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GEOMECHANICAL CHARACTERISTICS OF MARBLES FROM QUARRY SLOESTICA AND THEIR CORRELATED WITH VELOCITY OF ELASTIC LONGITUDINAL WAVES

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ABSTRACT
In this paper are presented geophysical and geomechanical characteristics of marbles from quarry Sloestica in R. Macedonia. Investigating space is built of dolomite marble which represent special fascia of marbleized limestone. Characteristic are only for vicinity of the village Zvan.
At the field and in the laboratory performed a number of investigations in order to define possible by precisely engineering-geological and geotechnical characteristics of the marble from the site Sloestica. The purpose of geophysical surveys is based on the velocity of spreading of longitudinal elastic seismic waves to define the appropriate depth of the limestone as a valuable raw material, and to help define the physical characteristics and condition of the rock mass. For the purposes of this paper has been developed seismic profile PR-1, which is located on the middle level of the excavation. With the interpretation of the results obtained along this profile are set aside two elastic environments.
Keywords: *marble, geomechanical characteristics, geophysical features, rock mass, seismic profile.*

INTRODUCTION

Quarry for construction - technical stone "Sloestica" is located in the western part of the Republic Macedonia about 10 kilometers northwest of the city Demir Hisar in the vicinity of the village Sloestica (Figure 1).

Figure 1 Geographic location of quarry Sloeshtica

Micro location of the area for research is hilly land, characterized by rounded hills whose altitude ranges to 900 m. Most of this area and its surroundings is bare rocky land of low class, which is further degraded by intensive processes of mining which occurred in the last 30 years.
As significant water flows is appear Boishka river that passes 300 meters east of the quarry, and it is only 1 kilometer northeast flows into the Crna River which is a main drainage artery of this area.

GEOLOGICAL CONSTRUCTION OF THE WIDER VICINITY OF THE QUARRY SLOESTICA

From geo-tectonic aspect investigated area belongs to Western Macedonian geotectonic unit (Arsovski 1997), and of the geological map of figure 2. we can see that the general environment of the quarry Sloestica is built from rocks with Mesozoic and Paleozoic age. Exception made only alluvial deposits of quaternary age that mark major surface water flow.

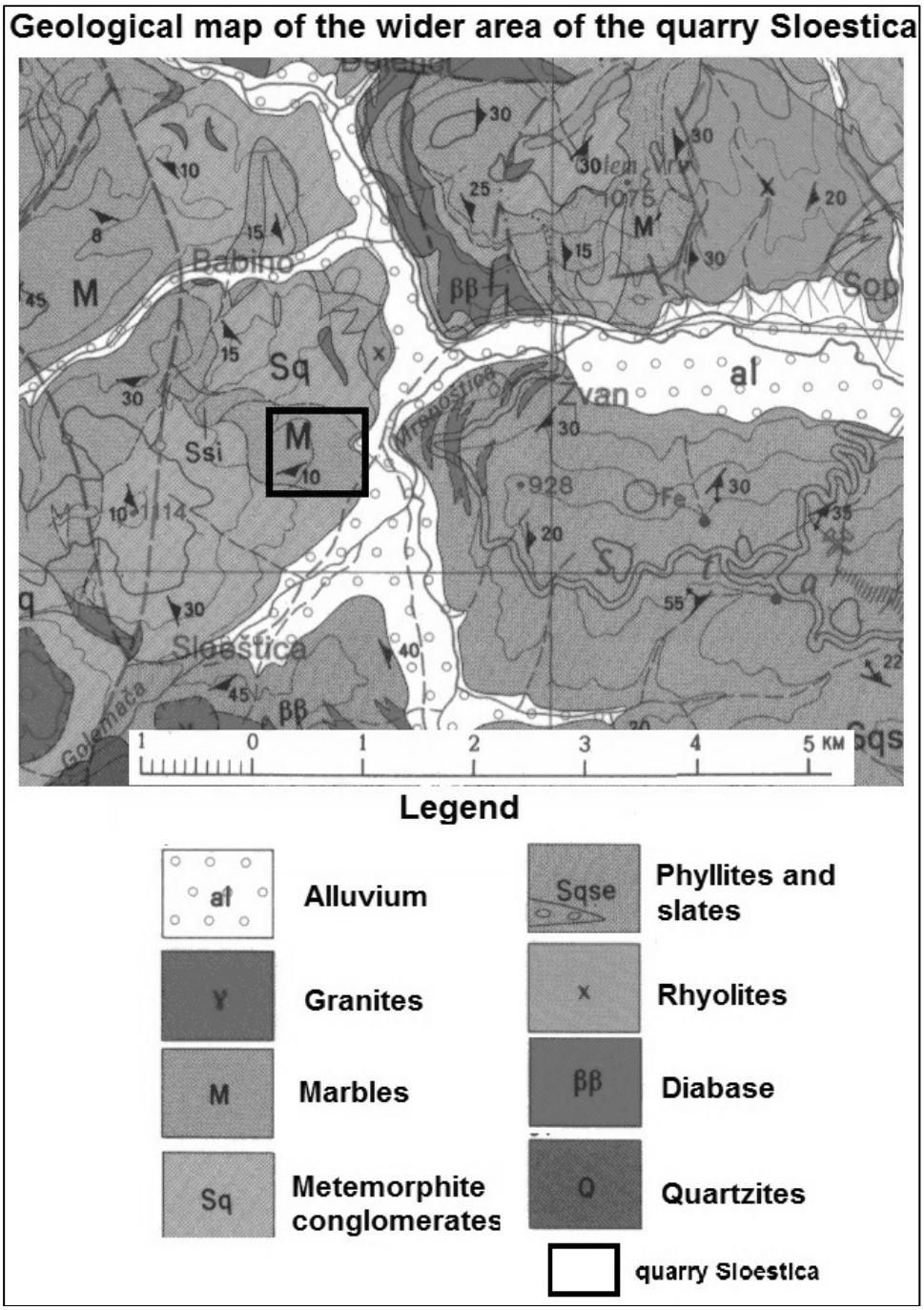


Figure 2. Geological map of the vicinity of the quarry Sloestica

Investigating area is built of dolomite marble which represent special fascia of marbleized limestone. Characteristic are only for vicinity of the village Zvan, until Sloestica quarry is located in the form of a small island in the surrounding metamorphic (metamorphic conglomerates) environment. Their color is pink to milky white and appear to be quite decomposed and karstic rock masses.

PHYSICAL-MECHANICAL CHARACTERISTICS OF MARBLES

At the field and in the laboratory is performed a number of investigations in order to define possible by precisely engineering-geological and geotechnical characteristics of the marble from the site Sloestica. In Table 1 are presented the most important physical-mechanical parameters of this marble. Analyzes are conducted in the a reputable laboratory in the Republic Macedonia.

Table 1. Physical -mechanical parameters of the deposit Sloestica

No.	Parameter	Method	Unit measure	Test result
1.	Compressive strength in dry state	Б.Б8.012- No - accredited method	MPa	130,5
2.	Compressive strength in water-saturated condition	Б.Б8.012- No - accredited method	MPa	121,3
3.	Water absorption	Б.Б8.010- No - accredited method	%	0,1
4.	Bulk weight	Б.Б8.032- No - accredited method	kN/m^3	27,00
5.	Specific weight	Б.Б8.032- No - accredited method	kN/m^3	27,80
6.	Degree of Density	Б.Б8.032- No - accredited method	%	96,8
7.	Porosity	Б.Б8.032- No - accredited method	%	3,20
8.	Persistence of effect of ice	Б.Б8.001	±5%	Permissible loss of compressive strength after 25 cycles of freeze-max.20%
9.	Mineralogical petrographic composition	Б.Б8.003- No - accredited method		a favorable
Sulphate-does not contain				
Sulfide - does not contain				

From the results it can be concluded that the level of monolith, tested samples of marble, no matter from which quasi homogenous zone are taken, showing excellent strength characteristics, which is essential for their application as technical or architectural building stone. With the laboratory operates be determined the index of the strength of the monolithic parts. The results are given in the following table.

Table 2. Results of testing an index of a point strength

Kind of rock	Bulk weight γ [kN/m^3]	Index of a point strength $J_{s(50)}$ [MPa]	Compressive strength $\sigma_p = 22 \cdot J_{s(50)}$ [MPa]	Tensile properties $\sigma_z = 1.5 \cdot J_{s(50)}$ [MPa]
marble	27.12	5.99	131.76	8.98
marble	26.92	6.08	133.73	9.12
marble	26.92	5.36	117.88	8.04
marble	27.12	4.75	104.55	7.13
marble	26.92	4.65	102.39	6.98
marble	26.92	5.14	113.17	7.72

Below are excerpts from the computer program ROCKDATA 3.0, which certain physical and mechanical parameters of rocks. The results of cohesion **cm = 1.2 MPa** and the angle of internal friction φ_m **= 45°** indicate a very favorable physical and mechanical parameters of the rock mass.

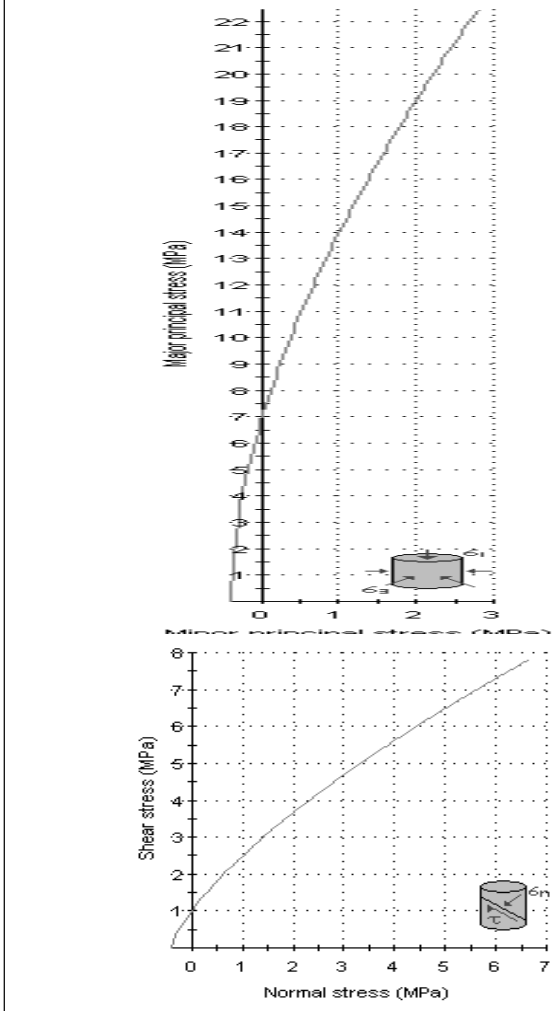
Hoek-Brown Classification sigci 105 MPa GSI 62 mi 9 D 0.7 Hoek-Brown Criterion mb 1.11551 s 0.00405726 a 0.502459 Failure Envelope Range Application Slopes sig3max 2.78534 MPa Unit Weight 0.027 MN/m3 Slope Height 125 m Mohr-Coulomb Fit **c 1.2455 MPa** **phi 45.0249 degrees** Rock Mass Parameters sigt -0.381899 MPa sigc 6.59817 MPa sigcm 15.376 MPa Em 12969.2 MPa	

Fig. 3 Excerpt from a computer program ROCKDATA 3.0

REVIEW OF THE RESULTS FROM THE GEOPHYSICAL INVESTIGATIONS

The purpose of geophysical surveys is based on velocity of spreading of longitudinal elastic seismic waves to define the appropriate depth of the limestone as a valuable raw material, and to help define the physical characteristics and condition of the rock mass. At the quarry Sloestica was applied the method of seismic refraction surveys. Refraction seismic surveys were carried out along several sections located in the zone of excavation. The results of Refraction seismic surveys along the profiles are displayed in seismic sections.
For the purpose of this paper is developed seismic profile PR-1 (Figure 4) which is located on the middle level of the excavation around elevation 750 m. With the interpretation of the results obtained along this profile are set aside two elastic environments.

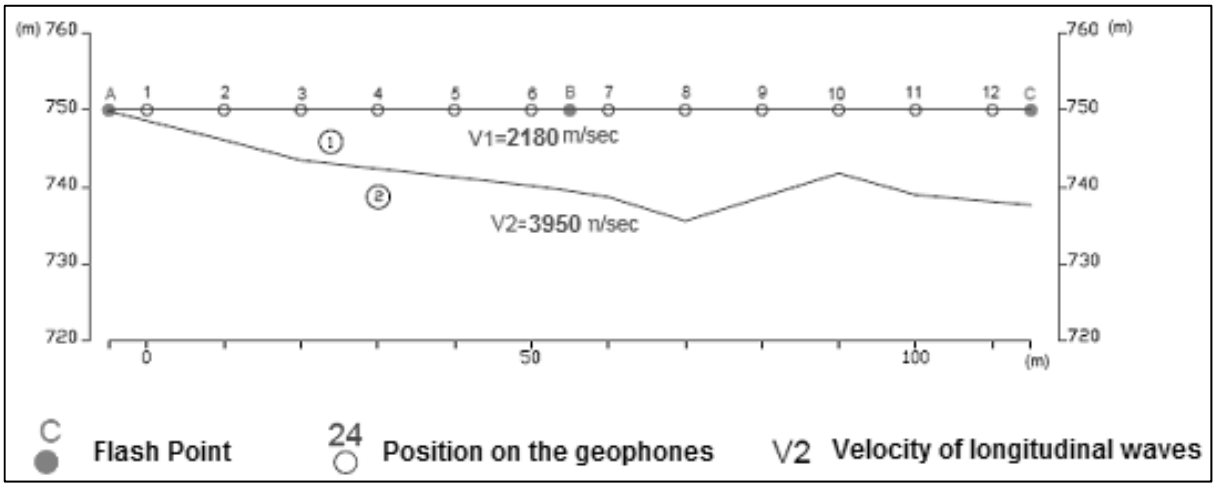


Figure 4. Seismic profile PR-1

Along this profile (PR - 1) on the surface is allocated elastic environment 1, for which are characteristic values of velocity of spreading of longitudinal elastic waves from 2.180 m/s. The thickness of this allocated elastic environment is variable along the profile and moves around 0.5 m from the initial part of profile and up to 14.5 near to the seismic geophone with No.8.

At the obtained seismic section can be observed increase the thickness of the elastic environment 1, from the initial part of the profile until geophone No.8. After that a decline in thickness near the geophone No.10 to about 8.2 m and increased again at the end of the profile around 12.2 m. Lithological, this allocated area would correspond to basic rock mass - marble, which with various tectonic movements is disrupted, whereby positions of the profile with the most greatest thickness could possibly indicate minor or major fault zones. It should be borne in mind that some impact of this elastic environment over time there was and the release the stresses on the effect of creating a valley of the excavation. Also negative effects on the quality of this environment has long-term use of explosives into the exploitation phase. All these parameters have more or less impact on the physical characteristics of this allocated elastic environment.

Under the allocated environment 1, also is allocated elastic environment 2, characterized by greater values of velocity of spreading of longitudinal elastic waves (from the 4.000 m/s). Lithological, this allocated environment would correspond to relatively fresh basic rock - marble.

At the diagram below (Figure 5) is represented the logarithmic dependence between the speed of elastic waves (Vp) and depth of field (h) in which they are performing research.

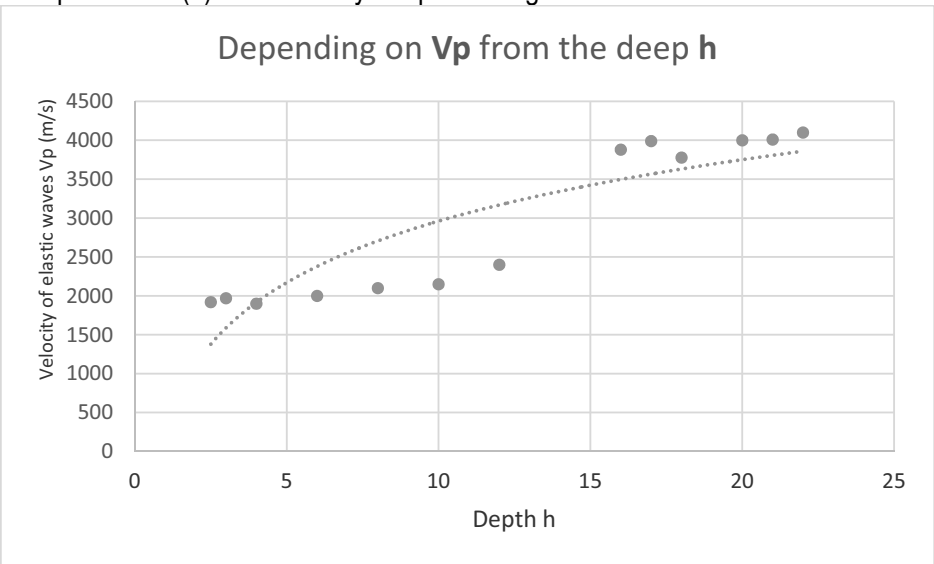


Figure 5. Depending correlation between the velocity of longitudinal waves (Vp) and depth (h).

Analyzing the diagram can come to the conclusion that this carbonate massif applying of the rule that by increasing the depth comes to increasing the velocity of seismic waves. Logical conclusion resulting from this situation is that increasing velocity is associated with a reduction of cracking of the massif.
At a depth of 23 meters velocity of seismic waves as high as 4,000 meters per second. From past experience we know that these velocity from the 4.000 m/s are characteristic of not cracked and fresh rock masses in the which it is possible exploitation of architectural decorative stone.

CONCLUSION

Quarry for construction - technical stone "Sloestica" is located in the western part of the Republic Macedonia about 10 kilometers northwest of the city Demir Hisar in the vicinity of the village Sloestica. Investigating area is built of dolomite marble which represent special fascia of marbleized limestone.
From the results from physical – mechanical analyze it can be concluded that from the level of monolith, tested samples of marble, no matter from which quasi homogenous zone are taken, showing excellent strength characteristics, which is essential for their application as technical or architectural building stone. Also the results of cohesion cm = 1.2 MPa and the angle of internal friction φ_m = 45° indicate a very favorable geomechanical parameters of the rock mass.
At the quarry Sloesnica was applied the method of seismic refraction surveys. Along this profile PR - 1on the surface is allocated elastic environment 1, for which are characteristic values of velocity of spreading of longitudinal elastic waves from 2.180 m/s. Under the allocated environment 1, also is allocated elastic environment 2, characterized by greater values of velocity of spreading of longitudinal elastic waves (from the 4.000 m/s).
Logical conclusion resulting from this situation is that increasing velocity is associated with a reduction of cracking of the massif.

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