Proceedings of the

VIII INTERNATIONAL GEOMECHANICS CONFERENCE

2 – 6 July 2018
International House of Scientists "Fr. J. Curie"
Varna, Bulgaria

SCIENTIFIC AND TECHNICAL UNION OF MINING, GEOLOGY AND METALLURGY

ISSN: 1314-6467

2018, Bulgaria

ORGANIZERS

SCIENTIFIC AND TECHNICAL UNION OF MINING, GEOLOGY AND METALLURGY

FEDERATION OF THE SCIENTIFIC ENGINEERING UNIONS IN BULGARIA

Co-organizers

- University of mining and geology "St. Ivan Rilski"
- University of architecture, civil engineering and geodesy
- National Institute of Geophysics, Geodesy and Geography
- University of Transport "Todor Kableshkov"
- University of Structural Engineering & Architecture "Lyuben Karavelov"
- Bulgarian chamber of mining and geology
- "Antech TFA" Ltd.
- "Assarel Medet" JSCo
- Association "Bulgarian Coal mining"
- "Geotechmin" Ltd.
- "Gips" JSCo.
- "Dundee Precious Metals Chelopech" EAD
- "Ellatzite-med" JSCo.
- "Kaolin" JSCo.
- "Metropolitan" JSCo.
- "Maritza-Iztok Mines" JSCo.
- "Minproekt" JSCo.
- "Minstroy holding" JSCo.
- "Niproruda" JSCo.
- "Hemus - M" JSCo.

With media partners

Journal "Mining and geology"
Journal "Geology and mineral resources"
Newspaper "Rudnichar"
Publishing house "Ore and metals"
Newspaper "Science and society"

ORGANIZING COMMITTEE

Chairman:

Prof. DSc Eng. Tzolo Voutov	Chairman, Scientific and technical union of mining, geology and metallurgy

Honorary Chairman:

Prof. DSc Nikolai Nikolaev	Chairman of the National Committee of Rock mechanics

Deputy Chairmen:

Prof. DSc Eng. Nikolai Valkanov	Chairman of the Bulgarian chamber of mining and geology
Prof. Dr. Lyuben Totev	Rector, University of mining and geology "St. Ivan Rilski"
MSc Eng. Shteryo Shterev	Vice-chairman, Scientific and technical union of mining, geology and metallurgy

Scientific Secretaries:

Dr. Eng. Kremena Dedelyanova	Secretary general, Scientific and technical union of mining, geology and metallurgy
Dr. Eng. Konstantin Georgiev	Honorary member of the ISM
Dr. Juliyan Dimitrov	University of mining and geology "St. Ivan Rilski"

Organizer:

Dr. Krassimira Arsova	Scientific and technical union of mining, geology and metallurgy

Members:

Prof. Dr. Dimitar Anastasov	Director, Branch of the University of mining and geology "St. Ivan Rilski", Kardjali
MSc Eng. Andon Andonov	Executive director, Maritza-Iztok Mines JSCo.
Prof. Dr. Bozhidar Bozhinov	University of mining and geology "St. Ivan Rilski"
MSc Eng. Stoyo Bosnev	Executive director, "Minproekt" JSCo.
Prof. Dr. Stoyan Bratoev	Executive director, "Metropolitan" JSCo.
Prof. Dr. Mihail Vulkov	University of mining and geology "St. Ivan Rilski"
Dr. Eng. Vladimir Genevski	Scientific and technical union of mining, geology and metallurgy
Dr. Eng. Iliya Garkov	Executive director, "Dundee Precious Metals Chelopech" EAD
Prof. Dr. Petar Daskalov	Scientific and technical union of mining, geology and metallurgy
MSc Eng. Dragomir Draganov	Executive director, "Ellatzite-med" JSCo.
Prof. DSc. Dimcho Iossifov	Scientific and technical union of mining, geology and metallurgy
Sashka Kojuharova	Executive director, "Eurotest-control" JSCo.
Assoc. Prof. Dr. Ivaylo Koprev	Dean MTF, University of mining and geology "St. Ivan Rilski"
Prof. Dr. Ivan Markov	Rector, University of architecture, building and geodetics
Prof. Dr. Valeri Mitkov	"Videx" JSCo.
MSc Eng. Delcho Nikolov	Executive director, "Assarel Medet" JSCo
Assoc. Prof. Dr. Pavel Pavlov	Vice-Rector, University of mining and geology "St. Ivan Rilski"
Prof. Dr. Dragomir Stefanov	University of mining and geology "St. Ivan Rilski"
MSc Eng. Dancho Todorov	Executive director, "Niproruda" JSCo.
Assoc. Prof. Dr. Stanislav Topalov	University of mining and geology "St. Ivan Rilski"

INTERNATIONAL ADVISORY COMMITTEE

Prof. Michael Zhuravkov	**- Belarus**
Corr. member Victor Prushak	**- Belarus**
Prof. Nikolai Nikolaev	**- Bulgaria**
Prof. Ivan Vrkljan	**- Croatia**
Assoc. Prof. Dr. Petr Konicek	**- Czech Republic**
Prof. Carsten Drebenstedt	**- Germany**
Prof. George Gazetas	**- Greece**
Prof. Ákos Török	**- Hungary**
Prof. Risto Dambov	**- Macedonia**
Prof. Dorj Dondov	**- Mongolia**
Prof. Anton Sroka	**- Poland**
Prof. Petru Ciobanu	**- Romania**
Prof. Vassilii Barishnikov	**- Russia**
Prof. Viktor Gordeev	**- Russia**
Acad. Mikhail Kurlenya	**- Russia**
Prof. Vladimir Sedlak	**- Slovakia**
As. Prof. Dr. Joze Kortnik	**- Slovenia**
Dr. Eng. Milinko Radosavljevic	**- Serbia**
Prof. Nebojsha Gojkovich	**- Serbia**
Prof. Ersin Arioglu	**- Turkey**
Prof. Resat Ulusay	**- Turkey**
Prof. Garri Litvinskii	**- Ukraine**

TOPICS

A. Physical and mechanical properties of rocks and structural characteristics of the massif.
B. Investigation of the stress condition and strain state of the rock mass.
C. Geomechanical provision of mining and civil engineering.
D. Mine surveying geodetic and geophysical methods used in geomechanics
E. Geomechanical state of explosive and seismic impacts.
F. Environment protection in mining and construction activities.
G. Education and qualification.

GEOMECHANICAL CHARACTERISTICS OF QUARTZITES AS CONSTRUCTION MATERIAL AND THEIR POTENTIALITY IN THE REPUBLIC OF MACEDONIA

Krsto Blazev, Blagica Doneva, Gorgi Dimov, Zoran Panov, Todor Delipetrov, Marjan Delipetrev
University of Goce Delcev, Faculty of natural and technical sciences, Stip, krsto.blazev@ugd.edu.mk

ABSTRACT
From a genetic point of view, quartzites can be magmatic and metamorphic. Taking into consideration the European standards for the use of construction stone where the magmatic rocks are explicitly required, in this case of interest are magmatic quartzites for which geological, physical, chemical and geomechanical investigations were performed.
The paper presents the deposits of magmatic and metamorphic quartzites. Geomechanical investigations of magmatic quartzites carried out at the Crn Vrv, Plavica, Peshter and Dogandjiski Kamen deposits were presented.
The problem with the use of magmatic quartzites, which, from the aspect of construction material, have excellent construction features is relatively expensive processing, and in that sense, for use as a granulate in the road infrastructure, concrete and asphalt requires their comparative utilization in electrometallurgy and as material in the industry for grinding and crushing.
Keywords: *magmatic quartzite, physical -chemical characteristics, geomechanical characteristics, potentiality.*

Introduction

Magmatic quartzites, also called silex, are present only in the eastern part of Macedonia. They belong to young Alpine formations of Vardar zone connected with Tertiary volcanism of Kratovo – Zletovo volcanic area. The most important deposits are Crn Vrv, Plavica and Peshter (fig. 1). According the tectonic regionalization, this part of the country belongs to Eastern Macedonian zone.

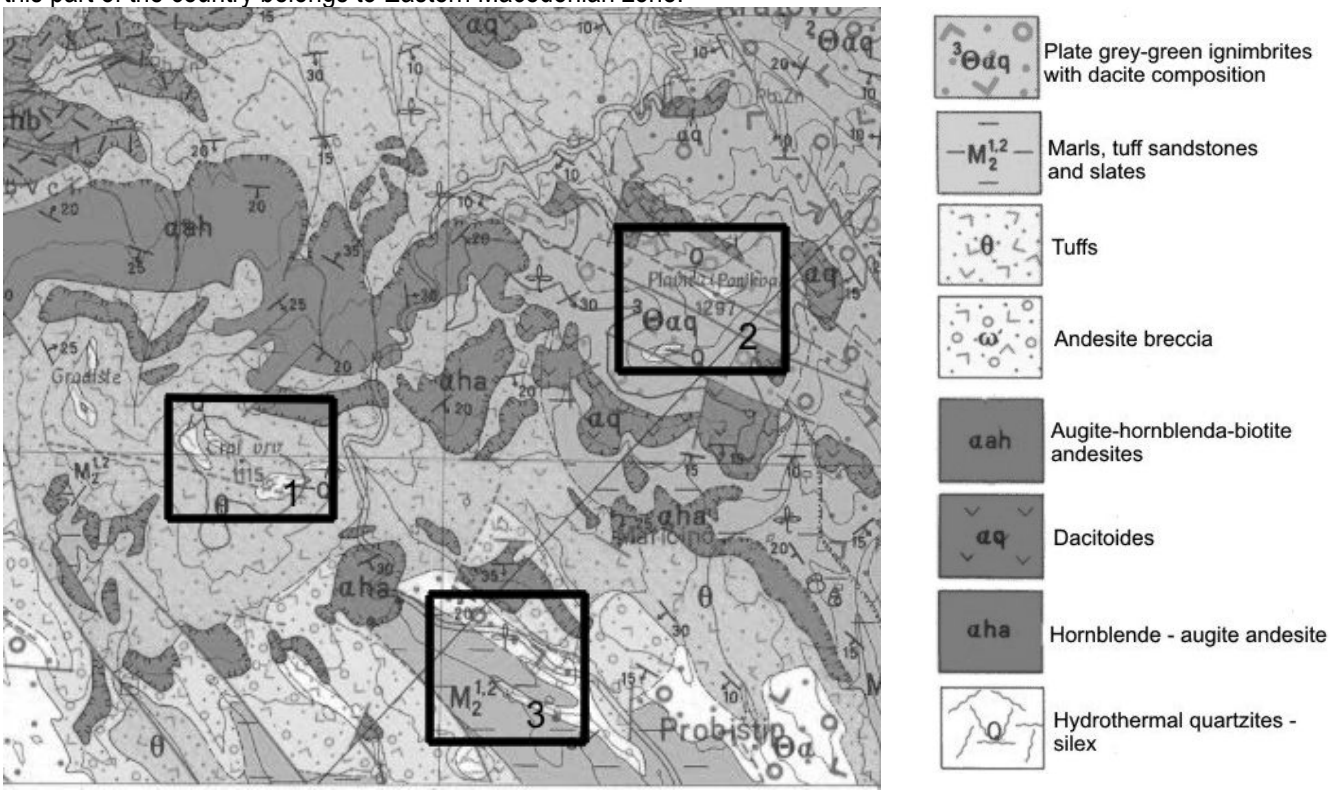


Fig.1: Geological map with areas of magmatic quartzite
1. Crn Vrv; 2. Plavica; 3. Peshter [1, 2]

Magmatic quartzite is formed with silification of the acid and intermediary volcanic rocks. This process took part separately or together with sericitization and chloritization.

According the investigations, it can be concluded that this type of quartzite origin in the process of the hydrothermal metasomatism of the intermediary volcanic rocks. The process of metasomatism was very intensive and in some parts of the rocks the percentage of silica is up to 98 – 99 %. Silicon matter is presented with microcrystal quartz mass.

Based on the rules of European standards for the use of construction stone and according the laboratory examinations, magmatic quartzite is very good for use in transport infrastructure as tampon layer.

Geological features of magmatic quartzite

Magmatic quartzites or silex appear in andesite – dacite rocks along the fault lines where silica components from hydrothermal solutions made intensive metasomatic alterations on the volcanic rocks and formed large masses of silicified rocks.

The areas of quartzites is variable and range between 600 m in Peshter (fig. 2) to 2 km in Crn Vrv (fig. 3). The thickness is also variable and is within 10 – 80 m. [2]

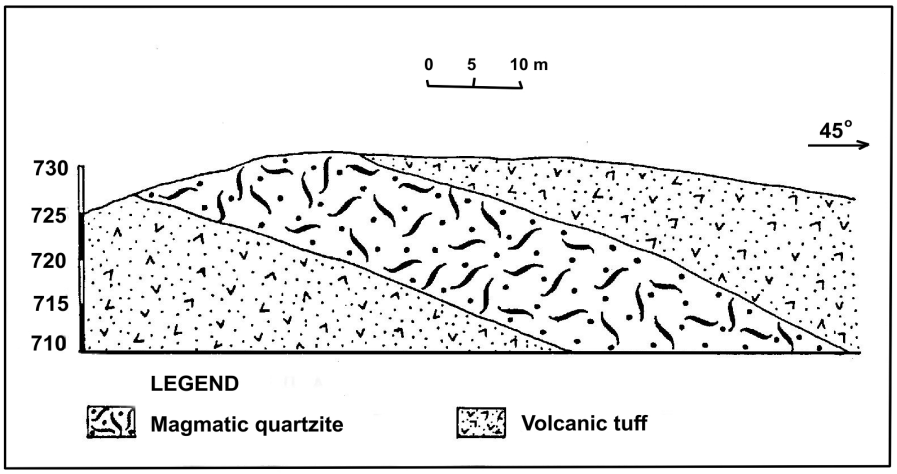


Fig.2: Geological profile of the deposit Peshter

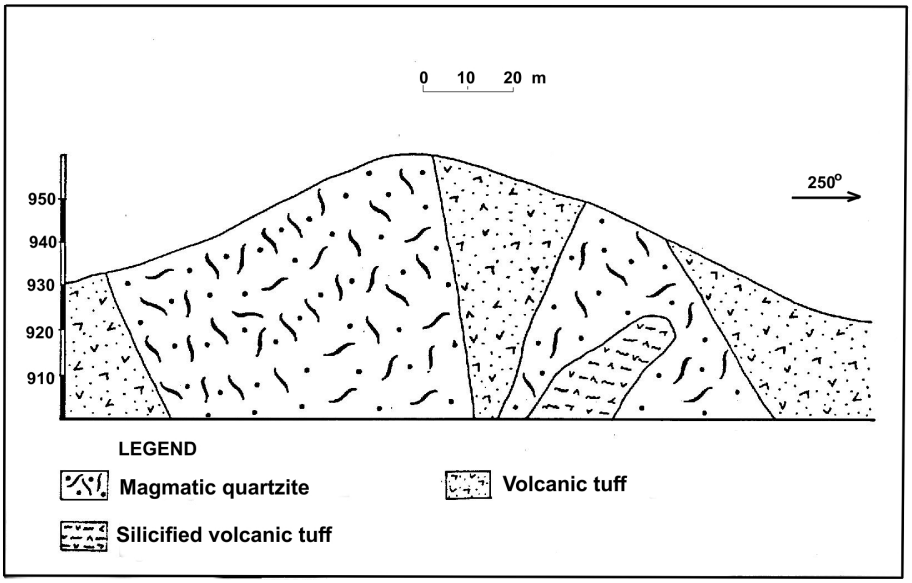


Fig.3: Geological profile of the deposit Crn Vrv

Magmatic quartzites have different color from grey – white, yellow to reddish, depending on the content of metals. They are compact and very strong rocks, usually hydrothermally altered, silicified and sometimes kaolinized. The structure is porphyry – clastic, and the texture is massive.

This type of rocks origin with long term and complex affection of gas and hydrothermal solutions which passed along the fractures and perform metasomatic alterations and formed silica rocks.

According their engineering – geological characteristics, magmatic quartzites are strong, poorly porous rocks resistant to ice, chemical and physical influences.

Because of their resistance and toughness, they are used in civil engineering as tampon layer in transport infrastructure.

Physical and chemical parameters of quartzite

Examinations of this mineral raw material showed that there are two types of quartzites. One is with better quality and composed of microscopic fine quartz as main component, and the other type contains relics from the mother rocks - tuffs and has lower quality.

Examinations from chemical aspect showed that quartzite has the following average composition: [4]

Table 1. Chemical composition of quartzite

SiO_2	95 - 98 %
Fe_2O_3	0,10 – 1,19 %
Al_2O_3	0,20 – 1,40 %
TiO_2	0,20 %
Na_2O	traces
K_2O	traces

Conducted research for determination the quartzite density with analysis of samples from different locations showed that density varies within 2,32 - 2,42 g/cm^3.

Geomechanical parameters of quartzite

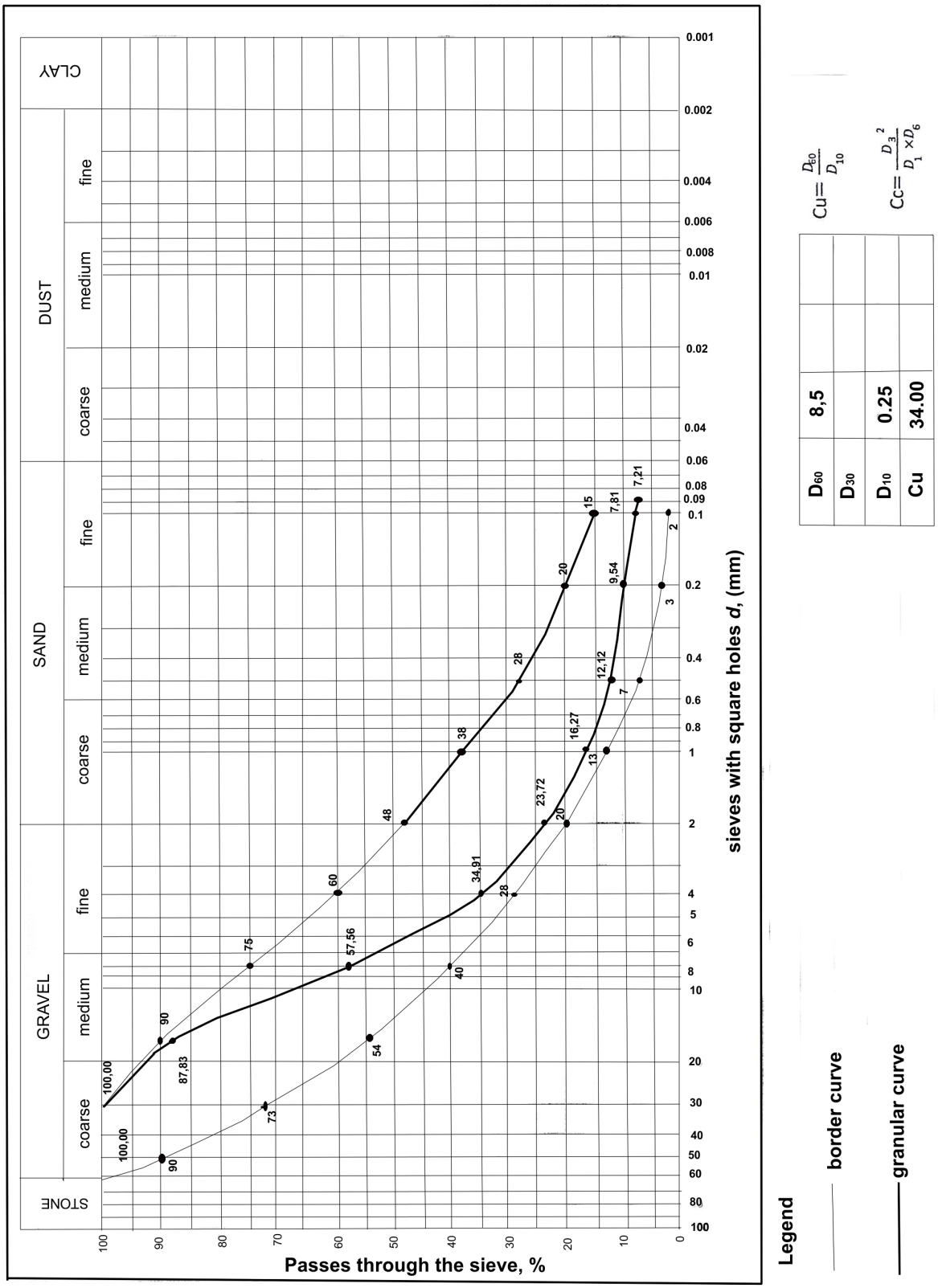
According the laboratory examinations of the material – magmatic quartzite, from the deposits in Eastern Macedonia, further are given the results of the geomechanical parameters. The following characteristics were examined: [5]

1. Granular composition
2. Volume mass – Proctor test
3. California bearing ratio
4. Abrasion loss value by Los Angeles method

Geomechanical characteristics

Test	Results	Criterion	Standard
Grain shape (% mass)	14.45	(max) 40 %	MKS.B.B8.048
Dilapidated grains	1.02	(max) 7 %	MKS.B.B8.037
Content of clay and silt particles (% mass)	1.6	(max) 5 %	MKS.B.B3.050
Sensitivity on ice influence (content of particles < 0.02 mm)	2.1 (F1)	/	MKS.U.E9.020
Consistency on ice Na_2SO_4 (loss of mass)	grains < 8 mm – 3.9 % grains > 8 mm – 3.5 %	grains < 8 mm to 10 % grains > 8 mm to 12 %	MKS.B.B8.044
Optimal water content / Maximum volume mass – Proctor test (modified method)	γ_{dmax} = 2.064 g/cm^3 W_{opt} = 5.70 %	/	MKS.U.B1.038
Granular composition	There is no deviation from the boundary belt for the tampon material	Boundary belt for the tampon material	MKS.U.B1.018
Degree of unevenness	34.0	(min) 15.0	MKS.U.B1.018
Abrasion loss value by Los Angeles method (% mass)	21.83	(max) 40 %	MKS.B.B8.045
California bearing ratio (CBR) %	81.39	(min) 80 %	MKS.B.B8.042
Determinated organic matters	0.8	(max) 5 %	MKS.B.B8.024

Granular composition



$Cu = \frac{D_{60}}{D_{10}}$

$Cc = \frac{D_3^{\,2}}{D_1 \times D_6}$

D_{60}	8,5		
D_{30}			
D_{10}	0.25		
Cu	34.00		

Examination of laboratory referent mass and water content – compactness after Proctor

Tampon 0 - 31.5 mm **Crushed material** **Total mass of the sample M = 6000 g**

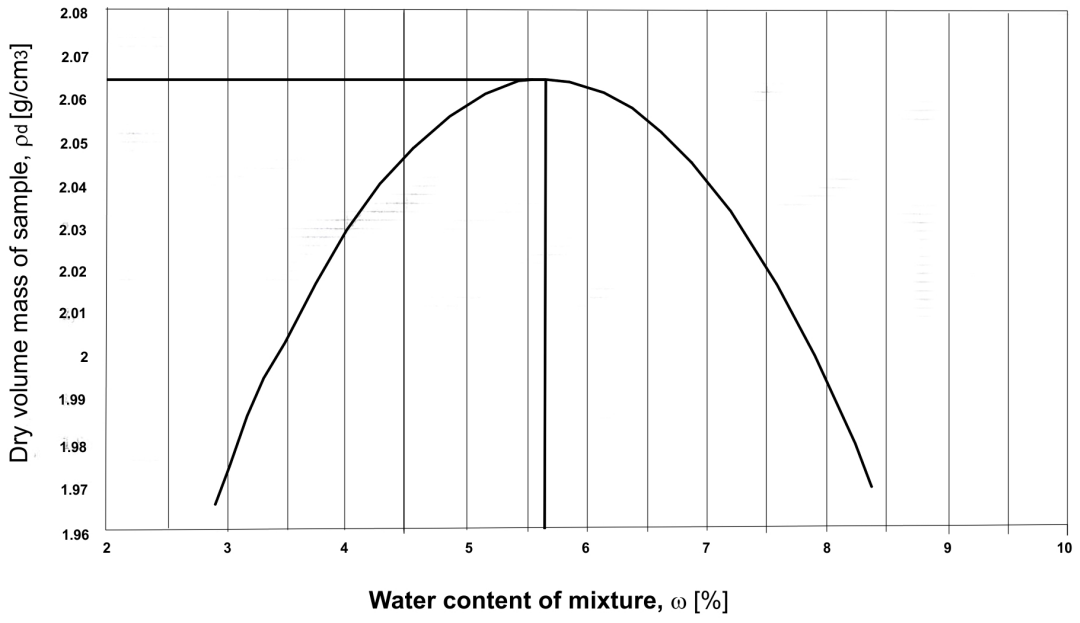
Test type: [ ] **Standard test** [X] **Modified test** **Mass of hammer - 4.5 kg**

Method of sample preparation: **Number of layers: 5** **Number of hits: 56**

Retained particles on sieve: **16 mm - 12,17 %;** **31.5 mm - 0.00 %;** **63 mm - 0 %**

Energy of compression: E = 2.70 MJ/m^3

Dimension of mold **H = 12.00 cm** **D = 15.00 cm**



Maximum dry mass ρ_{dmax} = 2.064 g/cm^3

Optimal water content ω_{opt} = 5.70 %

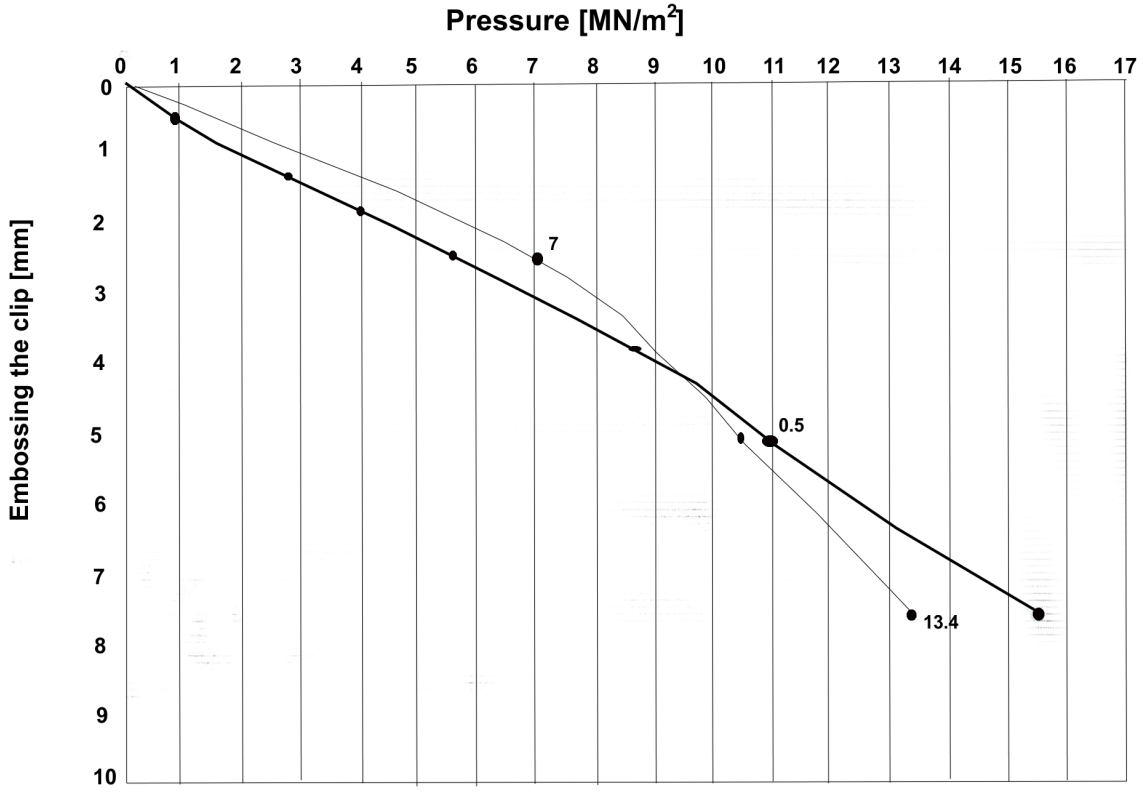
Determination of California bearing ratio (CBR)

Quartzite tampon (0 – 31.5 mm) Material: crushed material

Type of test		Material sieved through the sieve (mm)	Compression energy (MJ/m^3)
Modified	→	22.4	2.7

Determination of water content		
	Before testing	After testing
Water content	5.8	8.3

Mass of the sample		
Before testing (g)	After saturation (g)	After testing (g)
3055	3160	3156



CBR $_{2.54}$ = 81.39 [%]

CBR $_{5.08}$ = 103.91 [%]

Determination of abrasion loss value by Los Angeles method

Combination "B"	Passing through sieve (mm)	Stay on sieve (mm)	Mass of material after classification (g)	Total mass of material (g)	Number of balls	Number of revolutions	Residue on sieve 1.6 mm	Coefficient L_A (%)
	20	12.5	2500	5000	11	500	3908.5	**21.83**
	12.5	10	2500					

Conclusion

Magmatic quartzites, also called silex, are present only in the eastern part of Macedonia. They belong to young Alpine formations of Vardar zone connected with Tertiary volcanism of Kratovo – Zletovo volcanic area. These rocks are known with many different names, such as silexes, hydro-quartzites, metasomatic quartzites, secondary quartzites etc.

Based on the conducted chemical analyses, magmatic quartzite contains: SiO_2 95 - 98 %, Fe_2O_3 0,10 – 1,19 %, Al_2O_3 0,20 – 1,40 %, TiO_2 - 0,20 %, Na_2O and K_2O are present in traces.

According geomechanical examination granular composition, volume mass – Proctor test, California bearing ratio and abrasion loss value by Los Angeles method) can be concluded that this material, magmatic quartzite, has favorable physical – mechanical properties and can be successfully used as tampon in transport infrastructure. Also, this mineral raw material has large uses in ceramic and similar industries for coating grinding mills, in abrasive industry for production of flint – paper, as "sand" for cutting decorative stones, as material for making containers for aggressive chemicals, in electrical – chemical industry for obtaining ferro – silica or silica metal.

From the conducted geological investigation on the mentioned localities, can be concluded that this raw material is present in sufficient quantity for exploitation for civil engineering and other mentioned industries. But, knowing the high quality of the material from geomechanical point of view, extension of geological research is needed and thereby increasing the geological reserves.

Also, it is necessary development of modern technology for processing of this high quality mineral raw material.

References

1. Hristov S. et al. (1963 - 1968). Basic geological map of the Republic of Macedonia - sheet Kratovo 1:100000
2. Hristov S. et al. (1969). Interpreter of Basic geological map of the Republic of Macedonia - sheet Kratovo 1:100000.
3. Blazev K. (1991). Minerageny of silica raw materials in Macedonia and their economic significance. Doctoral thesis. Faculty of mining and geology – Stip.
4. Blazev, K. et al. (2009). Mining project for exploitation of Quartzite from the deposit Pester, Probishtip
5. Geing – Krebs und Kiefer (2017). Report from examinations of geomechanical characteristics of quartzite – 0/31.5 mm for evaluation for its use as tampon.