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PHYSICAL-MECHANICAL AND MINERALOGICAL-PETROGRAPHICAL CHARACTERISTICS OF THE GRANODIORITE OF "LOZJANSKA REKA", VILLAGE OF KRUSEVICA (WESTERN MACEDONIA)

Abstract

The granodiorite of the Lozjanska Reka, western Macedonia, has been examined in order to determine the possibility to be used as an architectural stone. 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 grained structure which has a positive effect for the technical characteristics and for the being a subject for processing.

Keywords: granodiorite; Lozjanska Reka; architectural stone; mineralogic-petrographic composition; physical-mechanical characteristics

INTRODUCTION

The granodiorite of Lozjanska Reka is located about 6.0 km north-west from the Čanište village and about 0.5 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 (Fig. 1). This area is geographically close to Selečka Mountain. The largest water artery in this part of the terrain is Čaniška Reka which has Lozjanska Reka, Kruševička Reka and Kosovska Reka 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, 1960, 1968 and 1974) has researched these terrains and distinguished many varieties of gneisses, mica schists, amphibolite and granitoid rocks. Some of the scientists 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, granodiorit-adamelite masses have taken root.

Fig. 1. Map of the R. Macedonia with position the locality “Lozjanska Reka”

In the period of making the Basic Geologic Map of SFRY the authors of the leave Vitolište (Dumurdžanov, Hristov, 1976a, 1976b) and Prilep (Rakičević, Stojanov, Arsovski, 1965a, 1965b) processed the leave content of the rocks of the leave Vitolište where the granodiorite Lozjanska Reka belongs.

Dumurdžanov (1985) explores the granitoids in details and concludes that they are mainly represented with granodiorite (70%) and quartzdiorite (20%), and less with quartz monocytes and granites.

METHODOLOGY

The location Lozjanska River is explored using terrain and laboratorical explorations. The terrain explorations have provided the distinguished insight of the terrain, familiarization with its geological and structural-techtonic characteristics, as well as the collecting of representative samples from the granodiorite for defining their chemical and mineralogical composition, structural-textural and physical-mechanical characteristics.

The mineralogic-petrographic research have been done at the Faculty of Natural and Technical Sciences in Štip, while the chemical content of the granodiorite of the determined in the chemical laboratory of the Faculty of Natural and Technical Sciences with the instrument AES-ICP. 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 are some cracks that 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 FEATURES

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, amphibolite and deluvial sediments (Fig. 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 schistosity 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, 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. The secondary minerals are the epidote, 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. Amphibolite appear as relatively sharply distinguished concordant stripes or irregular bodies. These rocks vary from light to dark-green, minisculeto largely granular, mostly schistified, rarely massive. The main minerals present with in the mare amphibol, oligoclase, andesine, less present are albite, oligoclase and epidote, while the granate, zoisite, biotite, diposide, titanite, quartz and rutile vary with their presence. They are often presenting minor quantities, locally they are present as important minerals.

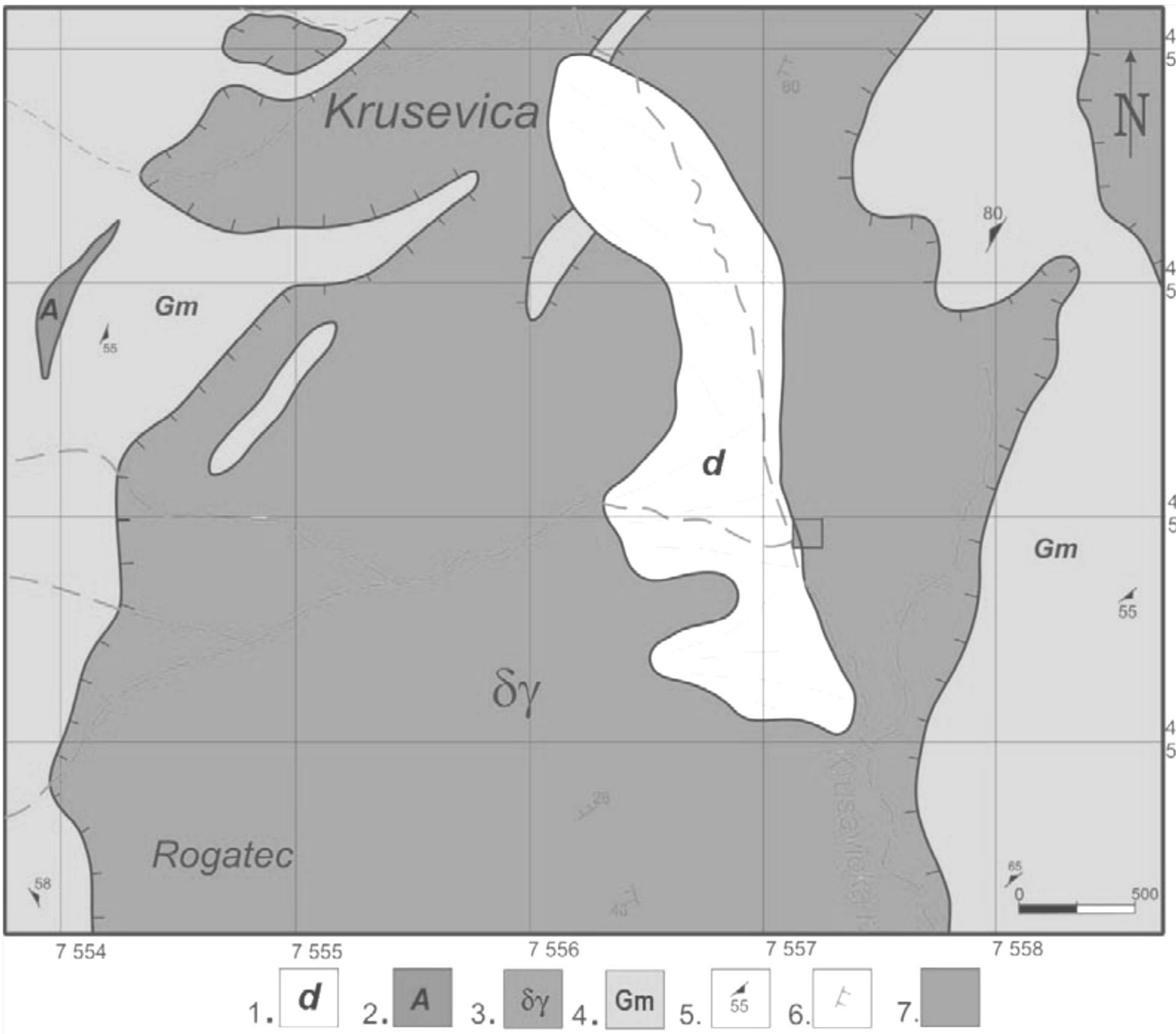

Fig. 2. Geological map of the locality "Lozjanska Reka"
1. deluvial sediments, 2. amphibolite, 3. granodiorite, 4. muscovite gneisses, 5. elements of foliation, 6. elements of fissures, 7. research area.

Based on the structural-textural characteristics and the mineralogical composition, there are two basic varieties with in the granodiorites including porfirical granodiorites and massive to medium to largely granular granodiorites. Based on the microscopical exploration, significant varieties within the mineralogical composition of the grandiorites is seen, especially within the massive type. Porphyroidical grandiorites are grey, largely granular rocks with prophyric structure and massive texture.

They are comprised of plagioclases, K-feldspar, quartz and biotite as main minerals, and titanite, granite, apatite and zircone as a side minerals. As a result of the secondary changes the chlorite, epidote, zoisite, sericite, kaolin and limonite matter are present. The massive granodiorites are not completely homogenous in it's composition and there are significant varieties regarding the presence of certain minerals. In distinguishhed partitions the K-feldspar are more present and the rocks represent quartz monocytes or granites and on some occasions when they are present less then 5% the same cross over to quartz diorite. The massive granodiorites are grey to dark-grey, medium to largely granular. They are comprised of plagioclase, caliumfeldspate, quartz and biotite as main minerals, and apatite, titanite, amphibole, zircone, granite and magnetite as a lesser frequent minerals.

Secondary there are the epidote, zoisite, sericite, albite, chlorite, kaolin and limonite matter. The deluvial sediments are largely dispersed on the Selečka Mountain in the valley of the Kruševička Reka (Figure 2). The sediments represent the material from the granodiorite sand metamorphic rocks.

PETROGRAPHIC-MINERALOGIC CHARACTERISTICS

There were some representative samples from the locality Lozjanska Reka selected for the mineralogic-petrographic examinations. 5 petrographic samples 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, Institute for Geology, by the author of the paper. The granodiorite is characterized with medium to large grained structure and light grey-pink colour equally present throughout the entire sample (Figs. 3 and 4). 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. On a microscope it can be seen that they have hypodiomorphic grain structure (Figs. 5 and 6). The main minerals are: quartz, plagioclase, orthoclase and biotite. The plagioclase is clearly defined and is present as hypodiomorphic and irregular crystals, lengthened and wider rectangular shapes.

The plagioclase is strongly metamorphized and the products are the epidote and the coesite, but also there is a zonal allotment and intense alterization of the plagioclase in the middle parts. The plagioclase is more present that the orthoclase and the quartz. According to the altered products and the weak zonal allotment, the plagioclase is intermediate, i.e. andesine-labradorite weakly acid. The orthoclase is xenomorphic, fresh and poorly clayed, and regularly poikilitic incorporates smaller crystals in the plagioclase and the biotite.

The orthoclase is weakly microclinised at separate crystals. The biotite is present in large 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 zoisite, 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 darkening of the quartz as well as the slightly present micro-cracks at the orthoclase.

Quartzdiorite is characterized with dark greygreenish color, medium grained structure with a particular slightly distinguished oriented striped texture. The hard rock is with massive 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 more common than the salic minerals. Probably, the rock is additionally metasomatic feldspatized. Na-feldspar is present in large irregular crystals which include many inclusions and crystals from epidote – zoisite 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 grains in the interspace of the remaining minerals. It is clearly evident that the coloured minerals are present with irregular shape 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. 3 and 4). This points out that the rock apart from the metasomatic processes has gone under metamorphism from regional retrograde metamorphism.

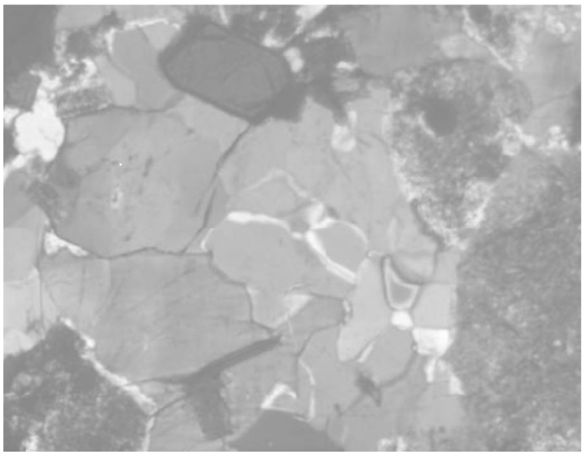

Fig. 3. Medium to large grained structure of the granodiorite. Crossed nicols, magnified 50×.

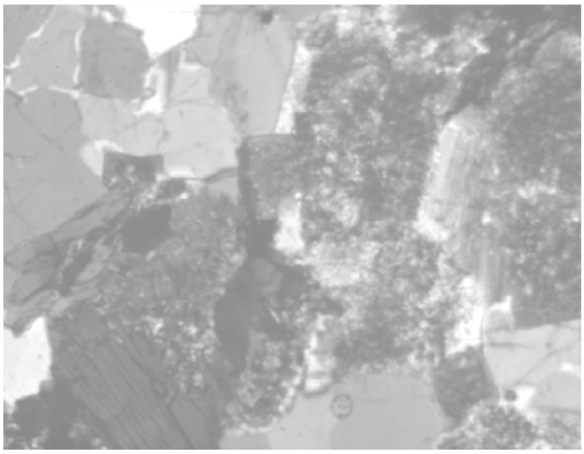

Fig. 4. Medium to large grained structure of the granodiorite. Parallel nicols, magnified 50×

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, zoisite and mining mineral (oxide mineral), and the apatite and the zircon are accessory minerals.

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 structure with slightly distinguished parallel schistose texture. The regular pattern of minerals throughout the sample can be seen.

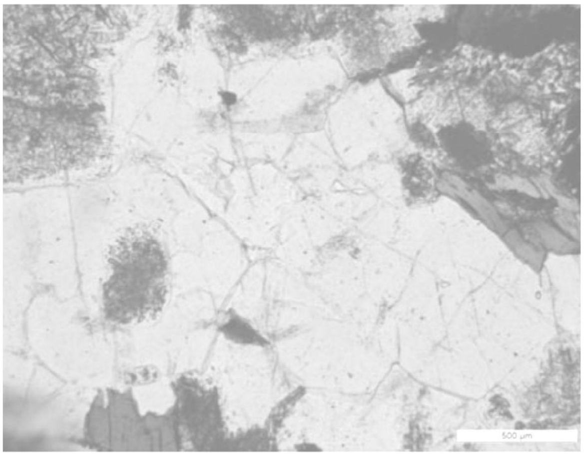

Fig. 5. *Hypodiomorphic grain structure of the ranodiorite. Crossed nicols, magnified 50×.*

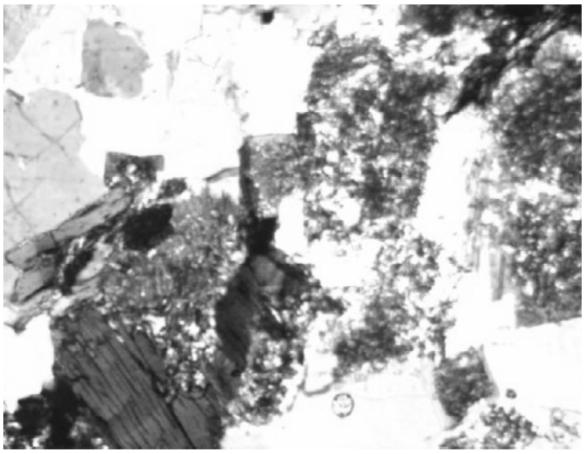

Fig. 6. *Hypodiomorphic grain structure of the ranodiorite. Parallel nicols, magnified 50×.*

With a microscope the grano-lepidoblastic structure with slightly distinguished striped texture can be observed.

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. Rarely are find some larger xenomorphic crystals of orthoclase.

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 – barytised, 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, orthite, 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. he quartz is darkening while the feldspar are with cracks and altered.

CHEMICAL EXAMINATIONS

The chemical characteristics of the granitoide rocks from the Lozjanska Reka locality, Kruševica, represent 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, 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 Lozjanska Reka locality, four 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*.

Table 1. Chemical composition of the granodiorites from the "Lozjanska Reka" locality (%)

Components	Symbol of the sample				
	Lz/1	**Lz/2**	**Lz/3**	**Lz/4**	**Lz/5**
SiO_2	65.60	66.30	65.89	65.60	68.50
Al_2O_3	16.25	16.42	16.85	16.24	15.03
Fe_2O_3	2.41	2.21	2.65	2.38	3.14
MnO	0.069	0.070	0.072	0.099	0.08
MgO	0.68	0.72	0.74	0.41	0.86
CaO	4.31	4.56	4.56	4.09	2,93
K_2O	4.78	4.75	4.92	4.94	4.29
Na_2O	3.70	3.71	3.75	3.58	3.99
TiO_2	0.412	0.423	0.431	0.334	0.20
P_2O_5	0.21	0.19	0.23	0.11	0.17
LOI	1.250	0.950	0.980	0.78	0.66
Total	**99.67**	**100.303**	**100.923**	**98.563**	**99.85**
Ba (ppm)	650	640	631	647	642
Sr (ppm)	250	265	247	250	260
Y (ppm)	22	26	27	24	25
Sc (ppm)	7	7	7	7	7
Zr (ppm)	237	242	251	240	242
Be (ppm)	2	4	3	2	4
V (ppm)	44	41	38	45	39

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 65.60 to 68.50. 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 influencedly. Analysis of trace elements (Table 1) indicate a significant presence of trace elements from the ranks of Ba, Sr, Zr and V.

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 granodiorite are presented in Table 2.

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 frost exposure.

According to the determined physical-mechanical characteristics, the examined stone from the rock of the village of Kruševica locality 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.

Table 2. Results of the physical-mechanical characteristics

No	**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	Compressive strength in dry conditions	B.B8.012	MPa	σpmin σpmax σpsred	146.30 185.40 171.90	BET/min. (80;160) BHS/min (100) AB/min. (120;140;160) Buffer/min.(100;120)
2	Pressure strength in water satiation condition	B.B8.012	MPa	σpmin σpmax σpsred	116.20 146.20 134.60	BET/min. (64;128) BHS/min (100) AB/min. (120;140;160) Buffer /min.(100;120)
3	Pressure strength after 25 frost cycles	B.B8.010	MPa	σpmin σpmax σpsred	104.60 161.80 142.40	/
4	Water absorption	B.B8.010	% (m/m)	U	0.167	BET/min. (1.0) AB/min. (0.75;1.0) Buffer /min.(1.0)
5	Resistance to destruction and scraping	B.B8.015	$cm^3/50\ cm^2$	Ab	8.40	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_v	2745	(2000–3000) kg/m^3
7	Volume capacity without cavities and cracks	B.B8.032	kg/m^3	γ_s	2775	(2000-3000) kg/m^3
8	Degree of density	B.B8.032	% (mm)/	G	98.74	/
9	Porosity	B.B8.032	% (m/m)	P	1.26	/
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) Buffer /min.(10.0;12.0)

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 Lozjanska Reka 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 composition, 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 amphibolites 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 electro-insulation material where the mica content is requested.

With the received values for the mineralogicpetrographic features of the granodiorite from the Lozjanska Reka 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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СЕЛЬСКОХОЗЯЙСТВЕННЫЕ НАУКИ / AGRICULTURE

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ВЛИЯНИЕ ДЛИТЕЛЬНОГО ПРИМЕНЕНИЯ УДОБРЕНИЙ НА МИКРОБОЦЕНОЗ ЛУГОВОЙ ЧЕРНОЗЕМОВИДНОЙ ПОЧВЫ

Аннотация
Изучали влияние длительного применения минеральных и органических удобрений на соотношение численности физиологических групп почвенных микроорганизмов и связанный с их деятельностью процесс минерализации органических веществ.

Ключевые слова: аммонификаторы, иммобилизаторы, удобрения, коэффициент минерализации.

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INFLUENCE OF LONG APPLICATION OF FERTILIZERS ON MICROBIOCENOSIS MEADOW CHERNOZEM SOIL

Abstract
Studied the effect of prolonged use of mineral and organic fertilizers on the ratio of the number of physiological groups of soil microorganisms and their activities related to the process of mineralization of organic substances.

Keywords: ammonifiers, immobilizers, fertilizers, mineralization rate.

Применение удобрений меняет условия обитания микроорганизмов в почве. Ее микробное сообщество выполняет функцию поддержания гомеостаза почв, поэтому быстро реагирует на изменения в среде обитания. Считается, что микроорганизмы являются хорошим биоиндикатором: они играют ведущую роль в круговороте азота, лимитирующего продуктивность большинства наземных экосистем [1]. Однако, длительное применение минеральных удобрений приводит к глубоким изменениям структуры комплекса почвенных микроорганизмов, изменению соотношения численности физиологических групп микроорганизмов, участвующих в различных микробиологических процессах и обеспечивающих плодородие почвы [2]. Увеличивается численность микроорганизмов, обеспечивающих необходимый уровень эффективного плодородия (аммонификаторы, азотфиксаторы), повышается активность ферментов, уменьшается фитотоксичность почвы, создаваемая микроорганизмами.

С целью выявления влияния длительного применения удобрений на почвенный микробоценоз были проведены исследования с луговой черноземовидной почвой длительного стационарного опыта, на опытном поле ФГБНУ «Всероссийский научно-исследовательский институт сои» РАН (Амурская область). В течение 53-х лет в почву вносились удобрения под каждую из пяти культур севооборота в рекомендуемой норме. Средняя нагрузка удобрениями на 1 га севооборотной площади по вариантам опыта представлена в таблице. Из минеральных удобрений вносили двойной суперфосфат и аммиачную селитру, из органических – полуперепревший навоз. В 2014 году под пшеницу вносили аммиачную селитру во всех вариантах опыта, кроме контрольного. Варианты опыта размещали систематически в 3-кратной повторности, площадь делянки – 180 м^2.

Микробиологические анализы проводили в свежих образцах почвы согласно общепринятых методик [3]. После предварительной пробоподготовки осуществляли количественный учет следующих микроорганизмов: бактерий, потребляющих органический азот – на мясопептонном агаре (МПА); бактерий, утилизирующих минеральный азот, и актиномицетов – на крахмало-аммиачном агаре (КАА). Направленность микробиологических процессов в почве определяли по коэффициенту минерализации-иммобилизации [4].

В результате определения численности микроорганизмов в 2014 году установлено, что в почве контрольного варианта, без применения удобрений, количество аммонификаторов азота снижалось от фазы кущения пшеницы к фазе полной спелости (таблица). В почве варианта с длительным применением одних только азотных удобрений количество аммонификаторов было выше контроля во все сроки наблюдения; на фоне минеральных азотно-фосфорных удобрений – только в фазу кущения пшеницы; а на фоне органо-минеральных удобрений – в фазу выхода в трубку.

Таблица 1 – Численность микроорганизмов почвы по фазам развития пшеницы

Период отбора образцов	Внесено удобрений: на 1 га севооборотной площади/ под пшеницу 2014 года	Микроорганизмы на средах, млн. ед. КОЕ/1 г сух. почвы		Коэффициент Мишустина
		МПА (аммонификаторы азота)	КАА (иммобилизаторы азота)	
Фаза кущения, 03.06.14	Контроль без удобрений	19,7	26,2	1,3
	N24/N30	28,2	47,1	1,7
	N24P30/N30	29,4	23,5	0,8
	N24P30 + навоз 4,8 т/N30	20,0	40,4	2,0
Фаза выхода в трубку, 23.06.14	Контроль без удобрений	16,4	40,2	2,5
	N24/N30	36,5	28,9	0,8
	N24P30/N30	17,9	28,1	1,6
	N24P30 + навоз 4,8 т/N30	38,3	24,8	0,6
Фаза полной спелости, 09.08.14	Контроль без удобрений	11,2	27,3	2,4
	N24/N30	40,1	27,9	0,7
	N24P30/N30	10,6	27,4	2,6
	N24P30 + навоз 4,8 т/N30	13,3	25,1	1,9

Численность иммобилизаторов азота в почве контрольного варианта была наиболее высокой в фазу выхода в трубку. Азотная и органо-минеральная системы удобрений повысили численность иммобилизаторов в фазу кущения. По всем системам удобрения в фазу выхода в трубку их численность была ниже контроля, а в фазу спелости – на уровне контрольного варианта.

Величина коэффициента Мишустина (отношение численности иммобилизаторов / аммонификаторов) в контрольном варианте во все сроки наблюдения была выше единицы, что свидетельствует о преобладании процессов закрепления азота в луговой