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MINERALOGIC-PETROGRAPHIC INVESTIGATIONS CARRIED OUT ON THE ROCKS ON THE RIGHT SIDE OF THE TIKVEŠ WATER RESERVOIR BY X-RAY DIFFRACTION

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A b s t r a c t: The paper presents data obtained from the mineralogic-petrographic examinations of the rocks in the vicinity of the Tikveš water reservoir near Kavadarci. Investigations carried out on the metamorphic complex of the Vardar zone determined that the complex consists of sericite-quartzite schists, phyllite schists, quartzite and quartz schists, amphibole quartz schists, cherts and interbeds of marbles and marbelized limestones hosted in various parts of the scaly complex. Detailed examination by X-ray diffraction discovered the following mineral assemblage: albite, sericite, quartz, amphibole, phyllosilicates, chlorite etc.

Key words: sericite-quartzite schists; quartzites; amphibole quartzite schists; albite; amphibole; quartz

INTRODUCTION

The general engineering-geologic characteristics of the terrain under investigation can be seen from the detailed geological map for the site. The map was compiled based on geological investigations as well as on compilation of the available documentation (Arsovski, 1968; Izmajlov, 1951, 1960, 1961).

The rock types distinguished at the cross section of the water reservoir (Fig. 1) are as follows: sericite-quartzite schists, phyllite schists, quartzites and quartz schists, amphibole quartz schists and cherts, marble interbeds and marble limestones hosted in different parts of the schistose complex which, according to the degree of metamorphism, can be classified as greenschists facies. The complex is part of the Early Paleozoic rocks that are widespread and widely dislocated in the Vardar zone.

Serpentinites and serpentinized peridotites overthrusting Paleozoic schists from the west have been found on the left slope of the cross-section.

The most common rocks on the right side of the water reservoir are sericite-quartzite schists falling rather steep (50 – 70°) towards the Crna riverbed (azimuth 230 – 250). The sericite-quartzite schists are present as carbonate-chlorite to phyllite-graphyte schists) occurring as cherts, interbeds and intercalations in the basal rocks.

It is characteristic that the rocks have weathered on the surface. Their tectonic distortion (boudinage, fissuration, and interbed milonitization) has made the zone of weathering fairly deep (occasionally over 30 meters thick).

On the surface, the rocks are intersected by interbedded, lateral and diagonal fissures of blocks of several dozens of centimeters in size and the small debris that often grades to clayey material that fills the space between the blocks.

Drainage of atmospheric waters caused the formation of open fissures (determined of up to 80 cm in size). The distortion of natural environment and cutting of slopes created the conditions for the formation of landslides, rockfalls and settlings.

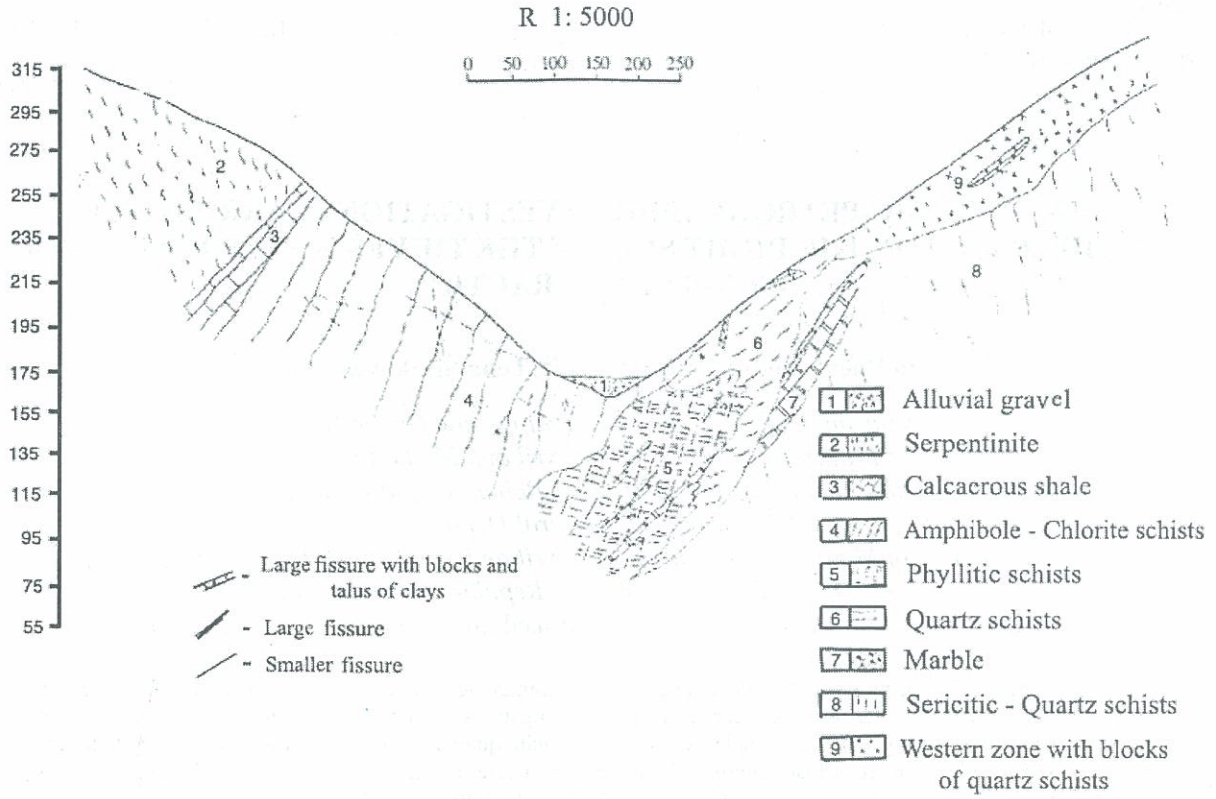

Fig. 1. Geological cross-section of the Tikveš water reservoir

The sericite-quartzite schists on the right side of the water reservoir are overthrusted by dark blue phyllite schists that are gradually facially connected with the former, being similar in their characteristics to those described above.

Quartzite and quartzite schists predominate the lowest parts of the right side of the cross-section. They generally fall towards the riverbed.

Quartzites are light in colour, massive and stratified occurring along with white marbles. Since their mass is significantly stronger than that of the other sericite-quartzite schists and phyllites they are fairly well preserved on the surface as blocks of variable size (from dozen cubic meters to 0.5 m^3) extending in the eroded schist mass. Sporadically, quartzite blocks are fissured and fall apart into small pieces.

All rocks described above occurring at the right side of the Crna riverbed (W – SW strike under an angle of 40 – 70°) are indicators that bending of layers exists.

Undulation seen in the quartzite layers and marbles, which are fairly preserved, can be seen on the surface south of the cross-section.

In general, the rock complex is a monocline block with layers extending WSW towards the riverbed under an angle of 45 – 70°. The steep parts are dominant in the sections closer to the river where they dominate on the surface and in the galleries. This leads to the assumption that a steep fault passes along the right side of the Crna riverbed some 30 m from the access portal of the drainage tunnel.

Folds occurring on the surface are slight anticlines (like the synclines with 70 to 100 m span). They are probably of gravitational origin conditioned by the settling of layers by the more compact rocks overlying the phyllite-graphyte and sericite-quartzite schists, which are eroded and lie beneath the more compact quartzite and marbles. This conclusion about the mechanism of the formation of folds is supported by the presence of intersected slopes in the quartzite layers in the

lower parts of the slope near the inner portal of the basal outlet.

Most probably part of these occurrences are associated with the formation of faults determined in the galleries (the Tisovec tunnel for irrigation, 200 m at depth) and a fault at the deep part of the tunnel that is characterized by some 0.5 m thick harnish and milonite zone. The faults extend to the river with variable angle.

Reliable data on the fissure system on the right slope of the cross-section of the water reservoir can not be provided since the surface parts are rather fractured and eroded without distinguishing any fissure systems.

In the galleries studied fissures falling to the riverbed have been determined 50 cm at depth. The fissures are related to the rock schistosity or coincide foliation.

In order to get the right idea for the formation of the thickness of this loose, fractured material, it is necessary to point out that it reduces going towards the river bed and totally wedges out that allows to assume that its genesis is closely related to the evolution of the river valley.

The upper parts were affected by exogene factors, first of all the effects of water and insolation.

The left side of the cross-section differs in its engineering-geologic characteristics as the rock there fall towards the hill under an angle of 55 to 65° and are less affected by insolation, and the intensity of weathering was low.

At the contact between the schists and the serpentinites there is intense falling apart since the rocks are rather broken.

The lower part of the left side of the cross-section (up to the level of 190 – 200 m), is built of relatively compact greenschists. In some parts they have been disharmoniously folded in small folds whose "b" axes bury under azimuth of 165 – 160/10 – 15°. Cleavage is strongly expressed in the rocks that allows cherty and verge leaching and weathering of rocks with clear expressed lineation (line orientation) in amphiboles. Fissure system, perpendicular to extension, is well expressed in them.

In the upper parts of the cross-section chlorite-carbonate schists overlie amphibole schists with interbeds and marble lenses along which they are overthrust by serpentinite and serpentinized peridotites from the western side along a reverse fault (scale). This made it possible the rocks in the bed wing to be intensely dislocated, with the occurrence of elongated folds intensely fractured by transverse, steep and elongated fissures and faults. Of these ruptures the most striking are the transverse ones.

In conditions of schist and marble alteration of different mechanical properties (the former being plastic and the latter friable) and geotectonic distortions that occurred in their evolution with serpentinite overthrusting, a boudinage was formed, or lens-like break up of noncomponental layers in the components.

Investigation determined that at the contact with serpentinites, phyllite and chlorite-carbonate schists are intensely fractured under the reverse fault 20 m at depth, being more compact in the deeper parts.

TIKVEŠ 1

Structure: nonmetablastic.

Mineral composition: amphibole, chlorite, albite, calcite.

Amphibole occurs as greenish hyipidiomorphic grains.

Pleochroism is weak with greenish and greenish yellow tinges. It possesses positive relief. Tarnish is steep. Angle of tarnish is small amounting to 10° – 13°.

Chlorite is green with clear pleochroism and low interference colours.

Albite occurs as small hypidiomorphic grains. It is colourless and interferes into white or pale colour of first order.

Calcite is colourless. Interferes to white of higher order. Since it occurs as small-grains, cleavage is poorly expressed.

The minerals have also been determined by X-ray.

The results obtained are given in Tables 1 and 2.

Table 1

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
6.2773	83.83	0.0590	14.08049	20.43	0.0600	29-0701
9.8044	24.01	0.1181	9.02152	5.85	0.1200	45-1371
10.5529	410.28	0.0787	8.38325	100.00	0.0800	45-1371
12.5512	136.59	0.1181	7.05272	33.29	0.1200	29-0701
13.8807	9.48	0.2362	6.38001	2.31	0.2400	41-1480
18.8467	37.60	0.1574	4.70863	9.17	0.1600	29-0701
22.0619	52.19	0.0590	4.02917	12.72	0.0600	45-1371; 41-1480
24.3255	17.26	0.1181	3.65912	4.21	0.1200	41-1480
25.1883	64.76	0.0984	3.53571	15.78	0.1000	29-0701
26.3158	25.60	0.1968	3.38672	6.24	0.2000	45-1371; 41-1480
27.2531	27.51	0.1181	3.27233	6.70	0.1200	45-1371
27.8157	74.38	0.1574	3.20742	18.13	0.1600	41-1480
28.6322	229.54	0.0984	3.11778	55.95	0.1000	45-1371
29.4358	87.44	0.0984	3.03447	21.31	0.1000	24-0027
30.4151	32.32	0.2362	2.93896	7.88	0.2400	45-1371; 41-1480
31.6904	8.83	0.4723	2.82354	2.15	0.4800	29-0701; 45-1371; 24-0027
33.0471	46.95	0.0787	2.71066	11.44	0.0800	45-1371
34.5280	27.36	0.1968	2.59772	6.67	0.2000	29-0701; 45-1371
35.2148	22.74	0.1181	2.54861	5.54	0.1200	29-0701; 45-1371; 41-1480
37.7140	7.94	0.4723	2.38527	1.93	0.4800	29-0701; 45-1371; 41-1480
38.4608	22.70	0.1574	2.34066	5.53	0.1600	45-1371; 41-1480
41.6608	6.25	0.4723	2.16797	1.52	0.4800	45-1371; 41-1480
43.1204	4.99	0.4723	2.09791	1.22	0.4800	41-1480; 24-0027
44.8917	16.38	0.2362	2.01916	3.99	0.2400	29-0701; 45-1371; 41-1480
48.1505	10.62	0.2362	1.88985	2.59	0.2400	29-0701; 45-1371; 41-1480
55.7425	9.50	0.3149	1.64911	2.32	0.3200	45-1371
58.1530	11.83	0.4800	1.58505	2.88	0.4000	45-1371; 24-0027

Table 2

Pattern list

Ref. code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
29–0701	42	Chlorite	0.000	0.318	$(Mg, Fe)_6 (Si, Al)_4 O_{10}(OH)_8$
45–1371	41	Amphibole	0.000	0.523	$Ca_2(Mg, Fe^{+2})_4 Al(Si_7Al) O_{22}(OH, F)_2$
41–1480	25	Albite	0.000	0.247	$(Na, Ca)Al(Si, Al)_3 O_8$
24–0027	18	Calcite	0.000	0.205	$CaCO_3$

TIKVEŠ 2

Structure: porphyroblastic
Mineral composition: albite, quartz, chlorite

Albite occurs as coarse grains (Fig. 2). Polysynthetic twins can be seen. It is colourless and interferes to white or yellow colour of first order.

Quartz occurs in xenomorphic much finer grains than albite.

It is colourless and possesses low relief and grey interference colour.

Chlorite is the least present. It is characterized by green colour, clear pleochroism and low interference colours.

The minerals were determined by X-ray. The results obtained are shown in Tables 3 and 4.

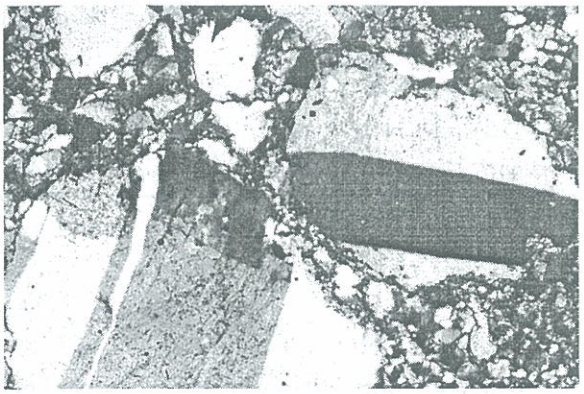

Fig. 2. Microphotograph of albite of a sample Tikveš 2

Table 3

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
6.2470	71.15	0.0984	14.14873	11.76	0.1000	07-0076
12.5199	91.97	0.1181	7.07023	15.20	0.1200	07-0076
13.9048	80.14	0.0787	6.36902	13.25	0.0800	20-0554
18.7242	12.02	0.4723	4.73917	1.99	0.4800	07-0076
20.9427	16.00	0.2362	4.24189	2.65	0.2400	33-1161
22.0701	158.97	0.1378	4.02769	26.28	0.1400	20-0554
23.0845	24.78	0.1181	3.85295	4.10	0.1200	20-0554
23.5762	119.04	0.0787	3.77369	19.68	0.0800	20-0554
24.3425	59.94	0.1181	3.65660	9.91	0.1200	20-0554
25.1571	36.79	0.1574	3.54002	6.08	0.1600	20-0554; 07-0076
26.6685	103.74	0.0787	3.34272	17.15	0.0800	20-0554; 33-1161
27.9521	604.96	0.0984	3.19207	100.00	0.1000	20-0554
30.5221	43.35	0.1574	2.92890	7.17	0.1600	20-0554
31.2819	30.44	0.1181	2.85947	5.03	0.1200	20-0554
34.4715	15.91	0.2755	2.60185	2.63	0.2800	07-0076
35.0948	21.46	0.2362	2.55705	3.55	0.2400	20-0554; 07-0076
37.5261	14.68	0.3936	2.39678	2.43	0.4000	20-0554; 07-0076
38.8709	10.57	0.2362	2.31691	1.75	0.2400	20-0554
39.5860	9.33	0.2362	2.27668	1.54	0.2400	20-0554; 33-1161; 07-0076
42.4863	22.77	0.2362	2.12774	3.76	0.2400	20-0554; 33-1161
45.3906	3.52	0.9446	1.99812	0.58	0.9600	20-0554
48.1890	21.39	0.3936	1.88843	3.53	0.4000	20-0554; 07-0076
51.1847	23.15	0.2362	1.78472	3.83	0.2400	20-0554
53.2690	11.12	0.3149	1.71970	1.84	0.3200	20-0554; 07-0076
59.9044	6.02	0.5760	1.54283	1.00	0.4800	33-1161; 07-0076

Table 4

Pattern list

Ref. Code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
20-0554	49	Albite	0.000	0.628	$NaAlSi_3O_8$
33-1161	41	Quartz	0.000	0.164	SiO_2
07-0076	40	Chlorite	0.000	0.116	$(Mg_{2.8}Fe_{1.7}Al_{12})\ (Si_{2.8}Al_{1.2})\ O_{10}(OH)_8$

TIKVEŠ 3

Structure: porphyroblastic

Mineral composition: chlorite, amphibole, albite

Chlorite is the most common. It is characterized by green colour, low interference colours and clear pleochroism.

Amphibole occurs in finer hypidiomorphic grains. Pleochroism is pale greenish and poorly expressed. The relief is positive. Tarnish is steep.

Albite occurs as large grains (Fig. 3). It is colourless and interferes to white or yellow colour of first order.

The results from the X-ray examinations are given in Tables 5 and 6.

Fig. 3. Microphotograph of albite of a sample Tikveš 3

Table 5

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
6.2718	74.25	0.0787	14.09272	33.00	0.0800	29-0701
9.7984	24.60	0.1181	9.02703	10.93	0.1200	45-1371
10.5545	225.01	0.0787	8.38199	100.00	0.0800	45-1371
12.5345	127.81	0.0787	7.06205	56.80	0.0800	29-0701
13.8950	11.60	0.1821	6.37350	5.16	0.1517	20-0548
17.4812	12.20	0.1402	5.07326	5.42	0.1169	45-1371
17.7076	18.97	0.1181	5.00888	8.43	0.1200	
18.8146	24.71	0.1574	4.71661	10.98	0.1600	29-0701; 45-1371; 20-0548
19.6690	15.11	0.1876	4.51360	6.71	0.1563	45-1371
20.9837	6.18	0.4723	4.23369	2.75	0.4800	45-1371
22.0833	125.05	0.0787	4.02531	55.58	0.0800	45-1371; 20-0548
22.9500	9.60	0.3641	3.87522	4.27	0.3034	45-1371; 20-0548
23.6151	22.60	0.0873	3.76755	10.04	0.0727	20-0548
24.2680	10.86	0.2362	3.66765	4.83	0.2400	20-0548
25.1759	54.37	0.1574	3.53742	24.16	0.1600	29-0701
25.5712	18.70	0.1322	3.48362	8.31	0.1102	20-0548
26.3243	37.27	0.1430	3.38565	16.56	0.1192	45-1371; 20-0548
27.2498	32.60	0.1091	3.27272	14.49	0.0909	45-1371

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
27.5379	43.33	0.2161	3.23913	19.26	0.1801	
27.9857	89.50	0.2637	3.18832	39.78	0.2197	20-0548
28.6669	116.06	0.0984	3.11409	51.58	0.1000	45-1371
29.4598	17.19	0.1181	3.03205	7.64	0.1200	
29.8665	16.70	0.0841	2.99168	7.42	0.0701	20-0548
30.3993	24.21	0.1968	2.94045	10.76	0.2000	45-1371; 20-0548
30.8752	23.20	0.1574	2.89621	10.31	0.1600	
31.7699	8.73	0.4723	2.81665	3.88	0.4800	29-0701; 45-1371; 20-0548
33.0528	57.03	0.0590	2.71020	25.34	0.0600	45-1371
33.9522	9.90	0.1034	2.64044	4.40	0.0862	20-0548
34.5334	41.85	0.1574	2.59732	18.60	0.1600	29-0701; 45-1371
35.1981	20.83	0.2362	2.54978	9.26	0.2400	29-0701; 45-1371; 20-0548
36.7429	17.70	0.1116	2.44605	7.87	0.0930	29-0701; 20-0548
37.5043	19.30	0.1603	2.39813	8.58	0.1336	29-0701; 45-1371; 20-0548
38.4450	8.79	0.2362	2.34158	3.91	0.2400	45-1371
39.4794	4.62	0.4723	2.28258	2.05	0.4800	45-1371; 20-0548
41.7264	22.42	0.2755	2.16472	9.96	0.2800	45-1371; 20-0548
44.2166	14.20	0.0749	2.04841	6.31	0.0624	45-1371
45.0455	11.90	0.4723	2.01263	5.29	0.4800	29-0701; 45-1371; 20-0548
48.4444	3.10	0.9446	1.87907	1.38	0.9600	29-0701; 20-0548
55.7513	12.71	0.2362	1.64887	5.65	0.2400	45-1371
58.1778	6.94	0.5760	1.58444	3.08	0.4800	45-1371

Table 6

Pattern list

Ref. code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
29-0701	42	Chlorite	0.000	0.528	$(Mg, Fe)_6(Si, Al)_4O_{10}(OH)_8$
45-1371	40	Amphibole	0.000	0.470	$Ca_2(Mg, Fe^{+2})_4Al(Si_7Al)O_{22}(OH, F)_2$
20-0548	23	Albite	0.000	0.218	$(Na, Ca)\ (Si, Al)_4O_8$

DP-1-19m

Structure: granoblastic

Mineral composition: quartz, albite, phyllosilicate (Fig. 4).

Quartz occurs as fine xenomorphic grains. It is colourless, with low relief and grey interference colours.

Albite occurs as fine hypidiomorphic grains. It is colourless. Interferes to white and yellow colour of first order.

Fine flaky phyllosilicate has also been determined. Tables 7 and 8 give data obtained by X-ray examinations.

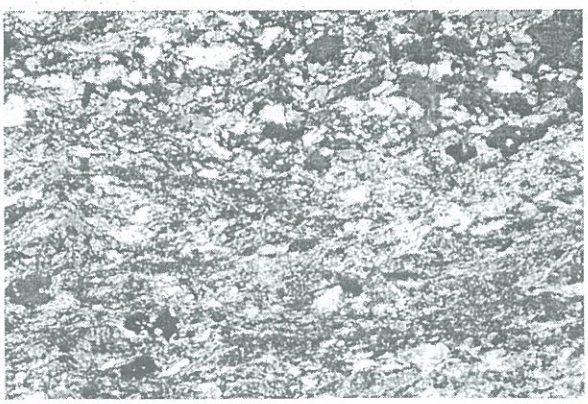

Fig. 4. Microphotograph of a sample DP-1-19

Table 7

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
8.8597	317.29	0.0787	9.98121	56.24	0.0800	07-0042
12.4635	14.30	0.2362	7.10215	2.53	0.2400	
13.8530	26.63	0.1574	6.39273	4.72	0.1600	09-0466
17.7553	29.80	0.1181	4.99556	5.28	0.1200	07-0042
19.8060	16.20	0.0327	4.48269	2.87	0.0272	07-0042
20.8476	116.85	0.0787	4.26103	20.71	0.0800	05-0490
22.0161	60.39	0.0984	4.03744	10.71	0.1000	09-0466
22.9608	13.11	0.3149	3.87341	2.32	0.3200	07-0042; 09-0466
23.5524	44.83	0.1574	3.77745	7.95	0.1600	09-0466
24.1788	37.25	0.2362	3.68099	6.60	0.2400	09-0466
25.4360	20.28	0.2362	3.50183	3.59	0.2400	09-0466
26.6273	564.13	0.0787	3.34781	100.00	0.0800	07-0042; 05-0490
27.9491	205.20	0.1181	3.19240	36.38	0.1200	09-0466
30.4702	33.79	0.1574	2.93377	5.99	0.1600	09-0466
31.2580	14.74	0.2362	2.86161	2.61	0.2400	09-0466
33.9433	13.05	0.0588	2.64112	2.31	0.0490	09-0466
34.9383	10.93	0.3149	2.56814	1.94	0.3200	07-0042; 09-0466
36.5374	34.95	0.1181	2.45933	6.20	0.1200	07-0042; 05-0490; 09-0466
38.8900	9.33	0.4039	2.31581	1.65	0.3366	09-0466
39.4823	17.47	0.1574	2.28242	3.10	0.1600	05-0490; 09-0466
40.3281	9.25	0.2362	2.23649	1.64	0.2400	05-0490
41.2587	9.51	0.2362	2.18817	1.69	0.2400	07-0042; 09-0466
42.4489	23.14	0.1968	2.12953	4.10	0.2000	07-0042; 05-0490; 09-0466
45.4219	33.74	0.1574	1.99682	5.98	0.1600	07-0042; 09-0466
48.2922	4.09	0.4723	1.88463	0.72	0.4800	07-0042; 09-0466
50.1100	44.09	0.0960	1.81894	7.82	0.0800	05-0490; 09-0466
51.2504	6.89	0.2362	1.78259	1.22	0.2400	09-0466
54.6942	7.19	0.7872	1.67821	1.28	0.8000	05-0490
59.9090	28.89	0.1920	1.54272	5.12	0.1600	05-0490

Table 8

Pattern list

Ref. code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
07-0042	23	Phyllosilicate	0.000	0.277	(K, Na) (Al, Mg, Fe)$_2$ ($Si_{3.1}$ $Al_{0.9}$)$O_{10}(OH)_2$
05-0490	55	Quartz	0.000	0.902	SiO_2
09-0466	42	Albite	0.000	0.275	$NaAlSi_3O_8$

DP-1-25 m

Structure: granoblastic

Mineral composition: quartz, chlorite, phyllosilicate.

Quartz occurs airless. It possesses low relief and grey interference colours.

Chlorite is green with low interference colours. It possesses clear pleochroism.

It occurs as fine flaky phyllosilicate.

The minerals were determined by X-ray. Data obtained are given in Tables 9 and 10.

Table 9

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
6.2610	133.64	0.0787	14.11709	15.78	0.0800	29-0701
8.8856	649.48	0.0590	9.95220	76.70	0.0600	01-1098
12.5343	314.12	0.0787	7.06215	37.09	0.0800	29-0701
17.7963	174.07	0.0984	4.98414	20.56	0.1000	01-1098
18.8436	53.35	0.0984	4.70941	6.30	0.1000	29-0701
19.9054	17.11	0.2755	4.46054	2.02	0.2800	01-1098
20.8720	146.99	0.0984	4.25611	17.36	0.1000	05-0490
22.0535	11.54	0.1181	4.03069	1.36	0.1200	
22.9305	10.99	0.2362	3.87847	1.30	0.2400	01-1098
23.8234	11.76	0.2362	3.73508	1.39	0.2400	01-1098
25.1827	174.96	0.0984	3.53648	20.66	0.1000	29-0701
26.6363	846.82	0.0984	3.34669	100.00	0.1000	05-0490; 01-1098
26.8258	390.41	0.0787	3.32348	46.10	0.0800	01-1098
27.8938	44.51	0.1574	3.19861	5.26	0.1600	01-1098
29.9087	31.10	0.1574	2.98755	3.67	0.1600	01-1098
31.2441	18.38	0.2362	2.86285	2.17	0.2400	01-1098
31.6648	23.54	0.1574	2.82576	2.78	0.1600	29-0701
35.0242	30.05	0.1968	2.56204	3.55	0.2000	01-1098; 29-0701
36.0096	20.57	0.1968	2.49416	2.43	0.2000	
36.5460	47.05	0.1574	2.45877	5.56	0.1600	05-0490; 29-0701
37.7527	10.14	0.4723	2.38292	1.20	0.4800	01-1098; 29-0701
39.4808	39.17	0.1181	2.28251	4.63	0.1200	05-0490; 01-1098
40.2596	18.90	0.1968	2.24013	2.23	0.2000	05-0490
42.4312	33.93	0.1968	2.13037	4.01	0.2000	05-0490; 01-1098
45.4819	137.56	0.1181	1.99432	16.24	0.1200	01-1098
50.1255	84.49	0.0720	1.81841	9.98	0.0600	05-0490; 29-0701
54.8466	22.50	0.1574	1.67391	2.66	0.1600	05-0490
55.8655	12.73	0.2362	1.64577	1.50	0.2400	01-1098
58.9830	6.59	0.4723	1.56601	0.78	0.4800	29-0701
59.9610	54.56	0.1200	1.54151	6.44	0.1000	05-0490

Table 10

Pattern list

Ref. code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
05-0490	60	Quartz	0.000	0.897	SiO_2
01-1098	39	Phyllosilicate	0.000	0.097	$H_2KAl_3(SiO_4)_3$
29-0701	50	Chlorite	0.000	0.254	$(Mg, Fe)_6(Si, Al)_4O_{10}(OH)_8$

DP-1-35 m

Structure: lepidoblastic

Mineral composition: chlorite, phyllosilicate.

Chlorite occurs as fine green crystals and low interference colours. It possesses clear pleochroism.

Fine flaky phyllosilicate has also been determined.

The minerals have been determined by X-ray. The results obtained are given in Tables 11 and 12.

Table 11

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
6.2624	461.38	0.0787	14.11383	36.92	0.0800	29-0701
8.8873	1249.79	0.0787	9.95028	100.00	0.0800	01-1098
12.5271	718.23	0.0984	7.06624	57.47	0.1000	29-0701
17.8058	330.81	0.0984	4.98149	26.47	0.1000	01-1098
18.7993	219.45	0.0984	4.72042	17.56	0.1000	29-0701
25.1632	442.73	0.1181	3.53917	35.42	0.1200	29-0701
26.8209	684.93	0.1378	3.32408	54.80	0.1400	01-1098
29.4675	88.26	0.0787	3.03128	7.06	0.0800	
31.5929	77.58	0.0984	2.83203	6.21	0.1000	29-0701
35.0654	19.14	0.2362	2.55913	1.53	0.2400	29-0701; 01-1098
36.0009	53.86	0.1968	2.49475	4.31	0.2000	
36.7323	9.31	0.3149	2.44673	0.74	0.3200	29-0701
37.6461	12.59	0.3149	2.38942	1.01	0.3200	29-0701; 01-1098
39.6793	5.91	0.6298	2.27155	0.47	0.6400	29-0701; 01-1098
42.2483	2.91	0.6298	2.13917	0.23	0.6400	01-1098
45.4030	193.74	0.1181	1.99761	15.50	0.1200	29-0701; 01-1098
48.5153	5.18	0.4723	1.87649	0.41	0.4800	29-0701
49.9041	4.45	0.6298	1.82747	0.36	0.6400	29-0701
55.3021	9.94	0.9446	1.66119	0.80	0.9600	29-0701
59.0429	13.96	0.4800	1.56327	1.12	0.4000	29-0701

Table 12

Pattern list

Ref. code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
29-0701	53	Chlorite	0.000	0.658	$(Mg, Fe)_6(Si, Al)_4O_{10}(OH)_8$
01-1098	19	Phyllosilicate	0.000	0.156	$H_2KAl_3(SiO_4)_3$

DP-1-38 m

Structure: lepidoblastic

Mineral composition: Chlorite, phyllosilicate, calcite, quartz

Chlorite is the most common. It is characterized by green colour, low interference colours and clear pleochroism.

Calcite – colourless, with low relief and grey interference colours.

Quartz occurs as fine xenomorphic grains. It is colourless, with low relief and grey interference colours.

Fine flaky phyllosilicate has also been determined in rock.

The minerals have been determined by X-ray. The results obtained are given in Tables 13 and 14.

Table 13

Peak list

Pos. °2Th.	Height cts	FWHM °2Th.	d-spacing Å	Rel. int. %	Tip width °2Th.	Matched by
6.2714	172.57	0.0984	14.09362	33.36	0.1000	29-0701
8.8898	207.04	0.1181	9.94755	40.02	0.1200	07-0042
12.5323	391.09	0.0787	7.06329	75.60	0.0800	29-0701
17.8186	52.48	0.0984	4.97793	10.14	0.1000	07-0042
18.8171	106.14	0.0787	4.71598	20.52	0.0800	29-0701
20.9008	107.77	0.0787	4.25029	20.83	0.0800	
23.1400	18.00	0.1378	3.84383	3.48	0.1149	24-0027
25.1663	187.65	0.0984	3.53874	36.27	0.1000	29-0701
26.6617	517.34	0.0984	3.34356	100.00	0.1000	07-0042; 02-0471
29.4925	134.36	0.1378	3.02876	25.97	0.1400	24-0027
31.6069	42.71	0.1574	2.83081	8.26	0.1600	29-0701; 24-0027
34.6500	25.02	0.3054	2.58885	4.84	0.2545	29-0701; 07-0042
34.9783	31.70	0.1603	2.56530	6.13	0.1336	29-0701; 07-0042
36.0421	16.05	0.2362	2.49199	3.10	0.2400	07-0042; 24-0027
36.5712	37.74	0.1181	2.45714	7.29	0.1200	29-0701; 07-0042; 02-0471
37.7176	8.48	0.4723	2.38505	1.64	0.4800	29-0701; 07-0042
39.5110	37.48	0.1181	2.28083	7.24	0.1200	24-0027; 02-0471
40.3144	22.60	0.1029	2.23721	4.37	0.0858	
42.4729	23.14	0.1181	2.12838	4.47	0.1200	07-0042; 02-0471
43.2541	15.62	0.1181	2.09174	3.02	0.1200	24-0027
45.4858	38.31	0.1968	1.99416	7.41	0.2000	07-0042
47.6286	27.62	0.2362	1.90933	5.34	0.2400	24-0027
48.2276	10.83	0.1305	1.88701	2.09	0.1088	29-0701; 07-0042
48.6516	15.27	0.2362	1.87155	2.95	0.2400	24-0027
50.1433	45.71	0.1574	1.81931	8.84	0.1600	29-0701; 02-0471
54.8995	15.37	0.1167	1.67242	2.97	0.0972	02-0471
55.2891	6.18	0.9446	1.66156	1.19	0.9600	29-0701
59.0766	9.08	0.3149	1.56375	1.76	0.3200	29-0701
59.9623	32.27	0.1440	1.54148	6.24	0.1200	02-0471
60.7484	8.69	0.2452	1.52466	1.68	0.2044	07-0042; 24-0027
61.4250	11.90	0.1567	1.50948	2.30	0.1306	29-0701; 24-0027

Table 14

Pattern list

Ref. code	Score	Compound name	Displacement °2Th.	Scale factor	Chemical formula
29-0701	57	Chlorite	0.000	0.519	$(Mg, Fe)_6(Si, Al)_4O_{10}(OH)_8$
07-0042	32	Phyllosilicate	0.000	0.217	$(K, Na)(Al, Mg, Fe)_2(Si_{3.1}Al_{0.9})O_{10}(OH)_2$
24-0027	39	Calcite	0.000	0.206	$CaCO_3$
02-0471	27	Quartz	0.000	0.136	SiO_2

CONCLUSION

The petrographic-mineralogical investigations of the rocks of the right side of the TikveŠ water reservoir carried out by X-ray diffraction indicated that the major minerals occurring in the metamorphic complex are chlorite, quartz, albite, amphibole, phyllosilicate, calcite etc. The mineral assemblage makes it possible to determine that the rocks metamorphosed in conditions of green schist facies.

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Резиме

МИНЕРАЛОШКО-ПЕТРОГРАФСКИ ИСТРАЖУВАЊА НА КАРПИТЕ ОД ДЕСНАТА СТРАНА НА БРАНАТА ТИКВЕШ СО ПРИМЕНА НА РЕНДГЕНСКАТА ДИФРАКЦИЈА

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Клучни зборови: серицитско кварцни шкрилци; кварцити; амфиболско кварцни шкрилци; албит; амфибол; кварц; хлорит.

На база на спроведените петрографско-минералошки истражувања на карпите од десната страна на езерото Тиквеш со примена на методите на рендгенска дифракција може да се констатира дека како главни минерали во овој метаморфен комплекс се појавуваат: хлорит, кварц, албит, амфибол, филосиликат, калцит и др. Ваквата минерална асоцијација во основа зборува за тоа дека овие карпи се метаморфозирани во услови на фацијата на зелени шкрилци.