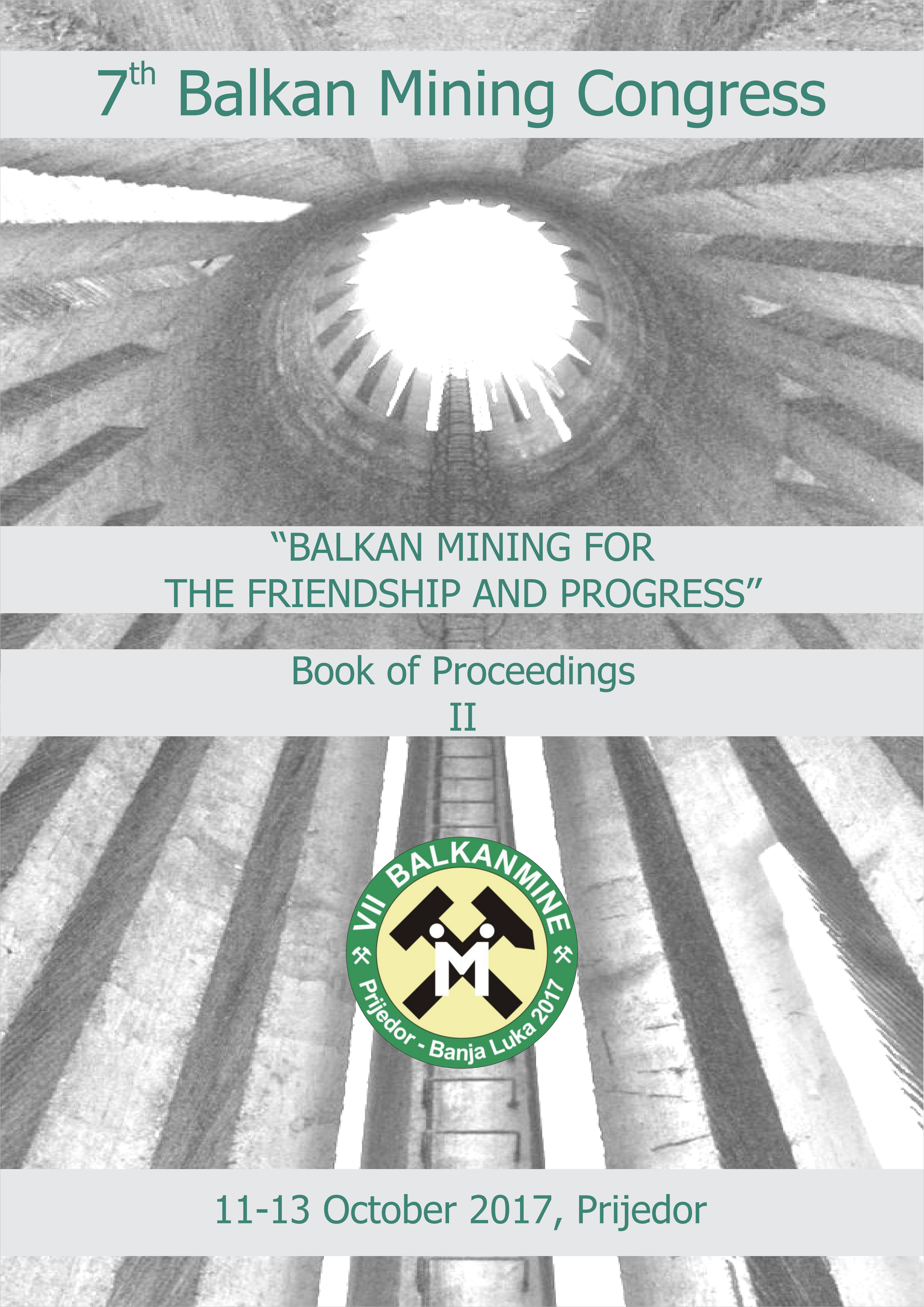
7th Balkan Mining Congress



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II Balkan Mining Congress

September 10-13, 2007.
Belgrade, Serbia
President of the Balkan Coordinating Committee:
Prof. dr Slobodan Vujić

III Balkan Mining Congress

October 1-3, 2009.
Izmir, Turkey
President of the Balkan Coordinating Committee:
Dr. Eng. Bahtiyar Ünver

IV Balkan Mining Congress

October 18-20, 2011.
Ljubljana, Slovenia
President of the Balkan Coordinating Committee
Dr. Marjan Hudej

V Balkan Mining Congress

September 18-21, 2013.
Ohrid, Republic of Macedonia
President of the Balkan Coordinating Committee:
MSc. Sasho Jovchevski

VI Balkan Mining Congress

September 20-23, 2015.
Petrosani, Romania
President of the Balkan Coordinating Committee:
Prof.dr. Nicolae Iliaş

IN MEMORIAM

Assistant professor Tomo Benović was born on January 06, 1958 in Bogutovo Selo in Ugljevik. From 01.02.1982.Tomo Benović was employed in Rudnik i termoelektrana Ugljevik in the following works: trainee, shift manager, technical manager of coal production, assistant director (for mines and technical business), manager for mining and geological service, director of RiTE Ugljevik, coordinator for coordination with Regulatory Authorities, Team Leader of Project Implementation and realization of investments and projector for the mine. Tomo Benović was the first Mayor of Municipality Ugljevik and in the period 2000-2002 he had been a member of the National Assembly of Republic Srpska. Tomo Benović had been in the following scientific and professional organizations and associations: the Chairman of the Alliance of Engineers and Technician of Mining - Geological and Metallurgy Profession, the membership of the International Coordination Committee of the Balkan Mining Congress from Bosnia and Herzegovina in two mandates.
At the Senate of the University of Banja Luka session, held on August 25, 2016, Tomo Benović PhD in mining was elected as Assistant professor for scientific research - Surface exploitation of the mineral raw materials. Assistant professor Tomo Benović tragically died on 27 November 2016 in a traffic accident.

Preface

Dear Colleagues,

On behalf of the University of Banja Luka, the Faculty of Mining Prijedor and the International Coordination Committee of the 7th Balkan Congress, we welcome you as respected and dear guests of the University and Faculty, Prijedor, Republic Srpska and Bosnia and Herzegovina. The 7th Balkan Mining Congress has a motto **"Balkan mining for the friendship and progress"**, which speaks enough about the basic idea of organizing and holding this event. This Conress has been held biennial in the Balkan countries.

This international meeting is an opportunity for Congress participants - authors of works, sponsors, exhibitors, representatives of institutions and companies to meet each other, exchange experiences in solving problems and issues related to the development of mining, geology, and the work of companies. Every opportunity to hear something new, something that is applied in other countries and conditions is the chance to find a chance in this transition period which is difficult for the work and development of mining companies. The exploitation of mineral resources could be beneficial, for the producers themselves,and for local communities and countries where are these mines located.

In contemporary trends in the mining and geology development, there are dilemmas to reconcile certain, at first sight, completely opposed and incompatible activities: mining, environmental protection, optimal economic effects of mining activities for the concedents and concessionaires. The Balkan Mining Congress is a unique opportunity to talk about these issues, exchange experiences, find solutions and align certain models of more rational solutions.

Wishing to feel comfortable and pleasant in Prijedor, and after the end of the Congress, you go home happy and with the view that it was worth being here, I greet you in my personal name and the name of the University in Banja Luka-Mining Faculty Prijedor and others co-organizer of the Congress.

Prijedor, October 2017.

Assoc. prof. Vladimir Malbašić

Chairman of the Organizing Committee
of the 7th Balkanmine Congress

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MEASURING THE SEISMIC EFFECTS OF A QUERRY FOR MARBLE

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ABSTRACT

Abstract: In the querry for white marble "Sivec", where the research was carried out during normal exploitation, in the zones where digging is done, marble masses appear, which are broken down, not quality, and they need to be quickly removed. Drilling and mining operations are applied using certain quantities of explosives. In this application there is a danger of damaging the quality marble masses that are located around the blasting zone.

This paper is actually a continuation of the paper from the same authors regarding the seismic effects from blasting in surface mines.

1. INTRODUCTION

To get a marble blocks and larger lamellas it is necessary to perform controlled blasting for the removal of the cracked masses. During these blasting, there is the greatest danger of the effect of seismic action, whereby existing invisible cracks can be activated or new ones created. Also, this seismic effect has influenced to the surrounding benches and workshops by creating oscillations that can cause certain vibrations and damage to the marble massif.

When mine holes are located it is important to correctly define the existing cracks, discontinuities and the general direction of fall and stretching of the rock mass.

This paper presents some of the results which were obtained by measuring and will be clearly explained with a special commentary, which will provide a clearer picture of the impact of the mine work on the surrounding benches.

2. DESCRIPTIONOF BLASTING SERIES WITH THE BASIC DRILLING-BLASTING PARAMETERS

These blastings are performed at the surface mine Sivec, which works within the frames of Marble Company AD Prilep. The mining was organized and carried out by the company Dam-explo, Radovis in cooperation with the experts and the mining group from the Sivec mine. All series are performed in marble mass with pronounced geological deformities, lasses and cracks of different character. The measuring points, ie the instruments detecting and registering the seismic oscillations were set at the same level as the location of the marble mass at different distances in a relatively straight line depending on the distance of the mine series, the measurement site and the working conditions. All blasting of the series were successful according to the foreseen schedule and schedule of activation.

The mine series are shown in the order of ignition and the effects of the obtained results from the seismic oscillations are presented below.

2.1. Blasting series No.1

This blasting series have a volume of 392 m^3. The blasting series is characterized by present cracks and loose masses in the upper part of the bench. In all the holes there is a visible presence of water and dirt that makes the ignition itself and the effects of the mining difficult.For this blasting, six horizontal holes were made at a height of 1.5 meters from the floor of the bench, the depth of which is different and ranges from 1.0 to 4.0 meters, arranged in one row with a distance of 2.0 to 2.4 meters.

The drilling diameter is 90 mm. Explosive Amonex-4, marked 60/1000, was used for chargingThe activation of the explosive in the hollows was carried out with the Nonel detonators U_{500}. The initiation of nonel tubes is with a capsule 8 and a slow-fitting wick.

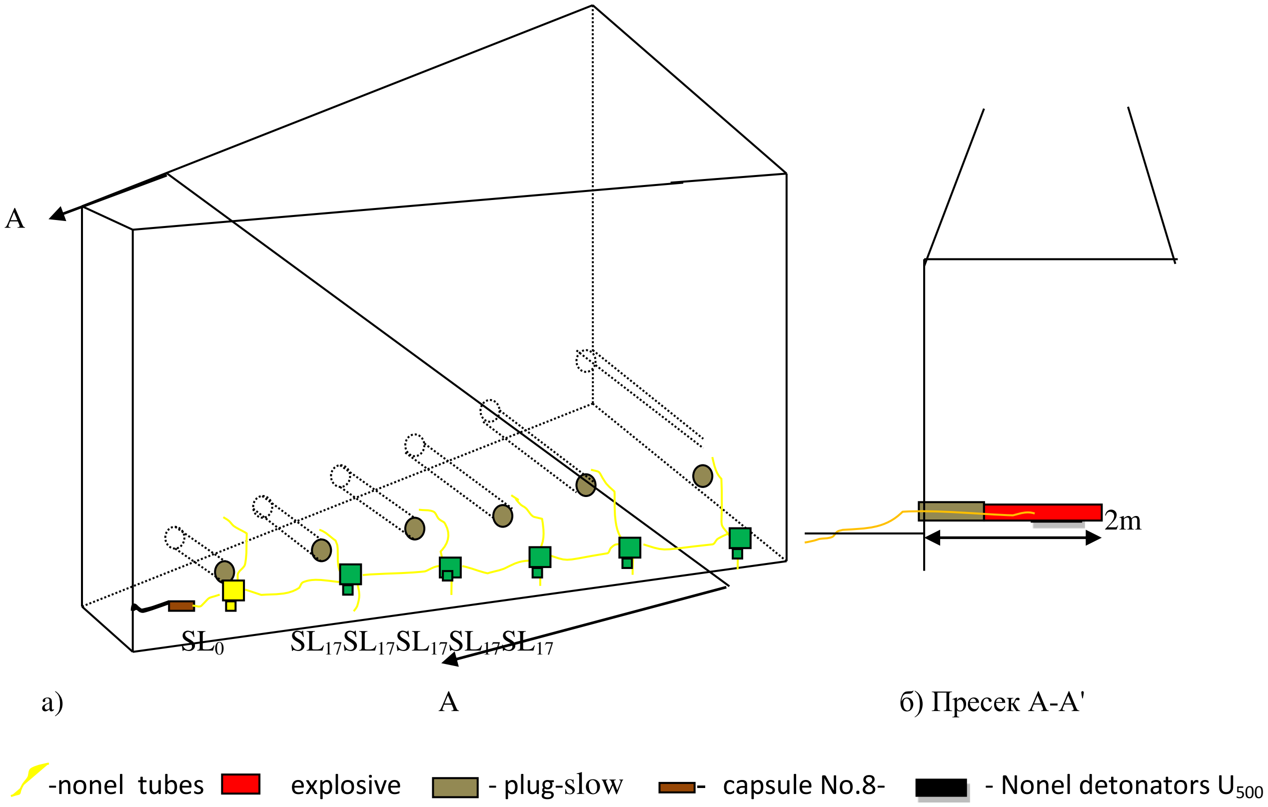

Figure. 1:Schematic of the blasting series No.1 and the way of connection

Table 1. Arrangement of the explosive in holes and their length

Ordinary number of drilling hole	Depth of the hole, L_b (m)	Quantity of explosives, Q_b (kg)
1	1,0	1,0
2	1,5	3,0
3	2,0	4,0
4	2,5	3,0
5	3,0	4,0
6	4,0	7,0
Total	**14**	**22**

Instrumental measurements

Registration of seismic vibrations was performed on 7 measuring instruments of type VIBRALOK.

The seismograph is constructed so that it can record the oscillation speed (v), calculating the acceleration (a) and the displacement of the ground (x), as well as the values for the frequency.

The Vibralok instrument is equipped with 8 megabytes of memory for measurement and can store 1000 individual measurements stored in this memory in accordance with the time sequence.The oldest measurements are deleted and replaced with new ones. The recording length can be set to 1,2,3 .... 5,10,20,30 ... 50, ... 100 seconds.

The measuring points are determined in cooperation with the responsible persons in the surface mine Sivec.

The corresponding influential parameters are given:

- Distance rom the center of the blasting series (MS) to the measuring points (MM),
- Maximum quantity of explosives per one interval, Q_i ,
- Total quantity of mine explosive, Q_{vk} ,
- Maximum oscillation speed per component, V_V ; V_T ; V_L ,
- The maximum resultant oscillation speed, V_{max} ,
- The real maximum resultant oscillation speed, V_{st} ,
- Calculated reduced distance, R.

Table 2. Results of seismic measurements for blasting series No. 1

Measuring place, MM	Distance of the minefield to MM, (m)	Maximum quantity of explosives per one interval ,Q_i, (kg)	Total quantity of mine explosive Q_{vk}, (kg)	Maximum oscillation speed per component, (mm/s)			The maximum resultant oscillation speed,V_{max} (mm/s)	The real maximum resultant oscillation speed V_{st}, (mm/s)	Calculated reduced distance, R, (m)
				V_V	V_T	V_L			
MM-1	195,5	I int- 1,0		-	-	-	-	-	
MM-2	152,0	II int- 3,0		-	-	-	-	-	
MM-3	117,8	III int- 4,0		-	-	-	-	-	
MM-4	91,2	IV int- - 3,0	22,0	1,14	1,35	1,87	2,573	2,100	32,5
MM-5	66,0	V int- -4,0		2,82	2,08	3,20	4,739	3,460	23,6
MM-6	72,0	VI int- -7,0		-	-	-	-	-	
MM-7	126,0			-	-	-	-	-	

According to the obtained results, the impact is insignificant, and only two instruments have recorded minor oscillations on the ground at the nearest measuring points MM-4 and MM-5. These oscillations according to the Criteria for vibrations do not affect to the surrounding marble masses.

Explosive consumption is:

$q= Q/V = 22/392 = 0,056\ kg/m^3$ or 0,019 kg/t or 19 g/t.

The following formula will be used to determine the safety distance from the blasting series of the surrounding marble massif:

$r_s= K_s\ \alpha\ \sqrt[3]{Q}$, (m)

where are:

- r_s - radius of the seismically dangerous zone, m;
- α - coefficient that depends on the action indicator of the explosion (we adopted n=1,1);
- K_s- a coefficient that depends on the physical and mechanical characteristics of the rock massif and ranges from 3-30;
- Q - total amount of explosive charge, kg;

For a quantity of 22 kg explosives that is initiated simultaneously for a dangerous zone of vibrations we get:

$r_s= K_s\ \alpha\ \sqrt[3]{Q}= 5*\ 0,98*\ \sqrt[3]{22}=$ 11,0 metres

This practically means that within a radius of 11 meters this 22 kg in the blasting series, will have an impact on the surrounding massif in the form of tremors, minor deformations and significant values of the oscillation speed.

2.2. Blasting series No.2

This blasting series have a volume of 300 m^3. For this blasting, seven horizontal holes were made at a height of 1.5 meters from the floor of the bench, the depth is 3.0 meters, arranged in one row with a distance of 2.0 to 2.4 meters.

The drilling diameter is 90 mm. Explosive Amonex-4, marked 60/1000, was used for charging. The activation of the explosive in the hollows was carried out with the Nonel detonators U_{500}. The initiation of nonel tubes is with a capsule 8 and a slow-fitting wick.

Table 3: Arrangement of the explosive in holes and their length

Ordinary number of drilling hole	Depth of the hole, L_b (m)	Quantity of explosives, Q_b (kg)
1	3,0	4,0
2	3,0	4,0
3	3,0	4,0
4	3,0	4,0
5	3,0	4,0
6	3,0	4,0
7	3,0	4,0
Total	**21**	**28**

- **Instrumental measurements**

Registration of seismic shocks was performed on 7 measuring instruments at the same locations as the previous mine series.

Table 4: Results of seismic measurements for blasting series No. 2

Measuring place, MM	Distance of the minefield to MM, (m)	Maximum quantity of explosives per one interval ,Q_i, (kg)	Total quantity of mine explosive Q_{vk}, (kg)	Maximum oscillation speed per component,(mm/s)			The maximum resultant oscillation speed,V_{max}, (mm/s)	The real maximum resultant oscillation speedV_{st}, (mm/s)	Calculated reduced distance, R, (m)
				V_V	V_T	V_L			
MM-1	232,6	I int- 4,0	28,0	-	-	-	-	-	
MM-2	189,7	II int- 8,0		-	-	-	-	-	
MM-3	154,0	III int- 8,0		-	-	-	-	-	
MM-4	124,5	IV int- - 8,0		-	-	-	-	-	
MM-5	87,0			0,68	1,422	0,938	1,835	1,460	29,8
MM-6	34,3			4,45	10,108	9,183	14,363	13,220	76,0
MM-7	85,7			1,29	2,683	2,047	3,614	3,350	34,0

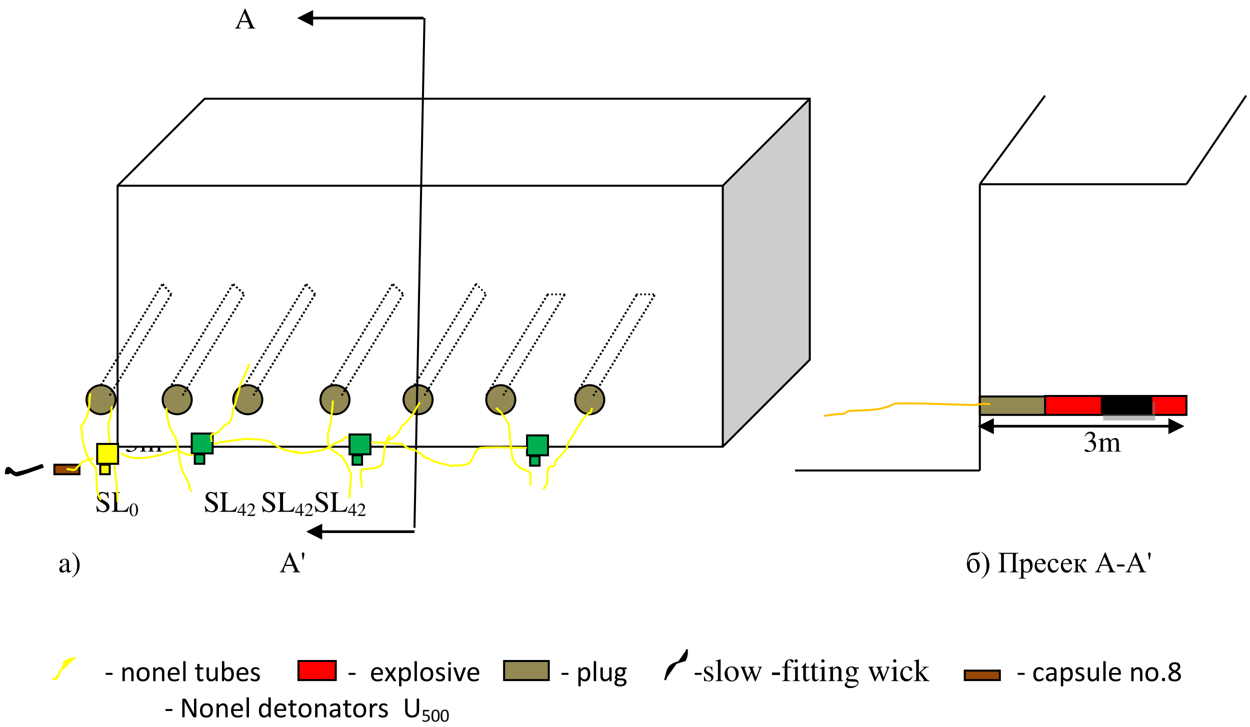

Figure 2. Schematic of the blasting series No.2 and the way of connection

According to the obtained results, the impact is insignificant, and only three instruments have registered minor oscillations on the ground, at the nearest measuring points MM-5, MM-6 and MM-7. These measuring points are from 140 to 330 meters from the site of the active excavations.

Explosive consumption is:

$q= Q/V = 28/300 = 0{,}09\ kg/m^3\quad 0{,}032\ kg/t$ or 32 g/t

The maximum oscillation speeds registered according to the above criteria are below the permissible values for oscillations (<2 cm/s) and therefore these oscillations - vibrations according to the Criteria for vibrations do not affect to the surrounding marble masses.The safety distance in relation to the vibrations of the blasting series on the surrounding marble mass is determined according to formula:

$r_s= K_s\ \alpha\ \sqrt[3]{Q}$, (m)

where are:

- r_s - radius of the seismically dangerous zone, м;
- α - coefficient that depends on the action indicator of the explosion (we adoptedn=1,1);
- K_s- a coefficient that depends on the physical and mechanical characteristics of the rock massif and ranges from 3-30;
- Q - total amount of explosive charge, кg;

For a quantity of 28 kg explosives that is initiated simultaneously for a dangerous zone of vibrations we get:

$r_s = K_s\ \alpha\ \sqrt[3]{Q} = 5 * 0,98 * \sqrt[3]{28} = 14,8$ metres

This practically means that within a radius of 15 meters this 28 kg in the blasting series, will have an impact on the surrounding massif in the form of tremors, minor deformations and significant values of the oscillation speed.

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Figure 3. Blasting effects relative to granulometric composition

CONCLUSION

As can be seen in the enclosed analyzes of the blasting series, the registered seismic waves with these blastings are within the permissible limits, so the impact is only on the near marble masses where it is possible to expand the already existing cracks and the appearance of new micro cracks.

The NONEL initiation system allows blasting at intervals, with the entire amount of explosives sequentially dividing and initiating, which ape directly reduces the formed oscillations.

To reduce the impact of blasting on nearby benches is recommended:

- Apply vertical holes in combination with horizontal holes in places where there is such a possibility,
- The blasting series should be placed more vertically in relation to the site that is protected and the smallest oscillations appear,
- The drilling geometry is in accordance with the other parameters,
- filling the mine holes is with a pre-defined and adopted type of explosive in accordance with the rocky massif,
- clamping of mine holes with clay plugs is required,
- The initiation is by applying a Nonel initiation system,
- Continuous monitoring of changes in the marble mass through periodic seismic measurements.

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