	0.002
Co	0.001	0.004	0.008	0.007	0.001	0.001	0.001	0.004	0.003
Ni	0.001	0.001	0.002	0.003	0.003	0.001	0.001	0.001	0.001
Cr	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000
Ag	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fe	0.001	0.000	0.001	0.050	0.076	0.003	0.002	0.001	0.001
Mn	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000

ICP method

Table 3

Chemical composition of waters from Kosmatec (ppm)

	1	2	3	4	5	6	7	8	9
Ca	30.90	30.80	31.62	31.33	31.94	32.05	32.14	31.73	32.60
Mg	1.867	1.648	1.962	1.714	1.789	1.944	1.998	1.709	1.641
K	0.789	0.819	0.988	1.064	0.978	0.811	0.955	1.032	0.978
Na	1.740	1.690	1.650	1.270	1.650	1.651	1.667	1.955	1.875
Al	0.016	0.010	0.029	0.036	0.031	0.001	0.002	0.027	0.043
P	0.026	0.053	0.073	0.072	0.100	0.055	0.086	0.066	0.067
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pb	0.019	0.043	0.045	0.060	0.035	0.061	0.020	0.013	0.021
Cd	0.002	0.004	0.002	0.002	0.001	0.000	0.001	0.001	0.001
Zn	0.002	0.001	0.000	0.027	0.002	0.001	0.001	0.000	0.001
Co	0.003	0.002	0.003	0.004	0.001	0.001	0.005	0.010	0.006
Ni	0.001	0.001	0.000	0.004	0.009	0.028	0.001	0.002	0.002
Cr	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ag	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fe	0.002	0.004	0.005	0.005	0.002	0.012	0.000	0.001	0.001
Mn	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.000	0.000

ICP method

Table 4

Chemical composition of waters from Stara River (ppm)

	1	2	3	4	5	6	7	8	9
Ca	45.63	45.83	44.83	43.88	47.15	42.81	44.12	47.37	46.94
Mg	1.610	1.619	1.772	2.035	1.745	1.546	2.150	1.850	1.818
K	1.066	0.038	1.008	1.190	1.117	1.491	1.356	1.458	1.360
Na	1.318	1.090	1.140	1.050	0.996	1.085	1.134	1.517	1.375
Al	0.058	0.051	0.058	0.057	0.053	0.049	0.051	0.037	0.045
P	0.034	0.068	0.098	0.099	0.083	0.077	0.065	0.085	0.064
As	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pb	0.033	0.046	0.056	0.024	0.030	0.020	0.020	0.020	0.010
Cd	0.000	0.062	0.001	0.001	0.000	0.001	0.003	0.001	0.001
Zn	0.010	0. 001	0.001	0.012	0.001	0.001	0.001	0.014	0.001
Co	0.001	0.002	0.006	0.007	0.001	0.008	0.001	0.001	0.001
Ni	0.001	0.001	0.000	0.004	0.009	0.028	0.001	0.002	0.002
Cr	0.001	0.001	0.001	0.001	0.001	0.011	0.001	0.001	0.001
Ag	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fe	0.024	0.009	0.009	0.021	0.017	0.012	0.017	0.014	0.020
Mn	0.003	0.002	0.002	0.000	0.001	0.002	0.001	0.005	0.002

ICP method

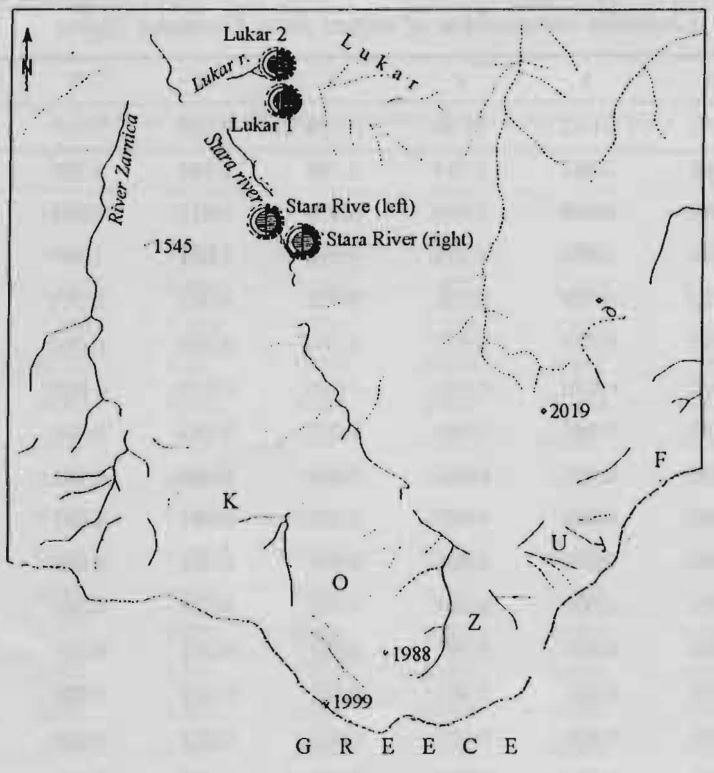

Fig. 2. Hydrochemical map of Lukar 1, Lukar 2, Kosmatec and the Stara River

PROTECTION ZONES OF THE KARST SPRINGS LUKAR 1, LUKAR 2, KOSMATEC AND STARA RIVER

The essential criteria in the determination of the protection zones, their number, dimensions and types were the total area, the supply, the type of spring (karts, boundary and fracture) and the hazard of contamination. Special attention was paid to the following criteria: occurrences of turbid water, afforistration of the area (also wood cutting), the state of erosion processes, the size and type of plants that cover the area, and data regarding human activities and potential sources of diseases in the surrounding area. The river basin round the springs and the places from which they receive the water were taken as factors in the determination of the protection zones around Lukar 1, Lukar 2, Kosmatec and the intake of the Stara River.

Three types of protection zones were determined based on legislation in the Republic of Macedonia, the results obtained from hydrogeological investigations and those of water abundance of the springs, the origin and water quality, the direction and speed of underground waters in the karts of Kožuf as well as the structural, hydrological, hydrogeological factors, the manner of intake and distribution:

– close protection zone or zone of strict contamination observation,

– wide protection zone or zone of sanitation limitation,

– wider protection zone or zone of hygiene-epidemiological observation.

Protection zones have been shown in the map (Fig. 3).

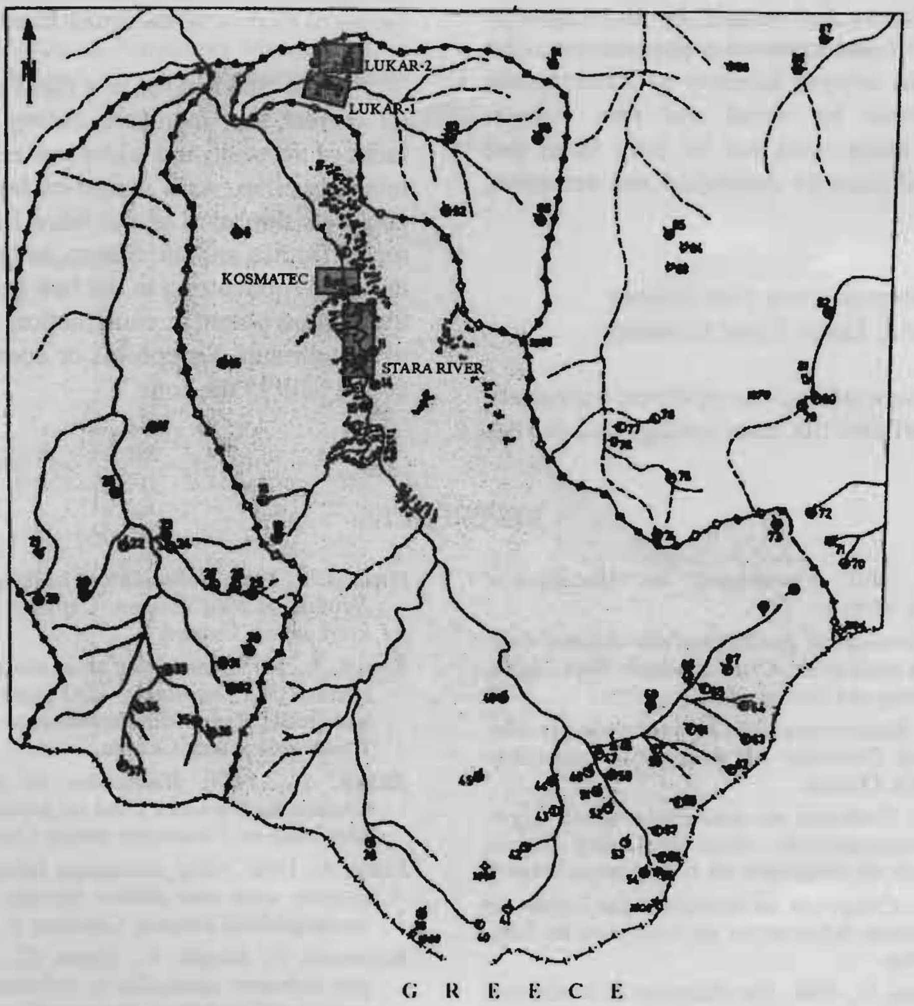

Fig. 3. Map of Lukar 1, Lukar 2, Kosmatec and the Stara River protection zones

Close protection zone around Lukar 1, Lukar 2 and Kosmatec

Based on the norm for determination and maintenance of the protection zones around the springs for water supply and taking in consideration their karst nature the following should be done for each spring:

The zone should extend 50 meters upstream from the spring, laterally up to 25 meters because of the steep slopes, and 15 meters downstream. The zone should be fenced in barbed wire and net. Unauthorized persons and the presence of animals should not be allowed in the zone.

Wide protection zone around Lukar 1, Lukar 2 and Kosmatec karst springs

This zone should include the whole area of karst layers in the Lukar and Kosmatec sites. It is an irregular polyangle area, which overlies water-bearing karst layers that supply the three springs representing also underground water reserves. The area amounts to several hectares of mountainous terrain overgrown by wood and rare valleys. Sheepfolds or stalls must not be built there and cutting of wood must be controlled and according to plan.

Wider protection zone around Lukar 1, Lukar 2 and Kosmatec

This is a zone of hygiene-epidemiological observation. It includes the three springs and the basins of the rivers Zarnica and Stara as far as the Macedonian-Greek border. Tourist, industrial, recreational, sports and agricultural or industrial facilities are not allowed in the zone. Human activities that may have a negative effect on the quality, cleanliness and water resources should not be allowed.

Close protection zone around the surface intake of the Stara River

Since the area of the surface intake of the Stara River is located in an inaccessible and aforested place the following boundaries are suggested for the zone: 500 meters opposite the intake, 100 meters along both banks laterally towards the hills and 20 meters downstream. The zone should be fenced in a barbed wire and a net should be placed in the lower part.

Wide and wider protection zone for the intake of the Stara River

Since Stara River is a rapid mountainous water current that increases during torrent, the surfaces of the wide and wider protection zones of the intake overlap. As a matter of fact, the two zones comprise the basin of the Stara River as far as the top of Dudica and mt. Šarena and part of mt. Kožuf massif. Woodcutting in the two zones must be controlled and planned, construction of roads brought to a minimum. Sheepfolds or country houses must not be built in the zone.

REFERENCES:

Арсовски, М., 1997: *Тектоника на Македонија.* Научна тема, Штип.

Boev, B., 1982: *Petrological, geochemical and volcanic features of volcanic rocks of the Kožuf Mountain.* Doct. Thesis, Faculty of Mining and Geology, Štip.

Боев, Б., 1990a: *Микроелементи во вулканските стени од Кожуф Планина.* XII конгрес на геолозите на Југославија, Охрид.

Боев, Б., 1990b: *Потекло на материјалот од кој се формирани вулканските стени на Кожуф Планина.* XII конгрес на геолозите на Југославија, Охрид.

Боев, Б., 1990c: *Староста на вулканските карпи од Кожуф Планина.* XII конгрес на геолозите на Југославија, Охрид.

Boev, B., Lepitkova, S., 1994: *The chemisam of biotite from the volcanic rocks of mount Kožuf.* Geologica Macedonica, **8**, 1, 19–24 (1994).

Иванов, Т., 1962: *Извештај за истражните работи во Дудица за 1961 година.* Стручен фонд на Геолошкиот завод, Скопје.

Кекиќ, А., 1973: *Извештај за инженерско-геолошките одлики на карпите по траса на довод од изворите Лукар до Кавадарци.* Стручен фонд на Геолошки завод, Скопје.

Кекиќ, А., 1974: *Извештај за хидрогеолошките одлики на горниот слив на реката Бошава.* Стручен фонд на Геолошки завод, Скопје.

Kekić, A., 1976: *Prilog poznavanju karsta i karstne izdani na gornjem slivu reke Bošave (planina Kožuf).* 8. Jugoslovenski geološki kongres, Ljubljana, 4, 71–94.

Котевски, Ѓ., Кекиќ, А., Танев, С., 1968: *Прелиминарен годишен извештај за регионалните хидрогеолошки истражувања во сливот на Црна Река и Бошава, извршени во 1968 година.* Стручен фонд на Геолошки завод, Скопје.

Котевски, Ѓ., 1971: *Хидроīеолошки одлики на сливното йодрачје на Црна Река и Бошава.* Завршен извештај. Стручен фонд на Геолошкиот завод, Скопје.

Ракичевиќ, Т., Пенџерковски Ј., 1963: *Толкувач за основна īеолошка карīа на ФНРЈ, лисī Кожуф.* Стручен фонд на Геолошки завод, Скопје.

Стојанов, Р., Петровиќ, М., 1957: *Геолошки извешīај за ХЕЦ Бошава и Кавадаречко Поле.* Стручен фонд на Геолошки завод, Скопје.

Старова, Н., Кировски, Б., 1973: *Главен йроекī за довод за водоснабдување на īрадоī Кавадарци и околниīе населби со вода од извориīе на Лукар.*

Резиме

ХИДРОГЕОЛОШКИ КАРАКТЕРИСТИКИ НА ПОДРАЧЈЕТО ОКОЛУ ИЗВОРИТЕ ЗА ВОДОСНАБДУВАЊЕ НА ГРАДОТ КАВАДАРЦИ ВО ФУНКЦИЈА НА ИЗДВОЈУВАЊЕ ЗАШТИТНИ ЗОНИ ОКОЛУ НИВ

Војо Мирчовски, Блажо Боев

Рударско-īеолошки факулīеī, Универзиīеī „Св. Кирил и Меīодиј"
ул. Гоце Делчев 89, МК-2000 Шīий, Реīублика Македонија

Клучни зборови: заштитни зони; извори Лукар 1, Лукар 2, Косматец; Стара Река

Врз основа на добиените резултати од хидрогеолошките истражувања, како и во согласност со постојните законски прописи во Република Македонија, за карсните извори Лукар 1, Лукар 2, Косматец и површинскиот зафат на Стара Река се издвоени: потесна заштитна зона, широка заштитна зона и поширока заштитна зона околу секое извориште.