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VII INTERNATIONAL GEOMECHANICS CONFERENCE

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SCIENTIFIC AND TECHNICAL UNION OF MINING, GEOLOGY AND METALLURGY

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25 years

Small steps. Big traces.

Dear Ladies and Gentlemen,
Dear Colleagues,
Dear Guests,

On behalf of the Organizing Committee and in my capacity as Chairman of the Scientific and Technical Union of Mining, Geology and Metallurgy I am pleased to welcome all the participants in VII INTERNATIONAL GEOMECHANICS CONFERENCE.

This scientific forum will take place for the seventh time in a row which shows its importance and prestige. This year the conference will be focused on Innovative Methods in Geomechanics. The topics cover the whole range of fundamental issues for the formation of stressed and deformed state of the rock mass, research methods for assessment, ecological issues and environment protection.

The IGC 2016 Conference offers an excellent opportunity for the international and local participants to exchange the experience, to share innovation, and to progress professional skills. In the conference this year involved colleagues from Belarus, Bosnia and Herzegovina, Bulgaria, Macedonia, Romania, Russia, USA, Slovakia, Serbia and Ukraine. The significance of the International Conference on Geomechanics is determined by the interest in her and the great activity of the scientific community in geomechanics worldwide.

The results from the studies discussed during the conference are a possibility for application of the geomechanical methods related to the development and utilization of the underground space in the mining industry, the construction, the industrial and public buildings, the transport facilities, etc.

It is our hope that you have been able as well to get a touch of our capital city, our Country, and the Bulgarian people, perhaps, with the intent to visit us again in 2018 on the occasion of the next VIII INTERNATIONAL GEOMECHANICS CONFERENCE.

I wish you all fruitful work and good luck!

Prof. Dr. Tzolo Voutov

Chairman of the Organizing committee

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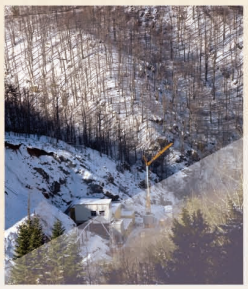

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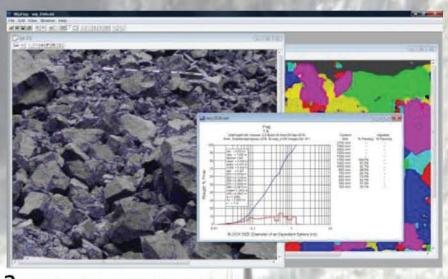
- Извършване на сеизмични измервания при осигуряване на взривосеизмична охрана на сгради и съоръжения.
- Определяне на зърнометричния състав на взривена и/или натрошена скална маса.
- Измерване на скорост на детонация на взривни вещества в реални производствени условия.

Апаратура за измерване на скорост на детонация на взривни вещества.

Апаратура за извършване на взривосеизмични измервания.

Водоустойчиви емулсионни взривни вещества и средства за взривяване.



Зърнометрична характеристика на взривена скална (минна) маса.

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in Bulgaria is a professional, scientific-educational, non-governmental, non-political non-profit association of legal entities - professional organizations registered under the Law on non-profit legal entities, whose members are engineers, economists and other specialists in the field of science, technology, economy and agriculture.

FSEU performed bilateral cooperation with similar organizations from many countries.

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ПО МИННО ДЕЛО, ГЕОЛОГИЯ
И МЕТАЛУРГИЯ

SCIENTIFIC AND TECHNICAL
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THE SCIENTIFIC AND TECHNICAL UNION OF MINING, GEOLOGY AND METALLURGY is a voluntary, non-governmental, politically uncommitted, uncommercial professional association.

About 1800 scientists, engineers, technician and other specialist in the field of mining, geology and metallurgy participate in the Union. Many juridical persons from the country and abroad who are working in this field are members of this association. The Union is an association in private favour and realizes its activity in favour of its members. The Scientific and technical union of mining, geology and metallurgy is a regular member of the FEDERATION OF THE SCIENTIFIC ENGINEERING UNIONS.

14 regional organizations, 34 scientific-technical associations and clubs and 6 incorporated associations function within the Union.

There are 25 collective members at present - juridical persons from mining and metallurgical branches and geology.

Governing bodies of the Union are the General meeting, the Managing committee and the Control committee. The latter two are elected by the General meeting and are authorized for 4 years.

The Scientific and technical union of mining, geology and metallurgy cooperates on problems in these fields with **the Ministry of economy and energy, the Ministry of regional development and public works, the Ministry of environment and water, the Bulgarian chamber of mining and geology, the Bulgarian academy of sciences, the University of mining and geology "St. Ivan Rilski", the University of chemical technology and metallurgy, the Union of scientists in Bulgaria** and other organizations and firms very actively.

The Union is member of 19 related international social organizations and academies. The most important are:

- The World Mining Congress - WMC
- The International Society for Rock Mechanics - ISRM
- The Academy of mining sciences of Russia
- The International Academy of ecology & life protection sciences
- The International Academy of mineral resources

The Balkan associations:

- The Balkan union of metallurgists
- The Balkan committee of mineral processing
- The Balkan geophysical association
- The Balkan association of mining experts "BALKANMINE" and others.

The Union is a co-founder of the publishing house "Earth93" and a co-publisher of the journal "Mining and geology". Useful information about national and international publications and activities in these fields is accumulating and exchanged in the Secretariat of the Union.

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A. Physical and mechanical rock properties. Methods and means of identification.

B. Stressed and deformed state of the rock mass. Technological solutions and systems for management of the rock pressure.

C. Stability of flanks and slopes.

D. Geodynamic impacts on underground and surface excavation equipment. Geomechanical securing of rock falls and landslides.

E. Mine-surveying methods and computer systems for monitoring and management.

F. Ecology and environment protection.

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Topic A

Физико-механични свойства на скалите. Методи и средства за определяне.

Physical and mechanical rock properties. Methods and means of identification.

Физико-механические свойства пород. Методы и средства определения.

Topic B

Напрегнато и деформирано състояние на скалния масив. Технологични решения и системи за управление на скалния натиск.

Stressed and deformed state of the rock mass. Technological solutions and systems for management of the rock pressure.

Напряженное и деформированное состояние горного массива. Технологические решения и системы управления горного нажима.

Topic C

Устойчивост на бортовете и откосите.

Stability of flanks and slopes.

Устойчивость бортов и откосов.

Topic D

Геодинамични въздействия върху подземни и надземни изкопни съоръжения. Геомеханично осигуряване на срутища и свлачища.

Geodynamic impacts on underground and surface excavation equipment. Geomechanical securing of rock falls and landslides.

Геодинамические воздействия на подземные и поверхностные сооружения в результате проведения земляных работ. Геомеханическое обеспечение обрушений и оползней.

Topic E

Маркшайдерски методи и компютърни системи за наблюдение и управление.

Mine-surveying methods and computer systems for monitoring and management.

Маркшейдерские методы и компьютерные системы наблюдения и управления.

Topic F

Екология и опазване на околната среда.

Ecology and environment protection.

Экология и охрана окружающей среды.

GEOPHYSICAL AND GEOMECHANICAL CHARACTERISTICS OF GABBRO FROM LOCALITY PANTELEJ, MACEDONIA

Krsto Blazev[1], Blagica Doneva[1], Todor Delipetrov[1], Gorgi Dimov[1], Marjan Delipetrev[1], Zoran Panov[1]
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ABSTRACT
The paper represents the geophysical and geomechanical characteristics of gabbro from the locality Pantelej in Macedonia. This gabbro is wide spread and it intruded in Paleozoic chlorite - sericite and graphite schists. In the area of the monastery Pantelej, above the gabbro lay sandstone and limestone from Upper Eocene and in some parts are intruded by the products of Kratovo - Zletovo volcanism. The age of the gabbro is determined as Jurrasic.
Analysing the geophysical characteristics, suitable methods for their exploration are seismical methods, due to relative large velocities of propagation of the elastic waves in gabbro.
From geomechanical aspect, gabbro is very suitable for application in civil engineering due to its strength and elastic features, and its colour gives possibility to use it as decorative material.
Keywords: *gabbro, geomechanical characteristics, geophysical features.*

Introduction

In the part of Eastern Macedonia, where the exploration terrain is located, geological composition of the terrain is very complex, from the aspect of lithology and tectonic. This part of the country, according the tectonic regionalization, belongs to Eastern Macedonian zone and smaller part belongs to Vardar zone. The contact between the Eastern Macedonian zone and Vardar zone is clearly marked with profound fault that separate Vardar zone from Serbian - Macedonian mass. This deep structure is channel for magma masses which additionally complicate complex lithological structure of this region.

Conducted geological investigations, especially from Geological Institute of the Republic of Macedonia, limited the gabbro complex and relatively detailed located the complex of gabbro in the area of Pantelej. With these investigations are obtained primary physical and mechanical, chemical, petrologic and mineralogical data for gabbro.

Geological features of gabbro

Gabbro occupies large area in the region of monastery Pantelej and Bogoslovec near Stip. Gabbro near Pantelej occurs as large masses between the vilages Stalkovica and Nivicani. They intruded in chlorite - sericite and quartz - graphite schists form Paleozoic. In the area of the monastery Pantelej, above the gabbro lied Upper Eocene sandstone and limestone, and the other parts are intruded with quartz - monzonite or covered with hornblende - augite - biotite andesite. They have grey - green color, massive texture with large crystals of colored components. Often are crushed and altered and locally are limonitized, kaolinized and uralitized. The structure is hipidiomorphic granular. In the composition are present basic plagioclases which are partialy or fuly transformed into epidote - coisite. Primary pyroxene is fully transformed in secondary amphibole, but also are present relics of primary crystals of monoclinic pyroxene. Lower presence show other colored minerals such as olivine which is serpentinized [1, 2].

Accessory minerals are leucoxene, rarely apatite and tremolite.

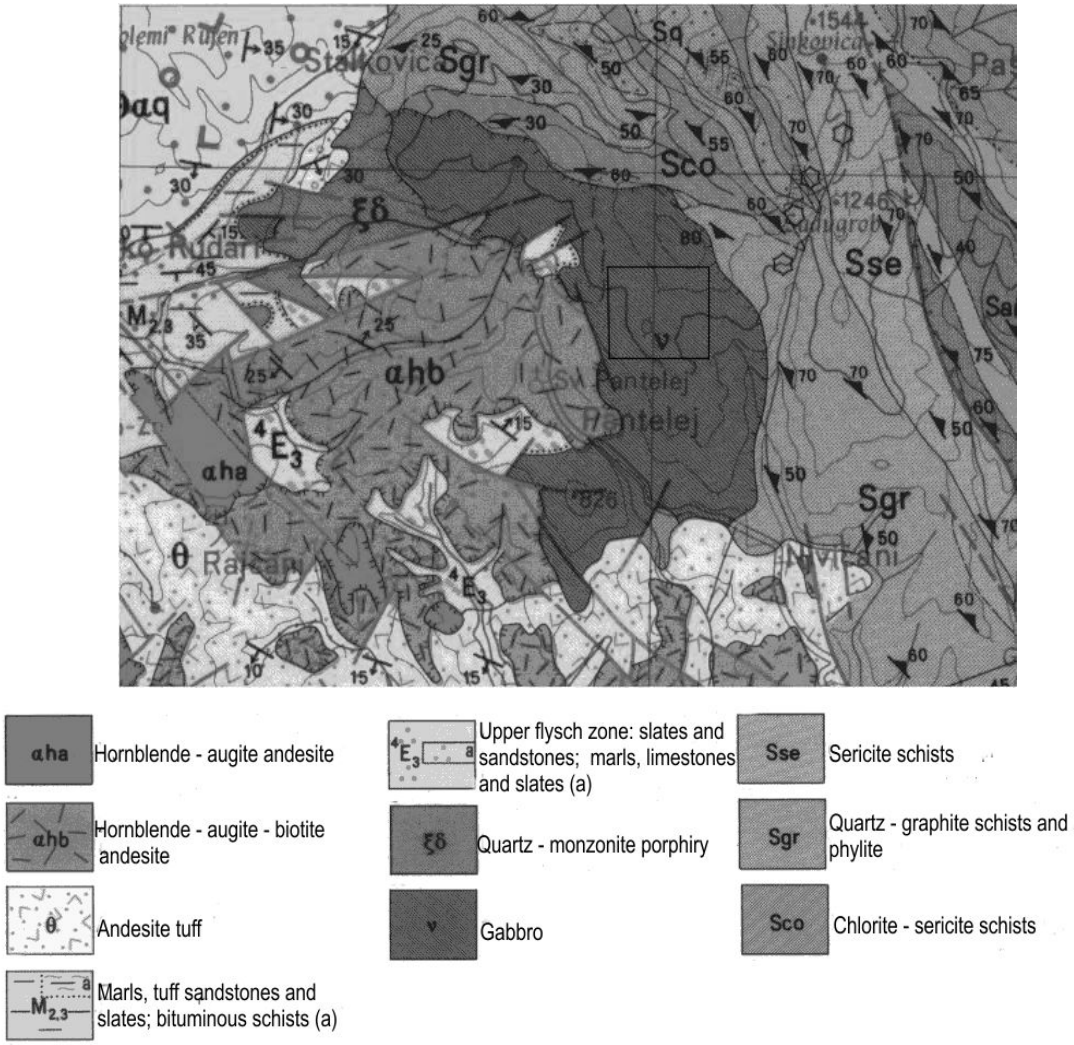

Fig.1: Geological map of the investigation area

Chemical, physical and geophysical parameters of gabbro

Examinations from chemical aspect showed that gabbro has the following composition:

SiO_2	45,14%	**MgO**	2,91 %
TiO_2	0,26 %	**CaO**	15,80 %
Al_2O_3	24,50 %	**Na_2O**	0,71%
Fe_2O_3	3,20 %	**K_2O**	0,69%
FeO	4,59%	**H_2O**	2,50%
MnO	0,22%		

Conducted research for determination the gabbro density with analysis of samples from different locations showed that density varies within 2,85 - 3,12 g/cm^3 or average density of 2.98 g/cm^3. Relatively wide density interval for gabbro is result of the different degree of cracking of the rock massif. From the investigations is concluded that from the surface in depth the density increases, and the degree of cracking decreases.

Thermal characteristics of gabbro

Rock masses are characterized by coefficient of heat conductivity (k), coefficient of temperature conductivity (a) and specific heat (c).

The coefficient of heat conductivity (k) shows the amount of heat passing through unit area during the unit time, when the temperature drops 1^{o}C per unit length. It is denoted by (k), and is expressed in units W/mK.

Specific heat (c) shows the amount of heat, expressed in calories, and need to heat unit mass for 1^{o}C. The dimension of the specific heat is kJ/kgK. Thermal features of gabbro are presented in table 1. [3]

Table 1: Thermal features of gabbro

Rock	Thermal conductivity (k) [W/mk]	Temperature conductivity (a) [10^6 m^2 / s]	Specific heat (c) [kJ/kg C^o]
Gabbro	1.7 - 2.9	0.78 - 1.3	0.68 - 1.0

Electrical characteristics of gabbro

Conducted in situ investigations of geoelectrical aspect showed the following results: the specific electrical resistivity of gabbro is within the interval 1 x 10^6 - 1,5 x 10^8 Ω/m.[3]

Geoelectrical measurements were performed with Terrameter SAS 1000.

Magnetic characteristics of gabbro

Analyses made for the magnetic properties of gabbro showed that magnetic susceptibility is in range 0,0055264 to 0,51496 expressed in SI units [m^3 / kg]. These data and the presence of minerals of iron and titanium, which have significant presence in the surrounding, give possibility for application of geomagnetic method in the explorations of gabbro. [3]

Seismic characteristics of gabbro

Seismic investigations are dominated as geophysical method in defining the geomechanical parameters of the rock masses, because, unlike other geophysical parameters, these directly indicate the condition of the rock masses in relation to cracking, density and its elastic properties. Conducted explorations showed that seismic velocities of gabbro depend on more parameters such as degree of cracking, depth of dipping and its elastic properties. In table 2 are given velocities of seismic waves in gabbro in function of pressure.

Table 2. Average wave velocities as a function of pressure

	200 MPa		400 Mpa		600 Mpa		800 Mpa		1000 Mpa	
Gabbro	V_p	V_s	V_p	V_s	V_p	V_s	V_p	V_s	V_p	V_s
	7.138	3.862	7.200	3.888	7.241	3.905	7.273	3.918	7.299	3.929

Geomechanical characteristics of gabbro

Regarding the use of rocks as building stone, especially important are geomechanical characteristics, and when it comes decorativeness should not be underestimated and the color and the possibility of obtaining a high glossy surface. On the investigating terrain was applied seismic method in order to define the degree of cracking and the zone of more compact rock massif that may be of interest to produce blocks that would have a commercial effect.

Collected and processed data showed that degree of cracking of the gabbro massif is not the same everywhere. From analyzing the fissure systems can be concluded that on the area north of the monastery Pantelej dominated two systems of cracks with dip elements 355/50° and 60/30°, and present are a few less pronounced crack systems. [4]

The end northwestern part of the massif, south-east of the village Stalkovica dominated system of subvertical to vertical cracks with orientation 245-65 °.

The analyzes indicate that the surface cracking of gabbro is relatively large and varies within the range from 5 to 15 m in depth and there are fissure systems inside gabbro massif that differ in intensity and dip elements.

On the investigating area was conducted the method of measurement with georadar with 400 V transmitter and antenna system of 100 MHz. With this equipment were recorded four georadar profiles to depth of 24 m, and recording is performed with the array of profile points on every half meter (fig. 2). The processing of measurements was with the software "EKKO_View Deluxe".

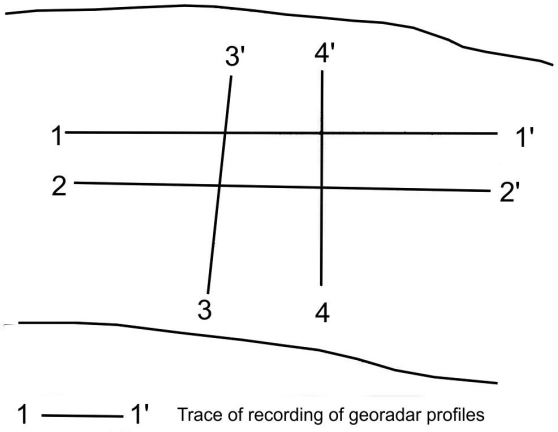

Fig.2: Geological map of the investigation area

Based on the results from geophysical explorations, on gabbro massif was made regionalization (vertical and horizontal) and were separated two zones:

- zone with relatively compact gabbro and
- zone of relatively cracked and crushed gabbro.

In the zones of relatively compact gabbro, i.e. zones A, A_1, A_2, and A_3 rock mass is well preserved, and in the zone with relatively cracked and crushed gabbro, rock mass is very cracked and crushed and this gabbro is practically unproductive and is not part of further investigations. [4]

Zone A appears on profile 3 on the west edge of the massif. Its area is around 1500 m^2. Surface cracking of gabbro in this zone is within 6 - 15 m.

Zone A_1 occur on profiles 1, 2 and 3. Total area is about 1700 m^2. Surface cracking is 6 - 12 m.

Zone A_2 is registered on the profiles 1, 2 and 3 with total area of 1800 m^2 and surface cracking form 6 to

10 m.

Zone A_3 is present in the edge east part of the gabbro massif and appears on the profiles 1, 2 and 3. Its area is 650 m^2. Surface cracking is within 6 - 10 m.

These data showed that on the studied part of the gabbro massif with total area of 20000 m^2, zone of relatively compact gabbro covers 5650 m^2.

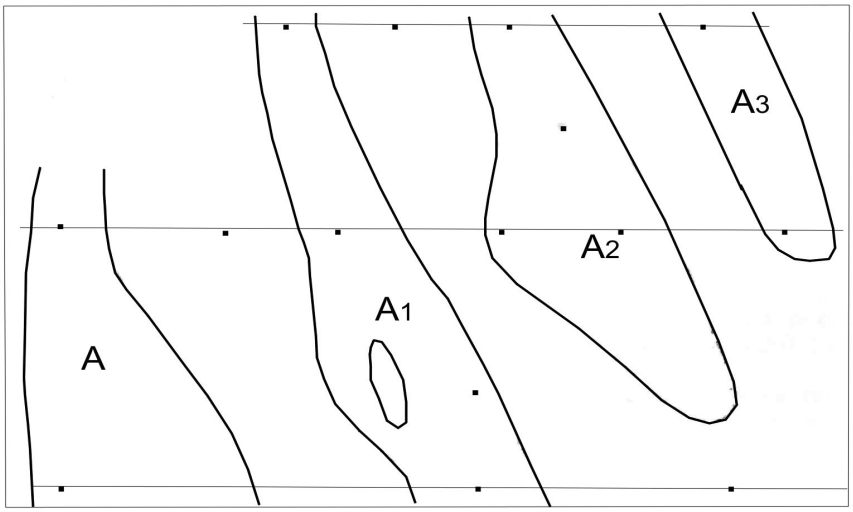

Fig. 3: Horizontal regionalization of gabbro massif

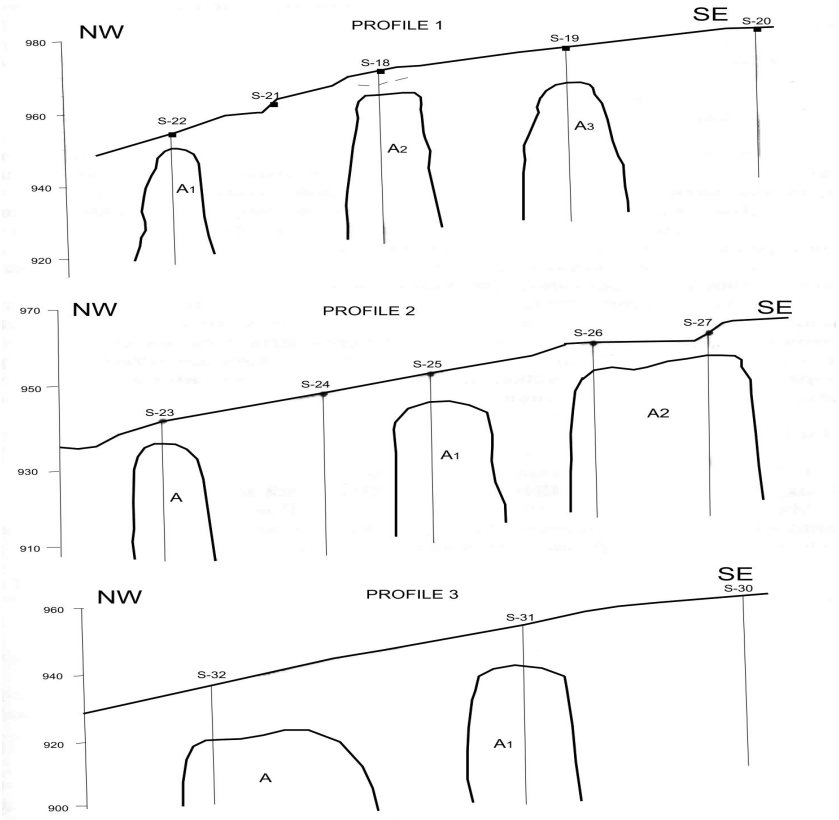

Fig. 4: Vertical regionalization of gabbro massif

From the conducted field and laboratory examinations of the gabbro massif on locality Pantelej, we can separate crushing as a very important geomechanical characteristic of gabbro (table 3) which is of special interest in building industry. [5]

Table 3. Coefficient of empirical criterion of fracture, according Hawk and Brown, 1980

Gabbro	Monolite without cracks **Q = 500 RMR = 100**	Excelent quality, unchanged monolite **Q = 100 RMR = 85**	Very good quality, cracks on 1 - 3 [m] **Q = 100 RMR = 85**	Good quality, cracks on 0.5 - 1 [m] **Q = 1.0 RMR = 44**	Poor quality, cracks on 30 - 50 [cm] **Q = 0.1 RMR = 23**	Very poor quality, cracks on 1 - 5 [cm] **Q = 0.01 RMR = 3**
	m = 25	m = 12.5	m = 2.5	m = 0.5	m = 0.13	m = 0.025

Conclusion

Gabbro rock massif on the exploration locality show high quality of physical - mechanical characteristics and as a material (buffer and granulate) it can be used in civil engineering. It is for the fissured surface layer of the investigation area, and under the surface, on depth above 6 m is possible exploitation of blocks which would be used for creation of plates and elements of interest for construction of monuments and decorative building stone.

Physical - mechanical characteristics show that built objects, monuments will have stabile properties for relative long time period, as well as stabile features of quality and color.

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