MINING AND ENVIRONMENTAL PROTECTION

PROCEEDINGS

Editor
Prof. dr Ivica Ristovic

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FOREWORD

After the consultations with business entities in the field of mining and environmental protection, faculties and scientific institutes, an initiative for organizing a scientific meeting on mining and environmental protection was taken in 1996. The Faculty of Mining and Geology in Belgrade, CENTER FOR ENVIRONMENTAL ENGINEERING, have organized the First Yugoslav Conference with International participants held from 25 to 27 April 1996 in Belgrade, Serbia. 2nd International Symposium was held in Belgrade from 25 to 27 1998. 3th Symposium was held in Vrdnik from 21 to 23 May 2001, 4th International Symposium was held in Vrdnik from 23 to 25 June 2003, and 5th International Symposium was held in Vrdnik from 10 to 13 June 2015.

Due to the large number of subjective and objective reasons organization of the symposium was discontinued in 2003. On the basis of the conclusions made at the 5th Symposium MEP 2015, and great interest of domestic and foreign scientific and professional public, the Faculty of Mining and Geology in Belgrade, in cooperation with co-organizers (National University of Science and Technology "MISIS", Moscow, Russia Berg Faculty TU Košice, Slovakia, University of Ljubljana, Faculty of Natural Sciences and Engineering, Slovenia, Goce Delcev University in Stip, Macedonia and University in Banja Luka, Faculty of Mining, Prijedor, Republic of Srpska, Bosnia and Herzegovina), shall organize the 6th International Symposium Mining and Environmental protection.

Previous Symposium, were very successful and scientist and companies from many countries gathered to exchange information and research results. The objective of this Conference is to bring together engineers, scientists and managers working in mining industry, research organizations and government organizations, on development and application of best practice in mining industry in the respect of environment protection.

At the Book of Proceedings of 6th International Symposium on Mining and Environmental protection are 59 Papers. One third is from abroad, or their authors is from different countries. At least 150 authors and co-authors took part in the preparation of these papers. The papers were reviewed by Reviewers and Scientific Committee. Only high-quality papers were selected, from two side, one from the scientific basis and the second from point of view of applicability in resolving problems at the development of mining.

We are very grateful to the authors of the papers, who contributed to a great extent to the success of this meeting by having sent enough number of high quality papers, and thereby made the work of the reviewers a pleasant one in respect of selecting the best quality papers. Also we would like to thank all of the participants in the Symposium, as well as the sponsors who helped and enabled us to hold such a great meeting.

Editor

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QUALITY AND EFFICIENCY OF HORIZONTAL MINING FACILITIES CONSTRUCTION, USING SMOOTH BLASTING IN SASA MINE, MACEDONIA

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Abstract: *This paper presents data from a research that has been conducted in Sasa mine, M. Kamenica. For this purpose, collected data about construction of horizontal mining facilities in several rock types was analyzed. Also, comparison of construction technology using smooth blasting and NONEL system for initiating to previously applied technology has been conducted*.

Keywords: *Type of rock, NONEL system, Smooth blasting*

1. INTRODUCTION

The horizontal mining facilities construction presents a complex system of many dependent elements. In Sasa Mine, this type of underground structures are constructed on different rock types. In this paper, horizontal mining facilities construction in gneiss and skarn will be considered.
Gneiss as waste rock in Sasa mine is characterized by high rate of metamorphism, as well as medium to high rate of crystalline. It is mostly with schist texture stratified in the thick beds, while massive parts are rare.
Skarns occurred as a consequence of post magmatic high-temperature phase of dacite's protrusion of surrounding silico-limestone parts. Various skarns have occurred according to mineralogical composition and time of creation, as a result of it.
Table 1 shows physical and mechanical properties obtained by laboratory tests that are required for this survey as follows: bulk density γ [MN/m^3], uniaxial compressive strength σ_c [MPa], tensile strength σ_t [MPa], bending strength σ_s [MPa], shear strengh τ [MPa], cohesion C [MPa], angle of internal friction φ [°], Poisson`s coefficient ν and modulus of elasticity E [MPa] [3].

Table 1. *Physical and mechanical properties obtained by laboratory tests on ore and associated rock in Sasa Mine, Revir Svinja Reka*

Rock type	γ [t/m^3]	σ_c [MPa]	σ_t [MPa]	σ_s [MPa]	τ [MPa]	φ [^{0}]	C [MPa]	μ	Ex10^3 [MPa]
Gneiss	2.7-2.8	65-93	12-17	8.6-15	7-31	34-41	10-31	0.16-0.18	39-45
Skarn	3.35-3.76	73-102	12-19	9-15	16-19	32-40	22-47	0.19-0.24	39-64

Technical properties needed for this research, as well as classification on gneiss and skarn according to these properties are given in Table 2 [1].

__Table 2.__ Technical properties obtained by laboratory tests on ore and associated rock in Sasa Mine, Revir Svinja Reka

Rock type	Extent of drilling J [mm/10min]	Extent of abrasive [mg]	Resistance to blasting	
			Maximum volume on the fraction-Bmax [cm^3]	Ratio evenly crushing K
Gneiss	11,93-32,53 Medium*	41,67-95,33 Medium - very high **	2,6-3,8 Hardly ***	1,10-1,13
Skarn	6,53-14,2 Medium*	35,5-87,33 Medium - very high **	2,2-3,9 Very hardly – hardly***	1,0-1,4

* Clasification by Baron, ** Clasification by Baron and Kuznjecov, *** Clasification by A.N. SSSR (Institut Skochinski)

2. APPLIED TECHNOLOGIES FOR HORIZONTAL MINING FACILITIES CONSTRUCTION

For the purpose of this research, constructions on horizontal mining facilities with the following properties have been monitored:

- projected profile size - 10,8 m^2;
- profile shape – horse – shoe shape;
- structure type – capital [3].

In both technologies, the same equipment and machinery are applied, as well as the same work organization, which allows comparability of results. Also the same is:

- length of holes – 2,6 m;
- holes dimeter - ∅45 mm;
- explosives type: Ammonite ∅38 mm, Eм Ex Al ∅38 mm, Ammonite ∅20 mm;
- type of cuts – parallel with a central empty hole with larger diameter (the number of holes in cuts depends on the strength and structural properties of the blasting material.

As already stated above, the horizontal mining facilities construction presents a complex system of many dependent elements. However, this paper will focus on the achieved outcomes of the construction quality in dependence of drilling and blasting parameters [4].

2.1. Existing technology for horizontal mining facilities construction

Sasa Mine continuously monitors the latest techniques and technologies used in the world's mines. For this reason, the existing technology is not outdated. The main features of this technology are:

- usage of drilling and blasting for excavation;
- usage of contour blasting, in order to obtain smoother excavated surface;
- usage of an electrical mines ignition with electrical millisecond detonators;
- usage of plastic explosives for bottom mine hole.

2.2. Innovative technology for horizontal mining facilities construction

In order to improve the results of the excavation phase, Sasa mine introduced a new manner of initiating mine series. NONEL system (Non-electric detonators) which whenapplied connects with the detonating fuse and electrical detonator. Also, optimization of drilling and blasting parameters is performed, such as: the number of mine holes, quantity of explosives for blasting in order to improve results in terms of constructed facility quality.

3. RESULTS

Results of horizontal mining facilities construction in gneiss and skarn using existing and innovative technologies are given as following.

In gneiss, constructions of two facilities have been monitored:

- the first facility has been constructed on IVb / 3 + 24 level, geological profile from 1485 to 1500, where existing technology is applied (Figure 1) [1];
- the second facility has been constructed on 990/2-0ps level, geological profile from 1175 to 1200, where innovative technology is applied (Figure 2) [1].
- In skarn, constructions of two facilities have been monitored:
- the first facility has been constructed on IVb/2-7 level, geological profile from 1040 to 1060, where existing technology is applied (Figure 3);
- the second facility has been constructed on 990/2+1ps level, geological profile from 970 to 990, where innovative technology is applied (Figure 4) [1].
- In all facilities 8 cycles of construction have been monitored with drilling length of 2.5 m. Results that are given in Table 3 present main values of reviewed 8 cycles [1].

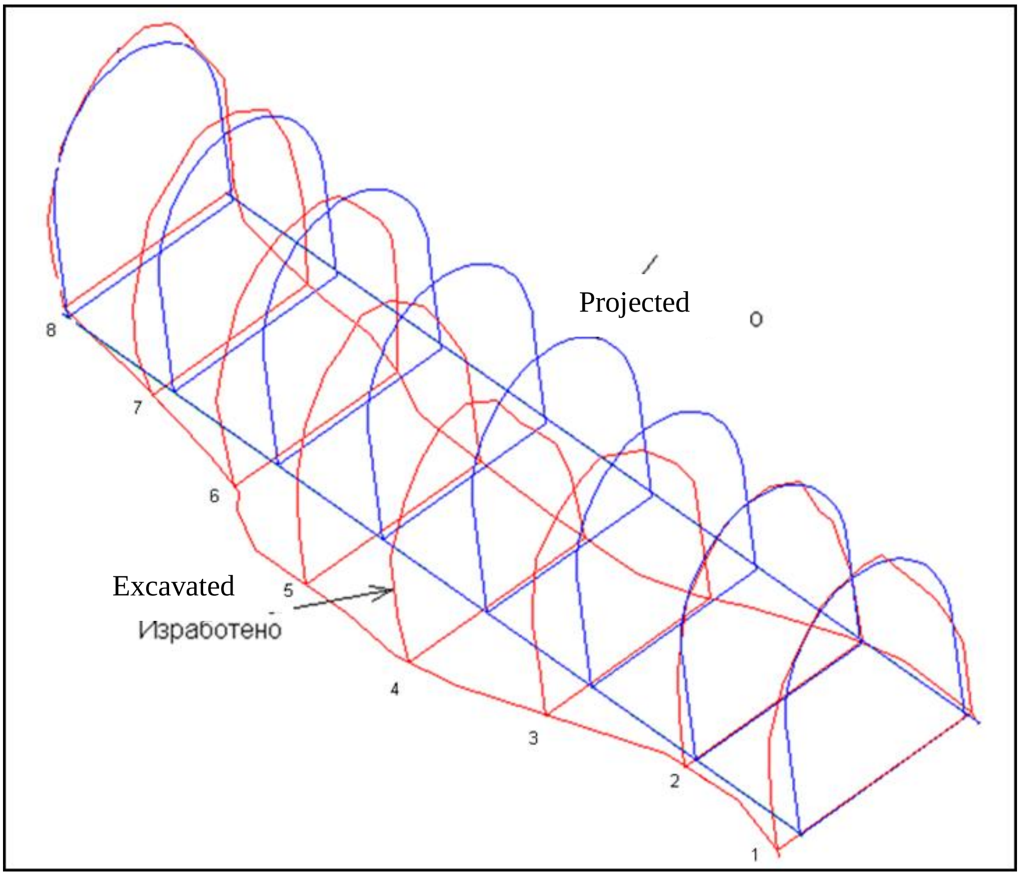

Figure 1. *Location of planned and excavated facilities profile in rock type – gneiss (every 2.5 m) with existing technology*

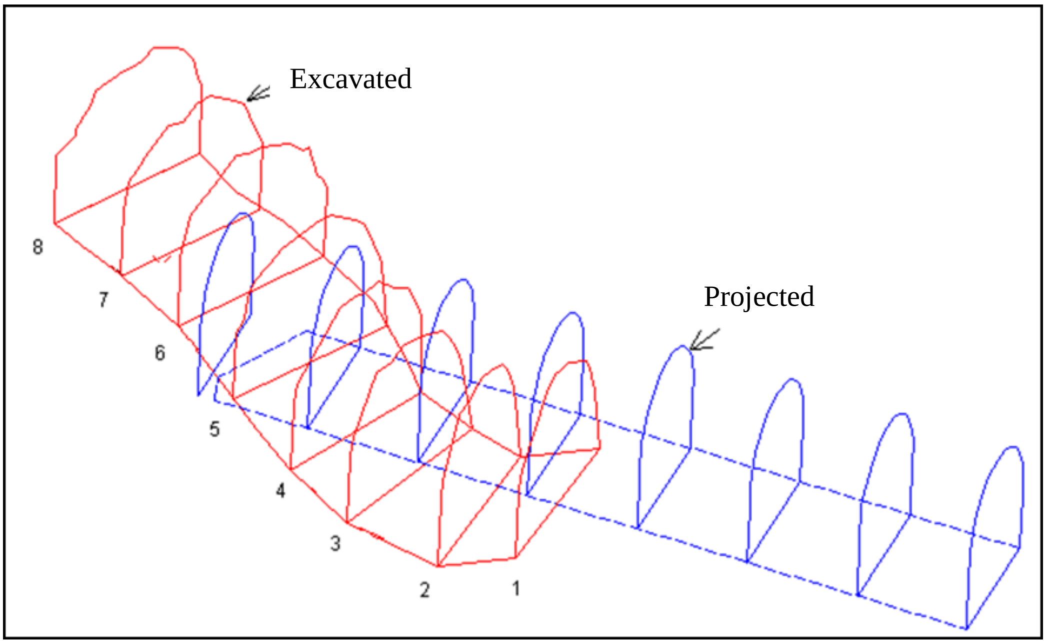

Figure 2. *Location of planned and excavated facilities profile in rock type – skarn (every 2.5 m) with existing technology*

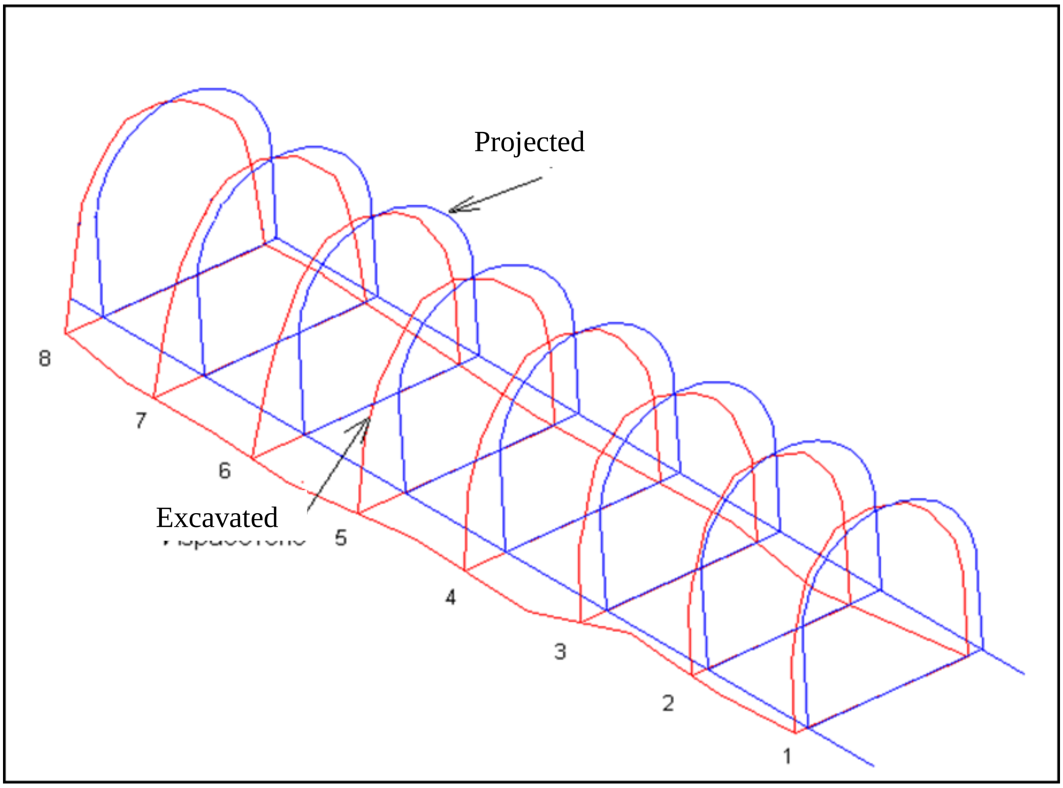

Figure 3. *Location of planned and excavated facilities profile in rock type – gneiss (every 2.5 m) with innovative technology*

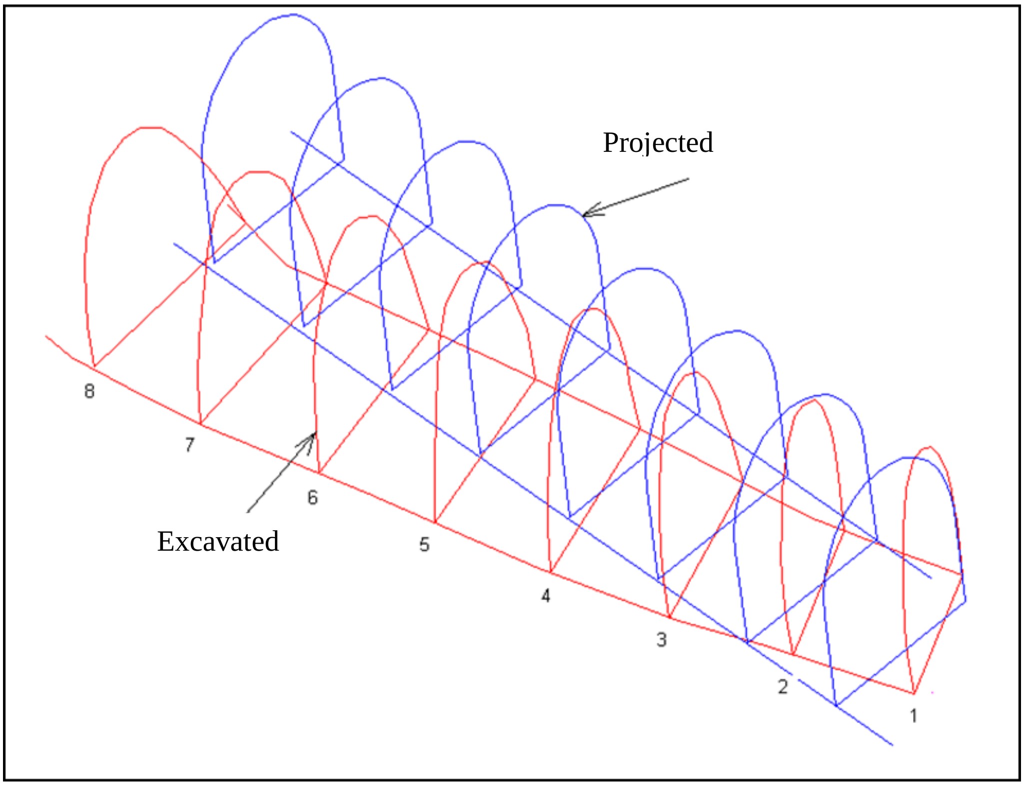

Figure 4. *Location of planned and excavated facilities profile in rock type – skarn (every 2.5 m) with innovative technology*

Table 3. *Results achieved by the application of existing and innovative technology*

Rock type	**Gneiss**		**Skarn**	
Technology →	**Existing**	**Innovative**	**Existing**	**Innovative**
Achieved results				
Advance length for one blasting [m]	2.26	2.31	1.65	2.11
Coefficient of use blast hole	0.86	0.89	0.64	0.78
Total quantity of explosive per one blasting [kg]	78.66	78.26	82.28	90.5
Initiation means [N^0]	39	38	43	43
Weight of excavation per one blasting [t]	78	91	90	92
Cavity profile size [m^2]	10.67	10.93	14.03	10.75
Deviation from the projected profile size [m^2]	-0.4	0.13	3.23	-0.05
Deviation from the projected profile size [%]	-3.7	1.2	29.9	-0.46

4. DISCUSION

Results of the analysis in gneiss can confirm the following:

- Increasing advance from one blasting of 2.26 to 2.31 m, or an increasing usage coefficient of mines hole from 0.86 to 0.89means greater length of advance from one blasting;
- In innovative technology a slight decrease in total explosives quantity and initiation means for one blasting in terms of existing technology can be seen;
- In existing technology, the excavated profile is lower than projected, ie profile with an average area of 10.67 m^2 instead of the one with 10.8 m^2, and it presents a deviation of 3.7%. In innovative technology, the excavated profile is higher than projected, or a profile with an average area of 10.93

m^2 instead of the one with 10.8 m^2, and it presents a deviation of 1.2%. From this we can see that we have out of profile excavation in innovative technology, whilst bearing in mind a very slight deviation which won't have a significant impact on the supporting costs [2]. The reduction in cross-section with existing technology may present a problem for normal technological process in some cases.

- In skarn, the following can be confirmed:
- Increasing advance from one blasting of 1.65 to 2.11 m, or an increasing usage coefficient of mines hole from 0.64 to 0.78 means greater length of advance from one blasting;
- In innovative technology, the increasing of the total quantity of the explosives can be noted from 82.28 to 90.5 kg. This increasing in explosives quantity for one blasting was necessary because of the poor results achieved with the existing technology in terms of the advance coefficient;
- In existing technology, the excavated profile is significantly higher than projected, ie profile with an average area of 14.03 m^2 instead of the one with 10.8 m^2 and it presents 29.9%. In innovative technology, the excavated profile is slightly lower than projected, or a profile with an average area of 10.75 m^2 instead of the one with 10.8 m^2, and it presents a deviation of -0.05% deviation. From this we can see that we have out of profile excavation in innovative technology, resulting in greater requirements in terms of supporting and thus making the mining facility costs significantly higher. While the reduction in cross-section with innovative technology is negligible or almost coincides with the projected profile, this in turn means good assessed parameters of drilling and blasting and reducing the cost of mining facility construction.

5. CONCLUSION

Based on the results of horizontal mining facilities construction with existing and innovative technology, it can be concluded that:

- Greater advance is achieved by applying innovative technology in both working environments;
- Cross section of constructed facility with innovative technology is much closer to the projected cross section;
- The biggest cross section deviation can be noted in skarn, meaningful 29.9%, which of course leads to the conclusion that in this case, drilling and blasting parameters are not well chosen.

This research allows us to see the need for continuous monitoring of results in mining facilities construction in order to identify gaps, optimize the parameters and introduce new techniques for improvement of the construction quality thereof.

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