GOCE DELCEV UNIVERSITY – STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES

Natural Resources and Technology

JUNE 2026

VOLUME: XX NO. 1

Online ISSN 1857-8829 Print ISSN 1857-6966

NATURAL RESOURCES AND TECHNOLOGY

Editorial Board:
Prof. Blazo Boev, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Zoran Despodov, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Zoran Panov, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Mirjana Golomeova, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Dejan Mirakovski, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Ivajlo Koprev, Ph. D, University of Mining and Geology “St. Ivan Rilski”, Sofia, Bulgaria;
Prof. Nikola Lilic, Ph. D, University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia;
Prof. Jože Kortnik, Ph. D, University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of geotechnology, mining and environment, Ljubljana, Slovenia;
Prof. Daniela Marasova, Ph. D, Technical University of Kosice, Institute of Industrial Logistics and Transport, Kosice, Slovakia;
Prof. Lucyna Samek, Ph.D, AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland;
Prof. Václav Zubíček, Ph. D, VSB - Technical University of Ostrava, Czech Republic;
Prof. Evica Stojiljkovic, Ph. D, University of Nis, Faculty of Occupational Safety in Nis, Serbia;
Prof. Ivica Ristovic, Ph. D, University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia;
Prof. Kemajl Zeqiri, Ph. D, Isa Boletini University, Faculty of Geosciences, Department of Mining, Mitrovice, Kosovo;
Prof. Aleksandar Nikoloski, Ph. D, Murdoch University, Collage of Science, Health, Engineering and Education, Department of Chemical and Metallurgical Engineering and Chemistry, Perth, Australia;
Prof. Ömer Faruk EFE, Ph. D, Bursa Technical University, Faculty of Engineering and Natural Sciences,
Department of Industrial Engineering, Bursa, Turkey.

Editor in Chief:
Prof. Afrodita Zendelska, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia

Editors:
Prof. Blagica Doneva, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia
Prof. Vancho Adjiski, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia

Language Editor:
Senior Lecturer Snezana Kirova, M.A., Goce Delcev University, Faculty of Philology, Stip, Republic of North Macedonia

Technical Editing:
Prof. Blagica Doneva, Ph. D, Goce Delcev University, Stip, Republic of North Macedonia

Editorial Office
Goce Delcev University - Stip
Faculty of Natural and Technical Sciences

Contents

Boris Tkalcev, Risto Dambov, Radmila Karanakova Stefanovska
ASSESSMENT OF SEISMIC EFFECTS DURING MINING MINES 4

Goran Jovanov, Risto Dambov, Dragi Peltechki
ANALYSIS OF BLAST SERIES IN THE BUCHIM AND BOROV DOL MINES USING THE O-PITBLAST SOFTWARE PROGRAM..13

Sara Aneva, Dragan Minovski,Vasilija Sarac, Biljana Citkuseva Dimitrovska, Todor Cekerovski
ROOFTOP PHOTOVOLTAIC (PV) SYSTEMS AS A TOOL FOR LOCAL ENERGY TRANSITION IN COAL-DEPENDENT MUNICIPALITIES 21

Merija Krstev
MATERIAL UTILIZATION EFFICIENCY IN PANEL CUTTING FOR FURNITURE MANUFACTURING: COMPARATIVE EVALUATION OF CONVENTIONAL AND INTEGRATED CAD-CAM OPTIMIZATION SYSTEMS..27

Manuscript received: 27.03.2026
Accepted: 20.05.2026

Natural Resources and Technology
Vol 20, No. 1, pp.13 -20 (2026)
Online ISSN 1857-8829; Print ISSN 1857-6966
DOI:------------------------
Original scientific papers

ANALYSIS OF BLAST SERIES IN THE BUCHIM AND BOROV DOL MINES USING THE O-PITBLAST SOFTWARE PROGRAM

Goran Jovanov[1], Risto Dambov[2], Dragi Peltechki[3]
[1]DPTU Buchim DOOEL, Radovish, North Macedonia
[2]Faculty of Natural and Technical Sciences, University Goce Delcev, Stip, North Macedonia
[3]RUDPLAN DOOEL, Strumica, North Macedonia
**Corresponding author: e-mail: goran_goksi@hotmail.com*

Abstract

This paper focuses on the investigation of the effects of blasting depending on the design of the blast series and the working environment, with an emphasis on the application of the software program "O-Pitblast". The main objective is to analyze how modern technologies can contribute to the optimization of mining processes, with particular attention to the control of seismic effects, granulometric analysis and cost.

The research examines the principles of blasting, the application of different blast series configurations in different environments, different geometries, and the use of advanced simulations to assess the effectiveness of explosives. It also addresses the potential of software tools to improve accuracy and reduce operational costs.

This paper contributes to a better understanding of the integration of technologies in modern mining operations, opening new opportunities for their practical application in future research and projects.

Keywords: *explosives, software tools, blasting, seismic effects, fragmentation*.

INTRODUCTION

Blasting is a process used in mining and construction to break up rocks and other materials. It involves the use of explosives to break up large rocks into smaller pieces. The force of the explosion breaks up the material, creating smaller pieces. Blasting is often used in quarries and mines to break up large rocks and boulders. The benefits of blasting include increased efficiency and cost savings in mining operations. Blasting is a cost-effective way to break up large rocks and boulders, allowing for easier extraction of minerals and other resources. Blasting also reduces the amount of manual labor required to extract resources, as well as the time it takes to complete the job. Blasting can also be used to create a more uniform size of material, which can be useful for further processing [1,3,9].

The process of mining enables the extraction of valuable mineral resources essential to the modern economy. The basic principles of mining are based on the theoretical and practical aspects of rock blasting, applying physical and chemical principles to efficiently and safely perform the activities.

The basic principle is based on creating a maximum force that generates enough energy to break the rocks, while maintaining control over the distribution of fragmentation and minimizing environmental effects [3,4,8]. The drilling and blasting process is carried out in several stages: blast series design, hole drilling, explosive placement, detonation and removal of materials [1,9].

In order to achieve the desired maximum productivity of the surface and underground mine with lower costs, the chosen mining method should ensure uninterrupted operation of the loading and transportation processes [4].

The technical conditions for mining are reduced to crushing the mineral raw material and waste rocks into pieces that will not be larger than the capacity of the bucket of the loading vehicle - excavator or loader, the transport vehicle and the receiving opening of the primary crusher.

The most economical blasting methods that guarantee mass production of blasting are the deep bore blasting methods with larger diameters; today it is 90% of the renamed blasting methods, and it is applied to all types of hard rocks for the fragmentation of which explosives should be used [1].

MATERIALS AND METHODS

Software analysis using the o-pitblast software program

O-Pitblast – A digital platform developed for drilling and blasting, pit operations from planning through execution to analysis of results. Its goal is to help engineers and operators optimize drilling and blasting processes, reduce costs and environmental impacts and improve safety [2].

O-Pitblast is a software solution developed for the blast design and optimization industry, which assists in the design, planning, analysis and optimization of blasting operations in mining, construction and quarrying [2].

O-Pitblast is specialized software that enables engineers and technicians to: plan blasts (blast planning), perform simulations and calculations, analyze vibrations, fragmentation, sound pressure and blasting effects, control and reduce environmental impact and increase blasting safety and efficiency.

O-Pitblast is used for:

Blast Design

- Drilling holes,
- Planning of initiation sequences,
- 3D visualization of blasting,
- Simulation of waves and effects.

Optimization

- Analysis of the results of previous blasting,
- Reducing overexplosion, poor fragmentation or environmental damage,
- Improving the efficiency of explosives.

Monitoring

- Measurement of vibrations (seismograph data),
- Prediction and analysis of environmental effects (sound pressure, flying stones),
- Compliance with environmental regulations [2,7].

It is most commonly used in surface and underground mines, quarries, blasting construction projects and infrastructure projects (tunnels, roads, etc.). Advantages gained by using O-Pitblast software are: precision in planning and implementation, better safety, reduced costs and waste, better environmental impact and higher productivity and automation [2].

Analysis of blast series in Buchim mine and Borov Dol mine

In this paper, an analysis will be performed using the O-Pitblast software program on two separate series in different environments of two surface mines. The series has the same number of holes, the same height, the same geometry and the same type of explosive. Based on the research and geomechanical data in the Buchim mine, the physical and mechanical properties of the rocks are much stronger compared to Borov Dol.

The comparative analysis was performed using the O-Pitblast software platform under identical blasting geometry conditions for both mines. Input parameters included burden (5.0 m), spacing (4.0 m), bench height (15 m), stemming length (6 m), 40 blast holes, total drilled length (600 m) and designed blasting volume (12,000 m^3). Fragmentation prediction was based on the Rosin–Rammler distribution model integrated in O-Pitblast. The simulations assumed homogeneous rock mass conditions within each blast block and a constant borehole diameter of 127 mm. Environmental parameters analyzed included vibration propagation, powder factor, explosive density and initiation timing delays of 42 ms and 67 ms. The comparison evaluated fragmentation quality (P50 values), operational reliability, explosive consumption and blasting costs.

This paper compares the two blasting series that have identical design parameters (bench height 15.0 m, 40 holes, double 600 m, burden 5.0 m, spacing 4.0 m, average stemming 6.0 m, design volume 12,000 m^3). [2,8]. The main differences are in the composition and method of initiation of the explosive material: the second series (Buchim) uses a thicker patronized emulsion (Demulex f65 160 kg) and boosters (40), while Borov Dol uses a less patronized material (Amonex 80 kg) and has no boosters. The total mass of explosives is 4,340.4 kg for Borov Dol and 4,366.3 kg for Buchim [8].

RESULTS

Tables 1 and 2 show blast series in the Borov Dol and Buchim mines with a total number of holes of 40, a hole depth of 15 meters and a drilling geometry of 5x4. The filling will be carried out with Anfo-Jet explosive and Amonex for initiating the explosive in Borov Dol. In Buchim the filling will be carried out with Anfo-Jet explosive and Demulex F65 for initiating the explosive. Each hole will be filled with 9 meters of Anfo-Jet explosive and will have a 6-meter plug. A U500 detonator with a length of 18 meters will be used to activate the series. Delayers between the holes and rows of 42 ms and 67 ms will also be used. A space of 12,000 m^3 will be drilled and 32,400.0 t of explosive will be used. Each hole will be filled with 9 meters of Anfo-Jet explosive and will have a 6-meter plug. An 18-meter-long U500 detonator will be used to activate the series. Delayers between the holes and rows of 42 ms and 67 ms will also be used. An area of 12,000 m^3 will be drilled and 32,400.0 t of explosive will be used.

Table 3 shows the cost of the blast series including all the necessary means for its mining. The cost of drilling is the same in both mines because the diameter and meters of drilling are the same in both series.

Table 1. Blast series in the Borov Dol and Buchim mines

<table>
<tr><th>Explosive Ordering</th><th>Explosive Product</th><th>Density & Weight</th><th>Type</th><th>Quantity</th></tr>
<tr><td rowspan="3">Borov Dol</td><td>Anfo - Jet</td><td>0.95 g/cm^3</td><td>Bulk</td><td>4,260.4 Kg</td></tr>
<tr><td>Amonex 4 f60</td><td>1.05 g/cm^3 - 1,000 Kg</td><td>Cartridge</td><td>80.0 Kg</td></tr>
<tr><td colspan="3" align="right">Total</td><td>4,340.4 Kg</td></tr>
<tr><td rowspan="3">Buchim</td><td>Anfo - Jet</td><td>0,95 g/cm^3</td><td>Bulk</td><td>4.206,3 Kg</td></tr>
<tr><td>Demulex f65</td><td>1,20 g/cm^3 - 2,000 Kg</td><td>Cartridge</td><td>160,0 Kg</td></tr>
<tr><td colspan="3" align="right">Total</td><td>4.366,3 Kg</td></tr>
<tr><th>Accessories Ordering</th><th colspan="2">Product</th><th>Type</th><th>Quantity</th></tr>
<tr><td rowspan="3">Borov Dol</td><td colspan="2">Surface Connector 42</td><td>SurfaceConnector</td><td>36</td></tr>
<tr><td colspan="2">Surface Connector 67</td><td>SurfaceConnector</td><td>3</td></tr>
<tr><td colspan="2">Detonator 500 / 18m</td><td>InHoleDelay</td><td>40</td></tr>
<tr><td rowspan="4">Buchim</td><td colspan="2">Surface Connector 42</td><td>SurfaceConnector</td><td>36</td></tr>
<tr><td colspan="2">Surface Connector 67</td><td>SurfaceConnector</td><td>3</td></tr>
<tr><td colspan="2">Detonator 500 / 18m</td><td>InHoleDelay</td><td>40</td></tr>
<tr><td colspan="2">Booster 500</td><td>Booster</td><td>40</td></tr>
</table>

Table 2. Parameters for blasting the blast series in Borov Dol and Buchim

Blast Resume	Borov Dol	Buchim
Bench Height	15.00 m	15.00 m
Total of Holes	40	40
Drilled	600,00 m	600,00 m
Design Burden	5,00 m	5,00 m
Average Stemming	6,00 m	6,00 m
MIC	108,5 Kgs	109,2 Kgs
Volume*	12.000 m^3	12.000 m^3
Tons	32.400,0 t	32.400,0 t
Specific Drilling	0,050 m/m^3	0,050 m/m^3
Design Spacing	4,00 m	4,00 m
Total Stemming Vol.	3,04 m^3	3,04 m^3

Blast Resume	Borov Dol	Buchim
Avg. Filling Coeff.	60,0%	60,0%
Powder Factor	0,362 Kg/m^3	0,364 Kg/m^3
Powder Factor	0,134 Kg/t	0,135 Kg/t
Rock Density	2,700 g/cm^3	2,700 g/cm^3
Design Volume	12.000 m^3	12.000 m^3
Avg. Stemming Vol.	0,076 m^3	0,076 m^3
Blasting mat	No	No

*Volume based on the hole's length.

Table 3. Explosive costs

Explosive Ordering	Explosive Product	Quantity	Unit Price	Total
Borov Dol	Anfo - Jet	4,260.36 Kg	67.00	285444.31
	Amonex 4 f60	80.00 Kg	103.50	8280.00
				266724.31
Buchim	Anfo - Jet	4,206.28 Kg	67.00	281820.99
	Demulex f65	160.00 Kg	114,00	18240,00
			Total	300060,99
Accessories Ordering	**Accessories Product**	**Quantity x Unit Price**		**Total**
Borov Dol	Surface Connector 42	36 x 138,00		4968,00
	Surface Connector 67	3 x 138,00		414,00
	Detonator 500 / 18m	40 x 196,00		7840,00
		Total		**13222,00**
Buchim	Surface Connector 42	36 x 138,00		4968,00
	Surface Connector 67	3 x 138,00		414,00
	Detonator 500 / 18m	40 x 196,00		7840,00
	Booster 500	40 x 300,00		12000,00
		Total		**25222,00**
Drilling Cost in Borov Dol and Buchim				
Diameter	**Meters**	**Unit Price**		**Total**
127	600	430.00		258,000.00
		Total		**258,000.00**
Blast Cost				**564,946.31**

Cost resume Borov Dol					
Per hole	14123.66	**Per m^3**	47.08	**Per tons**	17,44
Explosive %	51,99%	**Accessories %**	2,34%	**Drilling %**	45,67%
Cost resume Buchim					
Per hole	14582,07	**Per m^3**	48,61	**Per tons**	18,00
Explosive %	51,44%	**Accessories %**	4,32	**Drilling %**	44,23%

Table 4. Granulometric analysis of the blasted series in the Borov Dol mine

%	mm
10	23
20	53
30	89
40	133
50	186
60	253
70	342
80	471
85	565
90	699
95	935
Xm	**n**
186	0,91
Burden: 5,00 m	
Spacing: 4,00 m	
Stemming: 6,00 m	
Subdrilling: 0,00 m	
Diameter: 0 mm	
Powder Factor: 0,36 Kg/m³	
Kg / hole: 108,5	
Density Exp.: 950 Kg/m³	
RWS:100	
Rock Factor: 3,45	

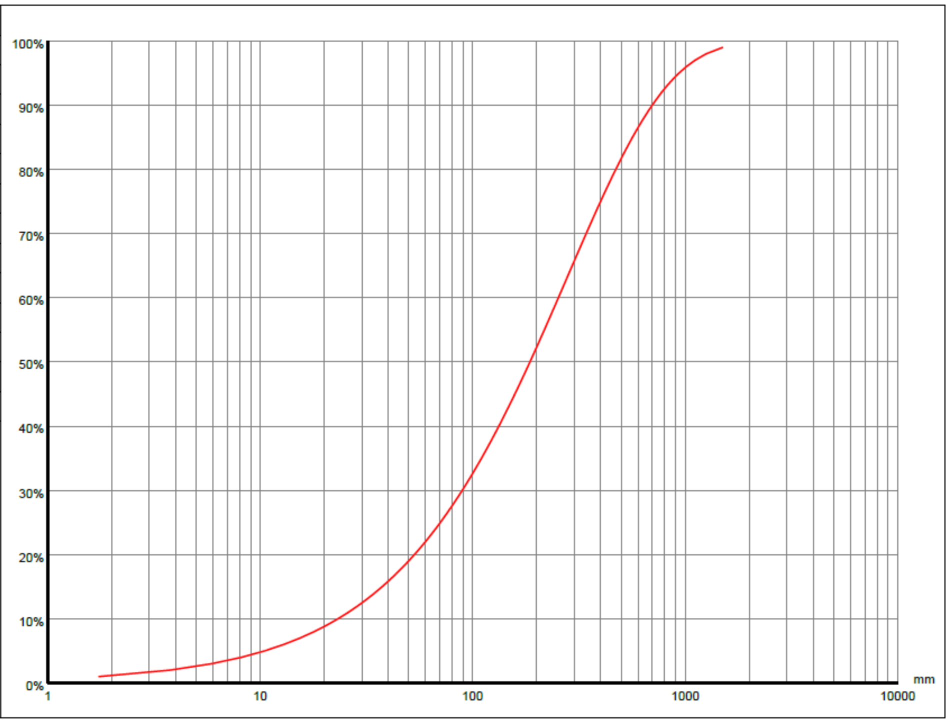


Table 4 shows the fragmentation of the blasted batch expressed as a percentage with a size of blasted material not larger than 1000mm. This table shows a granulometric curve (fragment size distribution curve) from explosive blasting. The table on the left shows a percentage particle size distribution which means that 50% of the material has fragments smaller than 186mm [3].

Parameters (bottom left):

Xm = 186 mm → average size of the fragments (P50).
n = 0.91 → uniformity parameter (from Rosin–Rammler distribution). The smaller the n, the greater the size inequality.
Burden = 5.00 m → distance between the blast holes and the front.
Spacing = 4.00 m → distance between holes in a row.
Stemming = 6.00 m → length of the unfilled part of the hole.
Subdrilling = 0.00 m → no additional drilling below the base.
Powder Factor = 0.36 kg/m³ → amount of explosive used per cubic meter of rock.
Kg/hole = 108.5 kg → mass of explosive per hole.
Density Exp = 950 kg/m³ → density of the explosive.
RWS = 100 → Relative explosive strength (relative to ammonite or ANFO).
Rock Factor = 3.45 → a factor that describes the hardness and structure of the rock.

Graph (right):

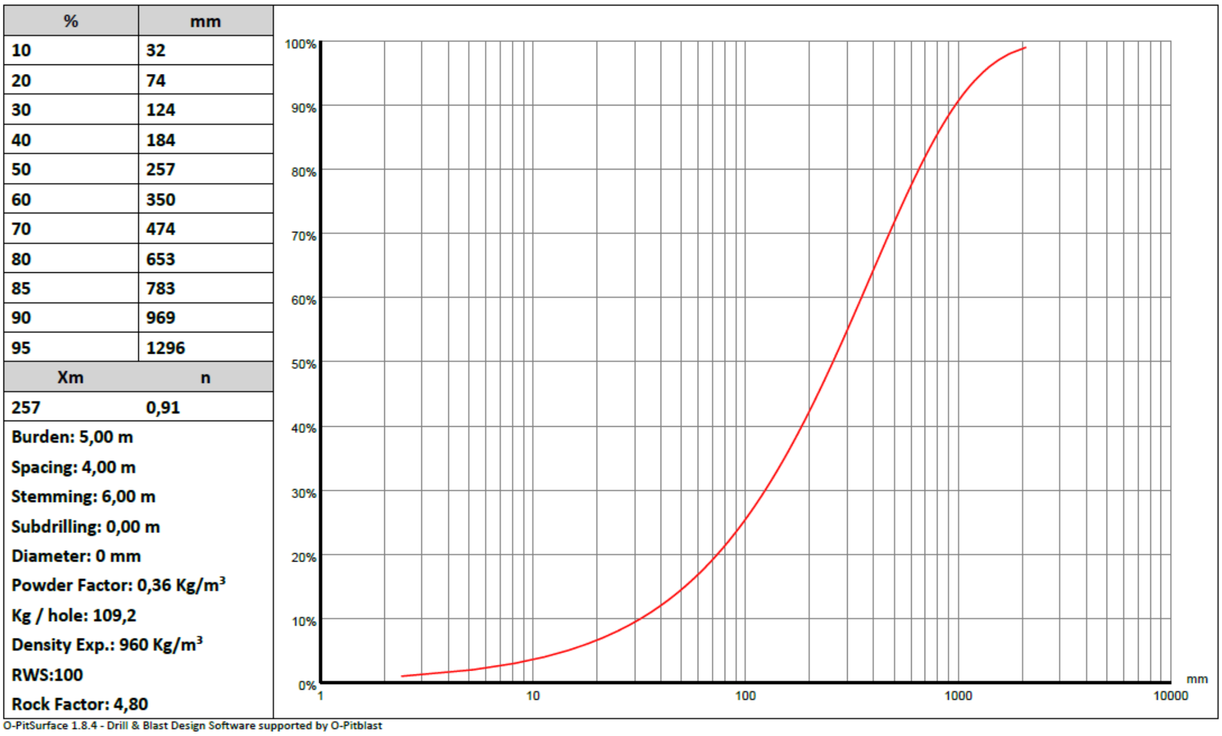
X-axis (horizontal): particle size (in mm), displayed logarithmically.
Y axis (vertical): cumulative percentage passed (%).
Red line: Rosin–Rammler curve describing the size distribution of fragments.

The more the curve is shifted to the left, the finer the crushing. If it goes to the right, then there are larger fragments (weaker crushing).

This document presents results from a simulation or analysis of a blasting operation, where:

Average fragment size is 186 mm.
The explosive is relatively weak (0.36 kg/m³), which produces moderate fragment sizes.
The rock is medium hard (Rock Factor = 3.45) [4].

Table 5. Granulometric analysis of the blasted series in the Buchim mine



%	**mm**
10	**32**
20	**74**
30	**124**
40	**184**
50	**257**
60	**350**
70	**474**
80	**653**
85	**783**
90	**969**
95	**1296**
Xm	**n**
257	**0,91**

Burden: 5,00 m
Spacing: 4,00 m
Stemming: 6,00 m
Subdrilling: 0,00 m
Diameter: 0 mm
Powder Factor: 0,36 Kg/m³
Kg / hole: 109,2
Density Exp.: 960 Kg/m³
RWS:100
Rock Factor: 4,80

O-PitSurface 1.8.4 - Drill & Blast Design Software supported by O-Pitblast

Table 5 shows the fragmentation of the blasted series expressed as a percentage with the size of blasted material being greater than 1000mm. and not greater than 1300mm. This is a granulometric (cumulative) curve — size distribution of blasting fragments (Rosin–Rammler type). On the left is the table with percentages and corresponding passing sizes (mm), and on the right is the logarithmic graph: X = particle size (mm), Y = cumulative percentage passed (%). The red line represents the cumulative distribution [4,8].

Parameters (bottom left)

Xm = 257 mm (medium/medium size)
n = 0.91 (dispersion parameter - smaller n → larger variation/inequality)
Burden = 5.00 m, Spacing = 4.00 m, Stemming = 6.00 m, Subdrilling = 0.00 m
Powder Factor = 0.36 kg/m³ (explosive by volume)
Kg / hole = 109.2 kg, Density Exp. = 960 kg/m³, RWS = 100
Rock Factor = 4.80 (higher number → confirmation of harder/less fragmenting rock)

This curve shows less fine (larger) fragments compared to the previous image (where P50 was 186 mm). Now P50 is 257 mm, so the fragmentation is somewhat coarser.

n = 0.91 is identical/similar to before — the shape/spread of the curve is similar (the rate at which the cumulative percentage increases), but the entire curve is shifted to the right (larger chunks).

Rock Factor = 4.80 (higher than before) suggests harder/less fragmenting rock, which explains the larger average size.

The drilling and explosive parameters (burden, spacing, powder factor) are similar to the previous example, so the difference is likely caused by rock characteristics (rock factor) and/or small differences in the exact energy/configuration.

Practical recommendations for finer granulometry (if necessary)

- increasing powder factor (more explosive/m³)
- reducing burden and/or spacing (smaller distance between holes)
- better assurance of stemming and correct timing
- application of additional techniques: pre-splitting, tighter collars or use of a stronger emulsion/benchmark explosive with a higher RWS
- consideration of mechanical subsequent crushing (if explosively obtained fraction is too large) [3,8,7].

DISCUSSION

The results obtained are consistent with previous blasting optimization studies reported in the literature. Previous researchers demonstrated that fragmentation efficiency strongly depends on the relationship between powder factor, burden, spacing and rock factor. The present study confirms that under identical geometrical parameters, rock mass characteristics and explosive initiation systems significantly influence fragmentation results. The finer fragmentation observed in Borov Dol (P50 = 186 mm) compared to Buchim (P50 = 257 mm) can primarily be attributed to differences in rock hardness and geomechanical properties. The use of boosters and higher-density emulsions in Buchim improved detonation reliability and energy transfer, which is particularly important in harder rock environments. However, the improved operational stability is associated with higher blasting costs. From an industrial perspective, blasting optimization should balance fragmentation quality, crusher performance, operational reliability and environmental impacts rather than focusing only on cost reduction.

CONCLUSION

The result of the software analysis of the two series in two separate surface mines in the Buchim and Borov Dol mines with the O-Pitblast software program is as follows:

The two blasting series, although designed with identical geometric and design parameters, show a different approach in the selection of explosive materials and initiation, which results in a difference in the energy stability, operational reliability and quality of the resulting fragmentation. At Borov Dol, the use of ANFO and Amonex without boosters provides an economical solution with an acceptable level of efficiency but requires strict control of the filling and ignition conditions. This approach is justified in dry hole conditions, stable geology and when cost minimization is a priority. However, the absence of boosters makes the system potentially less uniform, with the possibility of variations in ignition and local incomplete detonations, which can affect the homogeneity of the fragmentation.

At Buchim, the use of Demulex — a thicker emulsion with a higher detonation velocity — in combination with boosters and an identical initiation configuration result in a higher level of reliability, repeatability and controlled fragmentation. This system provides more complete detonation of ANFO, better energy transfer throughout the column and reduced occurrence of unprotonated fragments. Although it is more expensive and requires greater discipline in storage and application, its operational stability and predictability are significantly greater.

In comparison, Borov Dol is a technically efficient but sensitive system, while Buchim represents a more complex but reliable and replicable model. When selecting the optimal scheme for future blasting, it is recommended to adopt a hybrid approach:

- maintaining the cost-effectiveness of the ANFO-based system,
- but by introducing a minimum number of boosters and higher density cartridges in critical holes,

to achieve a balance between cost, reliability and fragmentation quality.

This approach would enable stable reproducibility of results, better energy balance, and cost control — which is essential for sustainable and safe mining operations.

The drilling design is identical in both series — no changes in burden/spacing/height are required due to differences in the explosives used. Buchim offers operational advantages in: reliability of initiation, replicability of results and better fragmentation control, thanks to Demulex f65 and the use of boosters. Borov Dol is more economical in terms of lower total cartridge quantity and no need for boosters, but is more sensitive to operational factors (moisture, charge, quality of detonators). The difference in total explosive mass (~25.9 kg) is minimal and not decisive in itself — the character and initiation of the charge dictate the main operational outcome. To minimize risks (misfires, unpredictable crushing, flyrock, vibrations), the Buchim model is preferred if the organization has the resources for additional material and training.

The Borov Dol series mining is more economically viable than the Buchim series mining. Both mining processes are well dimensioned and provide controlled granulation without extreme deviations. The Borov Dol series mining curve is located in smaller values, i.e. further to the left on the x-axis, indicating finer material, while the Buchim mining curve is shifted to the right, indicating coarser fragmentation. The difference in Rock Factor (3.45→4.80) explains this change – a higher Rock Factor indicates a harder, more compact rock, which under the same conditions creates larger fragments.

Estimates suggest that Buchim offers greater reliability and consistency in ignition, while Borov Dol is more economical but slightly more sensitive to operational variables.

REFERENCES

1. Dambov, R. (2011). Drilling and Blasting. Štip: Goce Delčev University – Faculty of Natural and Technical Sciences.
2. O-Pitblast. Official website: www.o-pitblast.com
3. Konya, C. J., & Walter, E. J. (1990). Surface Blast Design. Englewood Cliffs, NJ: Prentice Hall.
4. Hustrulid, W., Kuchta, M., & Martin, R. (2013). Open Pit Mine Planning and Design (3rd ed.). London: CRC Press.
5. Singh, P. K. (1993). Rock Blasting and Overbreak Control. Rotterdam: Balkema.
6. Dowding, C. H. (1985). Blasting Vibrations and Their Effects on Structures. Englewood Cliffs, NJ: Prentice Hall.
7. International Society of Explosives Engineers (ISEE). (2011). Blasters' Handbook. Cleveland, OH.
8. Jimeno, C. L., Jimeno, E. L., & Carcedo, F. J. A. (1995). Engineering Rock Blasting Operations. Rotterdam: Balkema.
9. Langefors, U., & Kihlström, B. (1978). Drilling and Blasting of Rocks. New York: Wiley. Rock Mechanics – General Principles for Geomechanics and Fragmentation.
10. Kanchibotla, S. S. (2020). Mine-to-Mill Optimization of Fragmentation and Throughput. Mining Technology.
11. Ouchterlony, F. (2019). Fragmentation Characterization in Blasting Operations. International Journal of Rock Mechanics and Mining Sciences.
12. Singh, T. N., & Xavier, P. (2021). Advances in Blast Design and Vibration Control in Surface Mines. Mining Engineering Journal.
13. Zhang, Z. (2016). Rock Fracture and Blasting: Theory and Applications. Butterworth-Heinemann.
14. Hamdi, E., & du Mouza, J. (2018). Assessment of Rock Mass Fragmentation by Digital Image Processing. Journal of Sustainable Mining.