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Original scientific paper

THE POSSIBILITIES OF USING THE GRANODIORITE OF KOSOVSKA RIVER, VILLAGE OF ČANIŠTE (WESTERN MACEDONIA), AS AN ARCHITECTURAL STONE

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A b s t r a c t: The granodiorite of the Kosovska River, western Macedonia, has been examined in order to determine the possibility to be used as an architectural stone. The analyses themselves as well as the laboratory testings have been done on samples of granodiorite. The samples were taken from the surface parts, and the results from their physical and mechanical examination have shown that rock mass itself satisfies all requirements form the use as architectural stone according to the state standards of R. Macedonia. Also the quality of the stone is greater in the deeper parts of the terrain where the influences from the outside have a very small effect. This stone does not have highly decorative features but it has a very fine granual structure which has a positive effect for the technical characteristics and for the being a subject for processing.

Key words: granodiorite; Kosovska River; architectural stone; mineralogic-petrographic content; structural-textural characteristics; basic minerals

INTRODUCTION

The granodiorite of Kosovska river is located about 0.5 km north-west from the Čanište village and about 6 km south-east from the village of Kruševica, in the series of gneisses which has been broken through with granite and granodiorite as part of the metamorphic complex of the Pelagon. This area is geographically close to Selečka Mountain as an eminent orthographic unit in this part of Macedonia. The largest water artery in this part of the terrain is Čaniška river which has Lozjanska river, Kruševiška river and Kosovska river as its confluents.

In the past period, up to now, in search of good quality granite, many other regions have been researched on many occasions in the area of Mariovo, but no significant results have been received.

Stojanov (1958 and 1960) has researched these terrains and distinguished many varieties of gneisses, mica schists, amphibolite and granitoid rocks. In the doctoral dissertation Stojanov stated some conclusions which concern the entire Pelagon and believes that in the beginning of the Algonquian orogenic movements a progressive metamorphosis has been done in the lower precambrian complex and towards the end of the orogenic movements granodiorite-adamelite masses have taken root.

In the period of making the Basic Geologic map of SFRY the authors of the leave Vitolište (Dumurdžanov, Hristov 1976) and Prilep (Rakičević, Stojanov, Arsovski, 1965) processed the leave content of the rocks of the leave Vitolište where the granodiorite Kosovska river belongs.

The Kosovska river granodiorite has been researched in detail by Spasovski (2010) when for the first time its mineralogic-petrographic and chemical content is determined.

RESEARCH METHODS USED

The mineralogic-petrographic research have been done on the Faculty of Natural and Technical Sciences in Štip by the author of this paper, while the chemical content of the granodiorite is determined in the chemical laboratory in Železara in Skopje.

The research of the physical-chemical characteristics was performed in the laboratory at the Faculty of Civil Engineering in Skopje. The examinations were performed during 2010. Because the rock masses are not well disposed, the samples were taken from the surface of the terrain. As a consequence in the samples themselves there are some cracks which is a result from the great influence of the atmosphere. However the examinations of the samples have shown credible values of their physical-mechanical characteristics. It is certain that the samples from the greater depths would give much better results.

GEOLOGIC CHARACTERISTICS

In the geologic structure of the area that is included in our observation and research there are three types of rocks that included: muscovite gneisses, granodiorite and quartz diorite (Fig. 1, 2).

The muscovite gneisses are outspread in the northern and north-eastern part of the researched area. They are characterized with grey colour with glittering radiance from the leaves of muscovite which can clearly be noticed. They are characterized with slightly distinguished parallel schistose texture. The structure of the gneisses is grano-lepidoblastic with slightly distinguished striped texture. The main minerals in the rock are: quartz, feldspar and mica. The participation of salic and femic minerals is approximately equal in quantity, i.e. the salic are slightly more present. The quartz is found in xenomorphic crystals as well as in feldspars. The feldspar is K-feldspar – orthoclase and plagioclase. The orthoclase is fairly clayed while the plagioclase is more strongly clayed. The plagioclase is albite to intermediate plagioclase. It is rare to find some larger xenomorphic crystals of orthoclase, as porphyroblastic. The mica is represented with muscovite and biotite and they are found in not clearly distinguished lines. It is typical for the biotite that it is bleached – baritised, so it has a fairly weak brownish interference. The secondary minerals are the epidote, ortite, rarely granite and mining mineral in irregular shapes. The epidote is quite common in long crystals andis regularly associated with mica lines. The apatite and the zircon are accessory minerals.

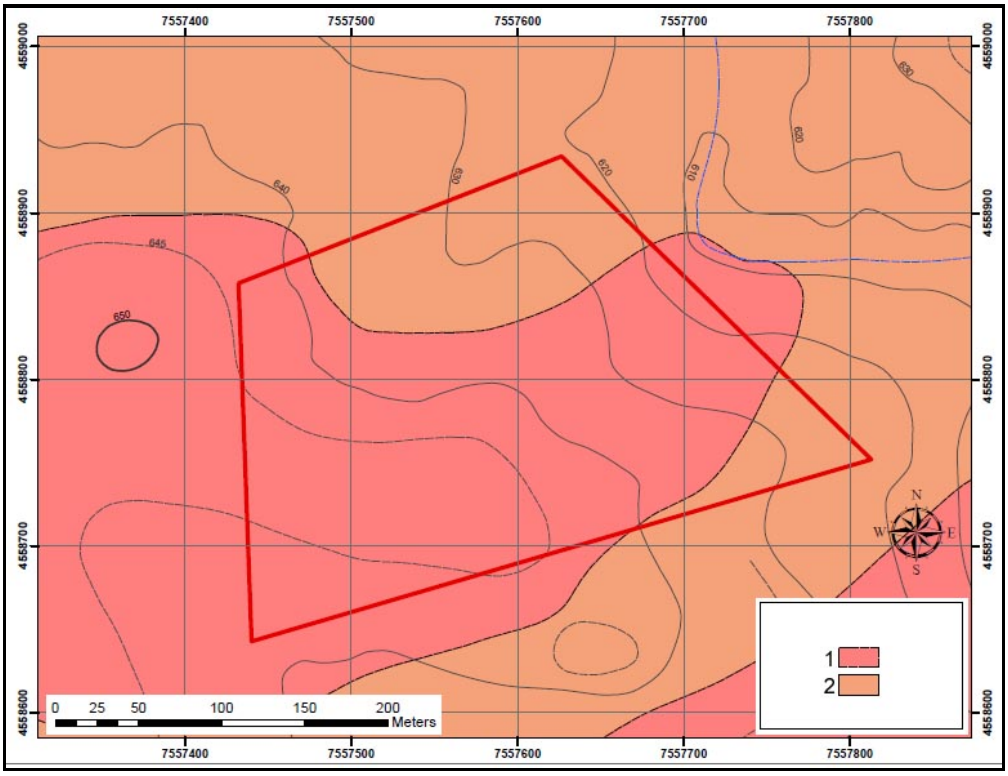


Fig. 1. Geological map of the locality Kosovska river (Spasovski, 2010)
1. granodiorite, 2. muscovite gneiss.

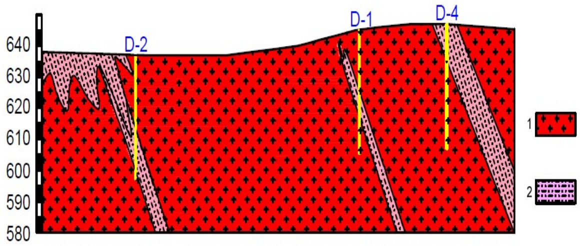


Fig. 2. Geological cross-section of Kosovska river
1. granodiorite, 2. muscovite gneiss

The amphibolic quartzite is characterized with grey-greenish to dark grey-greenish colour. The minerals are present in granules with medium size with a particular slightly distinguished oriented striped texture. It is a very hard rock with massive – oriented texture. As main minerals, the quartz, the amphibole, biotite, plagioclase and not so often K-feldspar, are noticed. When the quantity is concerned, the coloured minerals (amphibole, biotite and epidote) are slightly more common that the salic. The rock is additionally metasomatically-faldsparized. Na-feldspar is present in big irregular crystals with inclusions and crystals from epidote–coesite and amphibole. K-feldspar is less present and mostly in a shape of xenomorphic crystals. The quartz is xenomorphic with standardized size of the grains and they most often fill the interspace of the remaining minerals. The amphibole is present in big square crystals and it can rarely be found in a type of small leave crystals mixed with biotite and big crystals of the epidote. The biotite is also present in bigger and smaller leaves (liski) with different orientation. The secondary minerals are the ortite and the coesite while the accessory minerals that are present are apatite and the zircon.

The granodiorites are most commonly found and mostly constitute the middle part of the researched area. (Fig. 2). They are characterized with middle to large-grained content and light grey-pink colour equally present in the entire sample. The mineral grains are with the size of 5 mm, and rarely slightly bigger ones with 1 cm. With a microscope it can be spotted that they have hypodiomorphic grain structure. The main minerals are: quartz, plagioclase, orthoclase and biotite. The plagioclase is strongly metamorphic and the products are the epidote and the coesite and also a certain zonal allotment of the plagioclase is present. Separate crystals of the plagioclase have completely turned epidote with larger crystals of the epidote. The orthoclase is xenomorphic fresh and completely weakly clayed, and regularly poikilitic incorporates smaller crystals in the plagioclase and the biotite. The biotite is found in big square leaves and smaller rectangular leaves outspread – separate and in places grouped in small clumps. The biotite contains idiomorphic spires – microlites of the coesite and on the edges there are also crystals of the epidote and the apatite. The quartz is found in the interspace with smaller xenomorphic grains. The rock is quite strong, with slight cracks on it, i.e. with slight mechanic deformations which can be seen with the slightly distinguished undulose darkening of the quartz as well as the slightly present micro-cracks at the orthoclase.

PETROGRAPHIC-MINERALOGIC CHARACTERISTICS

There were some representative samples from the locality Kosovska river selected for the mineralogic-petrographic examinations. 5 petrographic slides are made which were examined with a polarized microscope with transmitted light brand Leitz, Wetzlar, Germany.

The mineralogic-petrographic examinations were performed at the Faculty of Natural and Technical Sciences at the Institute for geology by the author of the paper.

The granodiorite is characterized with medium to large grained content and light grey-pink colour equally present throughout the entire sample. The mineral grains are most common with the size of 4 to 5 mm, but there are also grains with the size of 1 cm.

With a microscope it can be seen that they have hypodiomorphic grain structure (Figs. 3 and 4). The main minerals are: quartz, plagioclase, orthoclase and biotite. The plagioclase is clearly defined and is present in hypodiomorphic and irregular crystals, lengthened and wider rectangular shapes. The plagioclase is strongly made metamorphic, and the products are the epidote and the coesite, but also there is a certain zonal allotment in the plagioclase, a more intense alterisation of the plagioclase in the middle parts. The plagioclase is in quantity more present that the orthoclase and the quartz, some separate crystals of the plagioclase are completely made epidote with larger crystals of the epidote. According to the altered products and the weak zonal allotment, the plagioclase are a type of intermediate plagioclase, i.e. andesine-labradorite weakly acid.

The orthoclase is xenomorphic fresh and completely weakly clayed, and regularly poikilitic incorporates smaller crystals in the plagioclase and the biotite. The orthoclase is weakly microclined at separate crystals.

The biotite is found in big square leaves and smaller rectangular leaves outspread – separate and in places grouped in small clumps. It has clear brown pleochroism. The biotite contains idiomorphic spires-microlites on the coesite, and on the edges there are also crystals of the epidote and the apatite.

The quartz is found in the interspace with smaller xenomorphic grains. It is slightly undulose darkened which points to the fact that it has slight mechanic deformations. Allanite and zircon are accessory minerals.

The rock is quite strong, with slight cracks on it, i.e. with slight mechanic deformations which can be seen with the slightly distinguished undulose darkening of the quartz as well as the slightly present micro-cracks at the orthoclase.

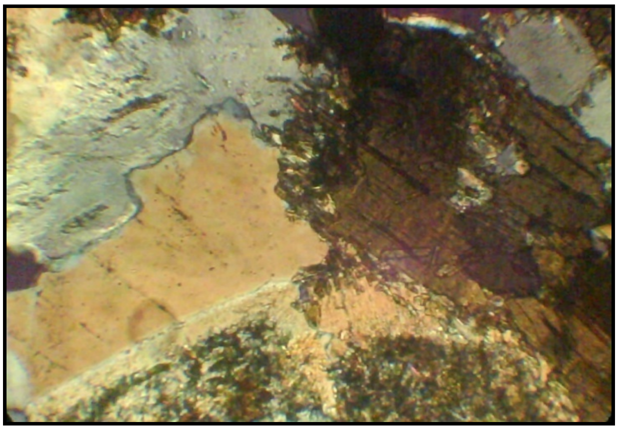


Fig. 3. Microphotography of the granodiorite of the Kosovska river locality. Crosswise nicols, magnified 10×.

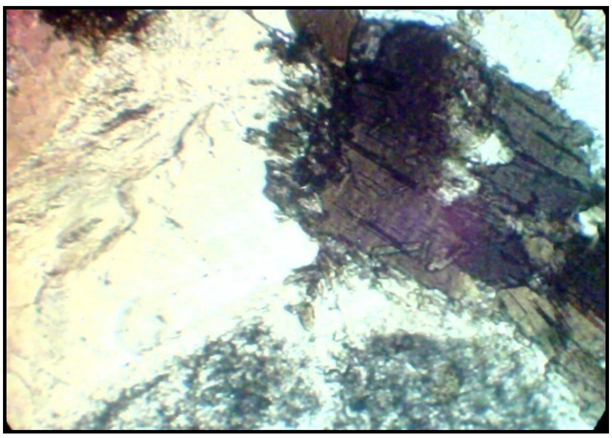


Fig. 4. Microphotography of the granodiorite of the Kosovska river locality. Parallel nicols, magnified 10×.

Quartzdiorite is characterized with dark grey-greenish color, medium grain size content with a particular slightly distinguished oriented striped texture. The hard rock is with massive oriented texture. The rock is constituted of quartz, amphibole, biotite, plagioclase and not so often K-feldspar, which are the main minerals. When the quantity is concerned, the coloured minerals (amphibole, biotite and epidote) are slightly more common that the salic. The rock is most possibly additionally metasomatic feldspatized. Na-feldspar is present in big irregular crystals which include many inclusions and crystals from epidote–coesite and amphibole. With separate albites, some polysynthetic lamellas can be seen. K-feldspar is less present and mostly in a shape of xenomorphic crystals. The quartz is present in xenomorphic standardized size of the grains in the interspace of the remaining minerals. It is clearly evident that the coloured minerals are present in irregular size of the crystals with different orientation, i.e. the crystals of the amphibole and the biotite are presented vertically and sidelong with a given slightly distinguished oriented texture (Figs. 5, 6, 7 and 8). This points out that the rock apart from the metasomatic processes has gone under metamorphism from regional – retrograded metamorphism.

The amphibole is found in big square crystals and with little leave-like crystals, stretched about shapes and densely mixed with biotite and big crystals of the epidote. The amphibole is weakly alkaline hornblende. The biotite is also present in larger and smaller leaves with different orientation. The secondary minerals are the allanite, coesite and mining mineral (oxide mineral), and the apatite and the zircon are accessory minerals

Fig 5. Microphotography of the amphibolic quartzdiorite of the Kosovska river locality. Crosswise nicols, magnified 10×.

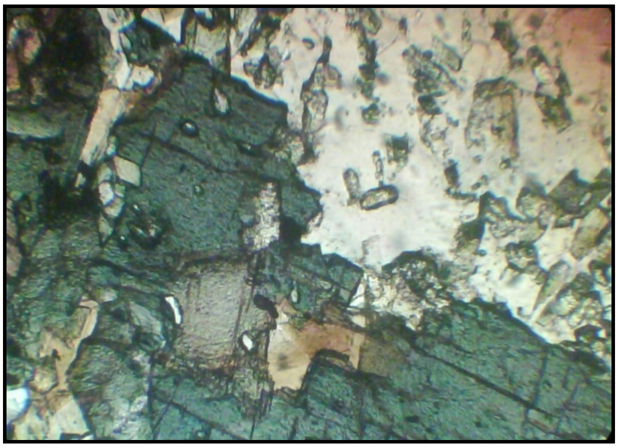
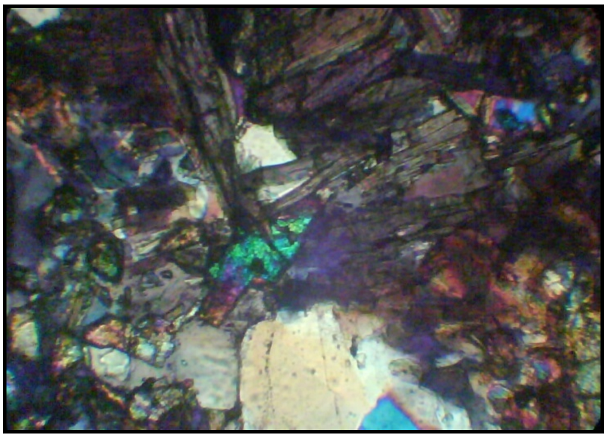


Fig. 6. Microphotography of the amphibolic quartzdiorite of the Kosovska river locality. Parallel nicols, magnified 10×.



Fig, 7. Microphotography of the amphibolic quartzdiorite of the Kosovska river locality. Crosswise nicols, magnified 10×.

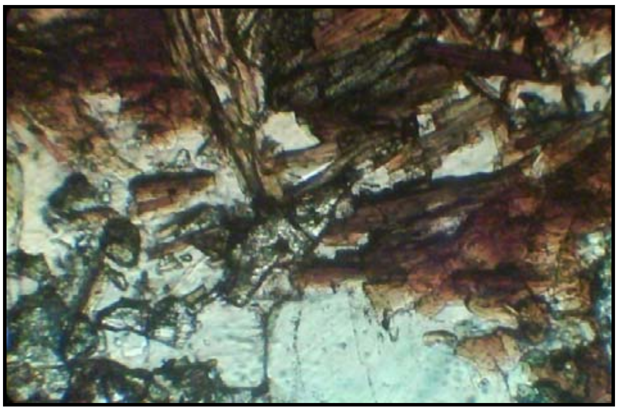


Fig. 8. Microphotography of the amphibolic quartzdiorite of the Kosovska river locality. Parallel nicols, magnified 10×.

Striped muscovite gneiss has grey color with glittering radiance from the leaves of muscovite which can clearly be noticed. They are characterized with medium grained contentand slightly distinguished parallel schistose texture. The regular pattern of minerals throughout the sample can be seen.

With a microscope the grano-lepidoblastic structure with slightly distinguished striped texture can be observed (Figs. 9 and 10).

Fig. 9. Microphotography of the thin striped muscovite gneiss of the Kosovska river locality. Crosswise nicols, magnified 10×.

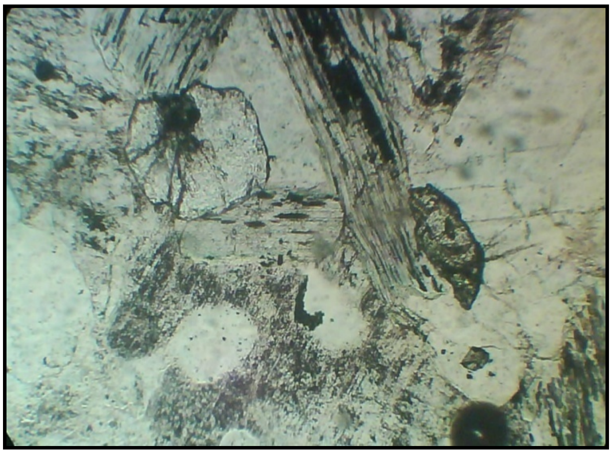


Fig. 10. Microphotography of the thin striped muscovite gneiss of the Kosovska river locality. Parallel nicols, magnified 10×

The main minerals in the rock are: quartz, feldspar and mica. The participation of salic and femic minerals is approximately equal in quantity, i.e. the salic are slightly more present.

The quartz is found in xenomorphic crystals as well as in feldspars. The feldspar is K-feldspar – orthoclase and plagioclase so the plagioclase is more present. The orthoclase is fairly clayed while the plagioclase is more strongly clayed.

The plagioclase is albite to intermediate plagioclase. It is rare to find some larger xenomorphic crystals of orthoclase, as porphyroblastic.

The mica is represented with muscovite and biotite and they are found in not clearly distinguished lines. It is typical for the biotite that it is bleached – baritised, so it has a fairly weak brownish interference. There is an impression that it is muscovite with separated Fe-component with thicker irregular shapes at the leaves themselves. It is possible that it is mica-phengite.

The secondary minerals are the epidote, ortite, rarely granite and mining mineral in irregular shapes. The epidote is quite common in long crystals and is regularly associated with mica lines.

The apatite and the zircon are accessory minerals.

It is a metamorphic rock which has pointed and not well defined striped texture. The quartz is undulose darkening while the feldspar are with cracks and altered.

CHEMICAL EXAMINATIONS

The chemical characteristics of the granitoide rocks from the Kosovska river locality, Čanište, respresent a contribution to the broadening of the knowledge for this massive on the territory of the Republic of Macedonia. This massif is evidently different from the surrounding rocks by its content, structural-tectonic features, color and the manner of its origination.

Basically, granodiorite is characterized with homogeneous – solid to compact texture, which locally turns to porphyroide. With such arrangement and intergrowth of the mineral components, a beige to greenish basic color spotted with biotite of black color is formed in the mineral aggregate.

For more detailed presentation of the chemical content of the granodiorites from the Kosovska river locality, five representative samples were taken from the granodiorites and one sample from a light grey rock with great compactness. The examinations of the taken samples were performed at the Faculty of Natural and Technical Sciences with the instrument AES-ICP. The chemical content of the analyzed samples are presented in Table 1.

From the table presented it can be stated that the analyzed samples are characterized with a constant chemical content which can be seen in the content of SiO_2 which is in range of 58.88 to 73.74. These rocks are distinguished as granodiorite, gneiss and amphibolite quartz-diorite. From the analyzed samples it can be spotted that there is a slight increase of Al, Ca, K, Fe and Mg, but especially Al which is probably due to the additional secondary processes which the analyzed samples were influenced by.

Table 1

Chemical content of the analyzed samples from the Kosovska river locality (%)

Components	Symbol of the sample					
	Kr-1	Kr -2	Kr 3	Kr -4	Kr -5	Kr -6
SiO_2	68.42	69.14	69.10	58.88	58.58	73.74
TiO_2	0.12	0.12	0.334	0.28	0.32	0.069
Al_2O_3	12.94	12.96	14.24	15.20	15.40	12.45
Fe_2o_3	3.20	3.10	2.08	8.30	8.20	2.07
MgO	1.02	1.02	0.31	2.03	2.13	0.30
CaO	4.05	4.15	2.09	6.95	6.95	2.35
Na_2O	4.82	4.79	3.94	4.06	3.99	3.90
K_2O	3.10	3.11	4.58	1.50	1.50	2.80
P_2O_5	0.80	0.78	0.51	1.20	1.20	0.48
Humidity110° OH^-	0.077	0.076	0.07	0.043	0.043	0.037
Humidity1000°OH^+	0.70	0.70	0.50	0.73	0.73	0.80
Total:	99.25	99.88		99.20	99.04	99.02

Note: The analyses 1, 2 and 3 are granodiorite and 4 and 5 represent the amphybolite - quartz-diorite, 6 gneiss.

PHYSICAL-MECHANICAL CHARACTERISTICS

The purpose of this research is to determine the physical-mechanical characteristics of the stone and to determine the eligibility of the material for its application in the civil engineering for the production of fractioned broken stone aggregate for concrete and asphalt compositions and for other applications in the trade in accordance with MKS standards.

The performed analyses are in accordance with the valid standards: MKS, B.B2.009, MKS B.B8.003, MKS S.E9.021, MKS U.E9.028, MKS SE4.014, MKS B.B8.045.

The received results for the physical-mechanical characteristics of the granodite are presented in Table 2.

Table 2

Results from the physical-mechanical characteristics

N°	Analysis	Method according to MKS	Unit	Symbol	Results from the analysis	Conditions for quality: BET.MKS B.B2.009 BNS/MKS U.E9.021/028 AB/MKS U.E9.028
1	Pressure strength in dry conditions	B.B8.012	MPa	$\sigma_p$min $\sigma_p$max $\sigma_p$sred	114.90 154.40 136.10	BET/min. (80;160) BHS/min (100) AB/min. (120;140;160) Tampon/min.(100;120)
2	Pressure strength in water satiation condition	B.B8.012	MPa	$\sigma_p$min $\sigma_p$max $\sigma_p$sred	110.80 122.93 118.45	BET/min. (64;128) BHS/min (100) AB/min. (120;140;160) Tampon/min.(100;120)
3	Pressure strength after 25 ice cycles	B.B8.010	MPa	$\sigma_p$min $\sigma_p$max $\sigma_p$sred	93.50 108.00 103.80	/
4	Water absorption	B.B8.010	% (m/m)	*U*		BET/min. (1.0) AB/min. (0.75;1.0) Tampon/min.(1.0)
5	Resistance to destruction and scraping	B.B8.015	$cm^3/50\ cm^2$	*Ab*		BET/min. (35.0) AB/min. (12.0;18.0;35.0)
6	Volume capacity with cavities and cracks	B.B8.032	kg/m^3	γ_r		(2000–3000) kg/m^3
7	Volume capacity without cavities and cracks	B.B8.032	kg/m^3	γ_z		(2000-3000) kg/m3
8	Degree of density	B.B8.032	% (mm)/	*G*		/
9	Porosity	B.B8.032	% (m/m)	*P*		/
10	Consistency to ice exposure	B.B8.001	Damage and loss (g)	*M*	No loss of the weight, damage and cracks	BET/min. (5.0) AB/min. (5.0) Tampon/min.(10.0;12.0)

After the performed analysis of the received results it can be concluded that for a stone material of high strength to pressure, rock breakage, high resistance to destruction and scraping, low absorption of water, compact to high transmission mass and constant to the ice exposure.

According to the determined physical-mechanical characteristics, the examined stone from the rock of the locality 'v. Čanište' is a eligible stone and it can be applicable in various fields as well as in civil engineering, as the following:

– production of concrete mixtures,
– production of bitumen layer,
– production of road metal.

CONCLUSION

The samples were taken from the surface parts of the terrain where the influences from the outside are quite intense. In the deeper layers of the ground, the rock mass is found as blocks and less affected by the atmospheric influence which enables a better quality. Based on the received results from the analyses it can be concluded that it can be used as an architectural stone.

The rock mass is medium-granular which makes the granodiorite from Kosovska river to give valid the physical-mechanical characteristics and eligibility for processing (cutting, polishing, etc.). The absence of pyrite enables endurance from the influences from the atmosphere.

The weaknesses of this stone are the following: it has average decorative values, heterogeneous appearance. These rocks masses are almost an easy subject to erosion in the surface parts, but they have decorative possibilities in the deeper parts.

According to the mineral-petrographic content, structural-textural characteristics the granodiorite is quite solid and can be widely used in the civil engineering primarily as architectural stone for production of tiles for interior and exterior use for tiling walls. The remaining part after the cutting can be used as technical stone for aggregate with different granulation for the use of concrete and asphalt mixtures, as well as for other building needs.

According to the mineral-petrographic content, structural-textural characteristics the amphibolite quartz-diorite can be widely used in the civil engineering. It can be used as architectural stone, as technical stone for stone blocks and separated aggregate for asphalt and concrete mixtures, as well as for other building needs.

Due to the great quantity of phyllo-silicates – micas it is expected the striped muscovite gneiss to have low strength characteristics and for that reason it is not recommended for use as technical stone. The feldspars are also significantly clayed so the stone would have weak resistance from the atmospheric influences. Generally the striped muscovite gneiss from its mineral-petrographic aspect and structural-textural characteristics is not suitable for building purposes. It can only be found useful as electroinsulation material where the mica content is requested.

With the received values for the mineral-petrographic features of the granodiorite from the Kosovska river locality, it can be concluded that it satisfies all criteria for an architectural-building stone, even some parameters are even higher that the requested ones.

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Р е з и м е

МОЖНОСТИ ЗА КОРИСТЕЊЕ НА ГРАНОДИОРИТОТ ОД КОСОВСКА РЕКА, С. ЧАНИШТЕ (ЗАПАДНА МАКЕДОНИЈА), КАКО АРХИТЕКТОНСКИ КАМЕН

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Гранодиоритот од Кошарска Река, западна Македонија, е испитуван со цел да се утврди можноста за негово користење како архитектонски камен. Самите анализирања, како и лабораториските испитувања, беа извршени на примероци од гранодиоритот. Примероците се земени од површинските делови. Резултатите од нивните физичко-механички испитувања покажаа дека карпестата маса ги исполнува сите барања за употреба како архитектонски камен согласно со државните стандарди на Македонија. Исто така, квалитетот на каменот е повисок во подлабоките делови на теренот, каде што надворешните влијание имаа многу мал ефект. Овој камен нема високи декоративни својства, но има ситно зрнеста структура која претставува позитивен ефект за техничките карактеристики и подложеност на обработка.