J. Int. Environmental Application & Science, Vol. 16(1): 25-31 (2021)
Research Paper

Application of Millisecond Delays for Improvement of Contour Blastings Results – Case Study Bellanica

Frashër Brahimaj[1,*], Risto Dambov[1], Shkurte Brahimaj[2]

[1]*University "Goce Delcev", Faculty of Natural and Technical Sciences, Stip, North Macedonia;* [2]*University of Mitrovica "Isa Boletini", Faculty of Geoscience, Department of Mining, 40000, Mitrovica, Kosovo*

Received February 24, 2021; Accepted March 30, 2021

Abstract: The stability of the slopes is of the utmost importance during the exploitation works in surface mines and during the opening of roads, because this directly affects the results of the works and safety. Achieving the highest possible stability of the slopes is done using contour blastings, to make the cutting of the massive that is mined. But in order to achieve the best results in cutting the massive that is being mined, milliseconds delays should be used, in order to create free face before each subsequent blasthole, in this case the impact of drillings of the preliminary rows on behind them will reduced. With the application of milliseconds delays 17 [ms] between drillings in the row and 67 [ms] between rows, the impact of blastholes of the front rows will be very small or no impact at all on behind them, making it possible to form benches and slopes safe and without cracks. This enables us to have safe mining work and safe driving on the road.

Keywords: *Benches, Slopes, Safe, Drilling, Explosive.*

Introduction

The need to exploitation ores and open new roads is very great, in almost all countries. In addition, we must always be safe during the exploitation of ore or removal of rock masses, and after the completion of works, so that there is no collapse of the slopes. Exploitation of hard ores and removal of rock masses cannot be done without the application of blastings. The application of blastings in these cases is done to break and shred ore or rock masses, but also to fix the benches.

In the case of exploitation of ores, or otherwise the case of mines, we must keep in mind that the slope of the mine is stable until the mine is in exploitation, but we must take care that the slope has even longer stability, due to non-deterioration of the environment and not endangering the land surface around the mine (Brahimaj, 2020). While in the case of opening roads and road construction, we must keep in mind that the road slope must be stable as long as the road will be in use (Brahimaj, 2013).

To achieve these results in the adjustment of the slopes it is necessary to apply contour blastings, to make the cut of the massive, without causing cracks in the face of the bench. As a case study, were taken contour blastings works in Bellanica, which will be elaborated in more detail in the continuation of this work using the O-Pitblast software.

Design of the blasting fields

Since the massif should be drilled and blasted, then loaded with the loader on a conveyor and transported, it is necessary to determine the width of the blasting blocks, in order to create conditions for unimpeded work for machinery depending on their size. The width of the block for the blasting in the opening of the new bench is determined based on the width of the cutting entrenchment, whereas the width of the blasting block in advance of the exploitation of the bench is determined by the number of drilling rows, from the burden "W", the distance between the rows "b", but based on the experience so far, the width of the block for the blasting should not exceed the number of four rows, this is done in order not to have an impact on the back of the blasting and to harm the bench that should remain without harm, for to have greater security (Brahimaj, 2020; Brahimaj, 2013).

The number of rows is also determined on the basis of the width of the workstation and on the basis on the specific charge of explosive. The drilling and blasting geometry is determined by the requirement to achieve a degree of crushing of the material with a minimum residue of large pieces, it is permissible that 5 ÷ 15 [%] of the blasted material emerge large pieces of larger size than required (blocks).

*Correponding: E – mail: fibi232@hotmail.com, Tel: +383(0) 49 771 370

Drilling will be placed, by dimensions a x b = 2.8[m] x 2.8[m]. This calculation of the above drilling geometry applies to ANFO explosives, local production ANFOKOS, which is an industrial explosive and has a detonation velocity 2900 [m/s] (Brahimaj et al., 2016).
Given the exploitation block width which is 11.66 [m], in the case where the product drilling is parallel to the contour drilling, the drilling will be done in three rows and the field data for this case are shown in Table 1.

Table 1. Drilling geometry parameters

Parameters	Symbol	Value	Unit
Height of the bench	h	10	[m]
Diameter of drilling of product	d_h	89	[mm]
Diameter of contour drilling	d_{hc}	76	[mm]
Patron diameter for product drilling	d_p	89	[mm]
Patron diameter for contour drilling	d_{pc}	27	[mm]
Drilling angle for product drillings	β	63	[^{0}]
Drilling angle for contour drillings	α	63	[^{0}]
Burden	W	2.8	[m]
Upper burden	W_u	3.14	[m]
The distance between drillings in row for product drillings	a	2.8	[m]
The distance between rows for product drillings	b	2.8	[m]
The upper distance between rows for product drillings	b_u	3.14	[m]
The distance between drillings in row for contour drillings	a_c	0.75	[m]
The distance between product and the contour drillings	b_c	2	[m]
The upper distance between product and the contour drillings	b_{cu}	2.24	[m]
The length of drilling for first row	l_{h1}	11.8	[m]
The length of drilling for second row	l_{h2}	12.0	[m]
The length of drilling for third row	l_{h3}	12.2	[m]
The length of contour drilling	l_{hc}	12.5	[m]
Number of product drillings (3 rows x 20 drillings)	n_h	60	Drillings
Number of contour drillings (1 row x 80 drillings)	n_{hc}	80	Drillings

Calculation of material needed for field detonation

The calculations will be made in tabular form with Microsoft Excel. For to make the calculations of explosive for product drillings will used the equation (Dambov, 2011; Dambov, 2013; Brahimaj et al., 2019; Džodič, 1985):

$$Q_e = \sum_{i=1}^{n} \frac{\pi \cdot d_h^2}{4} \cdot [(l_{hi} - l_s) \cdot n_h] \cdot \Delta$$

For to make the calculations of explosive for contour drillings will used the equation (Brahimaj, 2020):

$$Q_{ec} = \sum_{i=1}^{n} \frac{\pi \cdot d_p^2}{4} \cdot \left(\frac{l_{hi}}{l_p + l_e} + 1\right) \cdot l_p \cdot \Delta \cdot n_h$$

Where are:
d_p – the diameter of patrons [m]
l_h – the length of drillings [m]
l_p – the length of patrons [m]
l_e – the length of empty parts [m]
l_s – the length of stemming [m]
Δ – the density of explosives [kg/m^3]
n_h – number of drillings

Determination of the length of the stemming, is made based on the relation (Brahimaj et al., 2019, Brahimaj, 2013):

$$l_s = (0.8 \div 1.2) \cdot b$$

Where is:
b – the distance between rows [m]

Table 1. Calculations for blasting

Project	"Kosovo Motorway Project"									
Region – Municipality	Prizren – Malisheva									
Detonating company	"Jaha Company"									
		Contour				Production				
Naming	Symbol			Total	Unit				Total	Unit
Group		**G.1**	**G.2**			**G.1**	**G.2**	**G.3**		
Total drilling length	Ld	496	496	992	m'	236	240	244	720	m'
Number of holes	nh	40	40	80	holes	20	20	20	60	holes
Distance between holes	a	0.75	0.75		m'	2.8	2.8	2.8		m'
Distance between rows	b	2	2		m'	2.8	2.8	2.8		m'
Hole diameter	dh	76	76		mm	89	89	89		mm
Drilling angle	α,β	63	63		^{0}	63	63	63		^{0}
Stemming	ls	8.8	8.8		m'	2.8	2.8	2.8		m'
Cartridge diameter	dp	27	27		mm	89	89	89		mm
Cartridge length	lp	25.00	25.00		cm	33.00	33.00	33.00		cm
Compression	C	0%	0%		%	4%	4%	4%		%
Explosive density	Δ	1.15	1.15		g/cm^3	0.85	0.85	0.85		g/cm^3
Effective diameter of compression	d^1	27.00	27.00		mm	90.83	90.83	90.83		mm
Effective length of compression	l^1	25	25		cm	31.68	31.68	31.68		cm
Drilling length	l_h	12.4	12.4		m'	11.8	12	12.2		m'
Volume of rock per hole	Vh	14.923	14.923		m^3	78.509	78.338	78.167		m^3
Average rock height	h	9.948	9.948		m'	10.014	9.992	9.970		m'
Cartridge mass	q_s	0.165	0.165		kg	1.744	1.744	1.744		kg
Calculated number of cartridges in hole	nc	14.59	14.59		pcs.	28.41	29.04	29.67		pcs.
Estimated number of cartridges	nec	15	15		pcs.	28	29	30		pcs.
Filling length	lch	3.65	3.65		m'	9.00	9.20	9.40		m'
Hole filling in m'	Qm	0.66	0.66		kg/m	5.51	5.51	5.51		kg/m
Filling of a hole	Qh	2.40	2.40		kg	49.55	50.65	51.75		kg
Specific consumption of EXP.	q_{sch}	0.26	0.26	0.29	kg/m^2	0.63	0.65	0.66	0.65	kg/m^3
Subdrilling	Q	1.10	1.10		kg	0.50	0.70	0.90		kg
Total filling amount with EXP.	V	96.0	96.006	192.0	kg	990.991	1013.013	1035.035	3039.0	kg
Measure the volume of obtained	Vmd	596.91	596.91	1193.8	m^3	1570.18	1566.76	1563.34	4700.3	m^3
Detonating cord	L_f	546	546	1092.0	m'	302	306	310	918.0	m'
The length of cut catridge	lp	25	25		cm					
The distance between cartridges on detonating cord	lp	60	60		cm					
The number of empty parts with charged parts	Nec	14.59	14.59		pcs.					
The number of cartridges	Np	16	16		pcs.					
The number of empty parts	Ne	15	15		parts					
The length of charging with empty parts	lce	12.65	12.65		m					
Explosive patrons	Npt	584	584	1167	Patrons					

Field connection with Nonel system

To enable safe initiation of Nonel system connection, consideration should be given to connecting Nonel detonators that inserted into the drilling with Nonel connectors that are always on the surface and with the added care of passing the connection from one drilling to another, as well as from one row in another (Nako, 2001; Milenko, 2000; Brahimaj, 2008; Brahimaj, 2012).

After all these operations have been performed on each drilling and all Nonel connectors have been connected to each drilling, with each other and to the general detonating cord line of the contour, the field is considered connected. The connected field and the order of initiation in some combinations of Nonel connectors looks like in Figures, from Figure 1 to Figure 4.

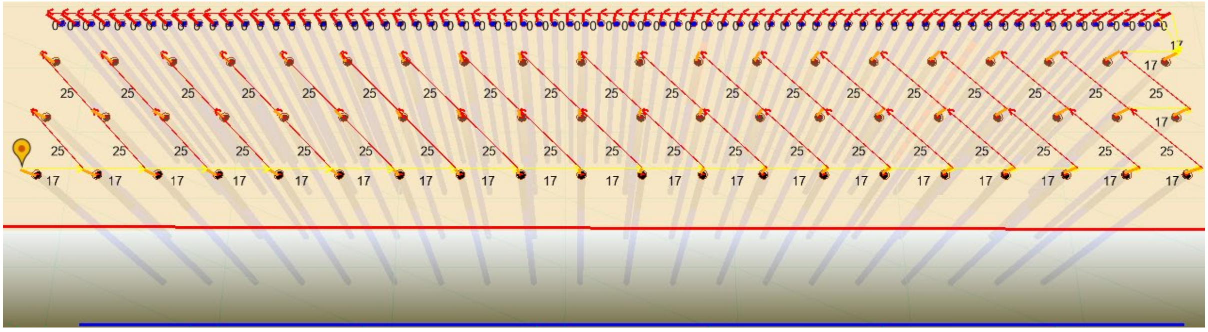


Figure 1. Field connection in combination with Nonel connector 17 [ms] and Nonel connector 25 [ms]

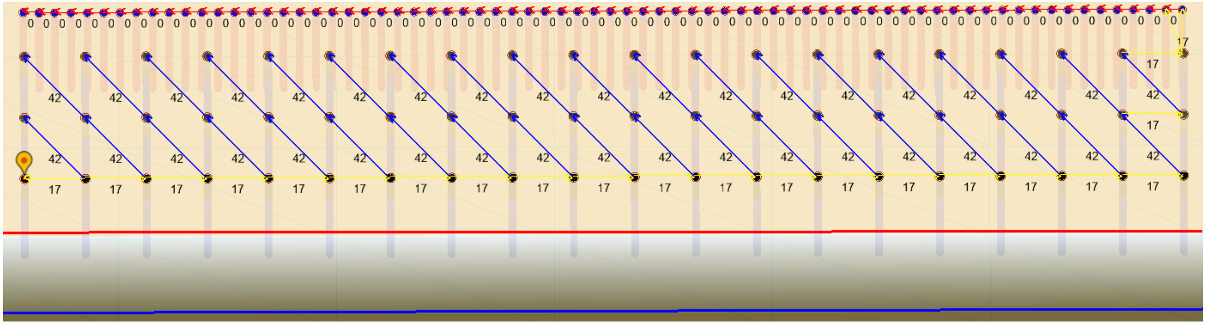


Figure 2. Field connection in combination with Nonel connector 17 [ms] and Nonel connector 42 [ms]

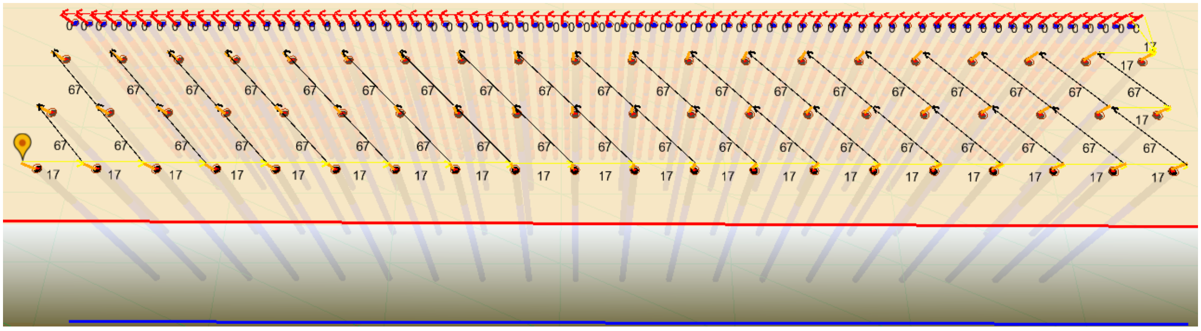


Figure 3. Field connection in combination with Nonel connector 17 [ms] and Nonel connector 67 [ms]

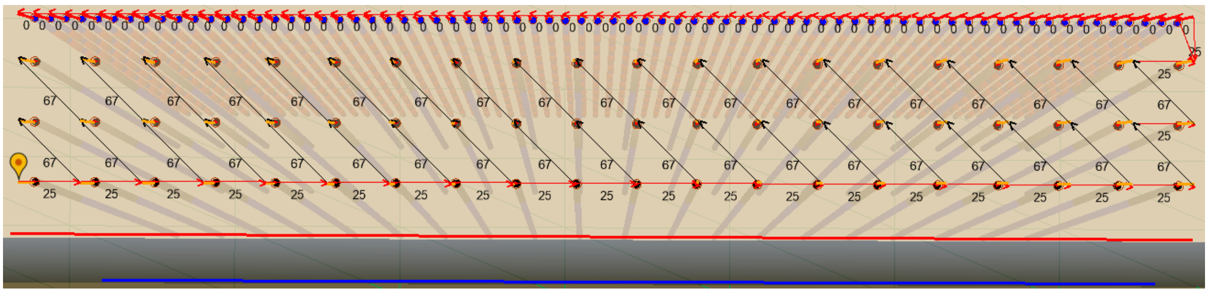


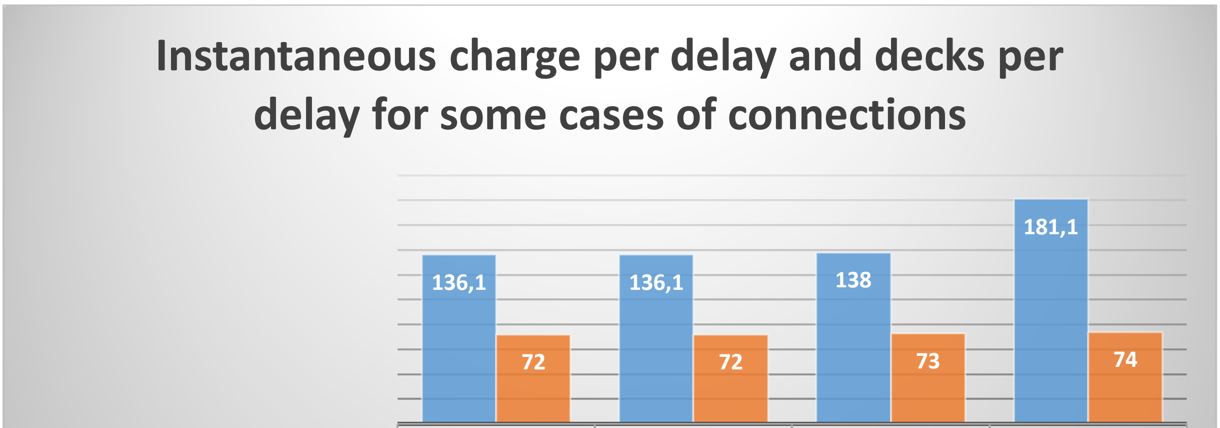
Figure 4. Field connection in combination with Nonel connector 25 [ms] and Nonel connector 67 [ms]

Results

The results obtained from the analysis of blasting results with O-Pitblast software for some blasting cases are presented below:

Analysis of blasting results with O-Pitblast software has been done for several different cases of blasting, analyzing blasting data for cases of different drillings connections.

Where, the results obtained after the analysis made for each case separately for the amount of instantaneous explosive and the number of drillings that blast at the same time, which are shown in the Figure 5.



	Connection with NC 17 [ms] and 25 [ms]	Connection with NC 17 [ms] and 42 [ms]	Connection with NC 17 [ms] and 67 [ms]	Connection with NC 25 [ms] and 67 [ms]
Instantaneous charge/delay [kg]	136,1	136,1	138	181,1
Decks/delay [drillings]	72	72	73	74

Figure 5. Instantaneous charge per delay and decks per delay for some cases of connections

By analyzing the data presented in Figure 5, we see that the combinations of drillings connections with Nonel connector 17 [ms] / 25 [ms] and Nonel connector 17 [ms] / 42 [ms] have a smaller amount of explosive which is initiated at the same time, they also have smaller number of drillings that are initiated at the same time, but in the number of drillings that are initiated at the same time. From this it can be seen that these combinations of connection with Nonel connector are better for use, because we have smaller quantities of explosives and smaller number of drillings that are initiated at the same time, which means that in these cases we have a lower level of ground vibrations.

However, if we start from the aspect of the action orientation of the explosion forces, the method of connection with Nonel connector 17 [ms] / 67 [ms] is better than these other methods, since in this method of connection we have more release of free face, as a result of greater delay between rows, this enables the material to be thrown forward and to have sufficient time for displacement from the rock massif, not allowing the blasted material of the next row, to face in the vicinity, with the previous row mined material, where in this case we would have the return of the explosion forces in the direction of bench which is in formation. This return of explosion forces in the direction of the bench which is in formation, will affect the damage of the upper edge of the bench, or in the worst case even the collapse of the bench, if the massif being mined is not stable. During contour blastings in highway works, in most cases this method of drillings connection was used, only in those cases when there were a lack of these Nonel connectors. Then Nonel connectors were used with another delay, but it always gone from what to have the lowest possible level of ground vibration and the greatest possible release of the free face between the rows.

By analyzing blastings, are obtained the results of influence of drillings on each other and on the bench behind of contour blasting, according to the delay between them, and these results are presented on the Figure 6.

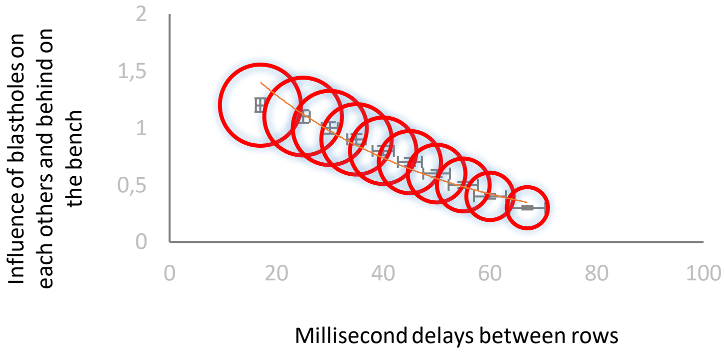


Figure 6. The influence of blastholes on each other and on the bench behind of contour blasting

With the application of more than four rows of the product, before the contour row, and with the application of millisecond delays with short time intervals, damages are caused in the bench that is formed, and such a case is presented in Figure 7.

Figure 7. Damage to the bench from the impact of product blastholes - the case in Bellanica

Whereas with the application of less than four rows of the product before the contour row, and with the application of millisecond delays with long time intervals, safe and without damage bench are formed, where such a case is presented in Figure 8.

Figure 9. The bench formation without damage - the case in Bellanica

Conclusion

If we rely on the work done on the construction of highways in Kosovo, in which a considerable number of contour blastings have been made, where in many of them blastings, have been made different tests for combination of different forms of connections, the place of initiation of drillings and the combination of Nonel connectors with different delays times. After analyzing the blast results, it was found that the field connection combinations with Nonel connector 17 [ms] / 25 [ms], with Nonel connector 17 [ms] / 42 [ms], and Nonel connector 17 [ms] / 67 [ms], give the best results in cutting rock mass, without affecting the surface of the bench in formation. Also, these combinations have a very low level of ground vibrations. But among these combinations, the best results in cutting and fragmentation of rock mass are given by the combination of connection with Nonel connector 17 [ms] / 67 [ms], as there is a small delay between the drillings in the row, and is a great delay between of rows, enables the formation of a free face for the subsequent row from the previous row, enabling the mined material to be thrown forward at a sufficient distance, so that when the throwing of the subsequent blasted material begins not to have obstacle to throwing, but to be thrown forward and to encounter in the air the previous blasted material. In this case we will have secondary fragmentation of the mined material as a result of the match between the pieces of mined material. This throwing of the material forward has the effect of not having much impact behind the drillings of the production the force of the explosion. Also, the time of initiation of contour drillings in this case is much earlier than the time of initiation of production drillings, enabling the explosion force from production drillings to be amortized in the cutting line formed previously after the initiation of contour drillings.

References

Dzodič R, (1985) Tehnologija bušenja i miniranja, Pristina. (Drilling and mining technology) Pristina. https://dergipark.org.tr/tr/download/article-file/571709

Brahimaj I, (2008) Determining technical-economic parameters towards the advancement of massive detonations in exploring bauxites in Kosovo. M.Sc. Thesis. Mitrovica.

Brahimaj I, (2012) Contribution in the selection of optimal parameters of massive detonations in the limestone deposits of Gremnik. Ph.D. Thesis. Mitrovica

Brahimaj I, Brahimaj F, (2019) The massive and special blastings. Mitrovicë: University of Mitrovica "Isa Boletini". https://www.umib.net/wp-content/uploads/2020/03/11.5.1-Conference-2019-Proceedings-IMGC-2019.pdf

Brahimaj F, (2013) Appliance of contour blasting within road infrastructure Morine – Merdare. Msc. thesis. Mitrovica.

Brahimaj F, (2013) Elaborate for blasting, Pristina, Kosovo.

Brahimaj F, (2020) Contribution for improvement of contour blastings in forming final slopes on the roadways and surface mines. Ph.D. Thesis. Stip

Brahimaj F, Dambov R, Brahimaj S, (2019) The contour blasting aplication in the Kosovo motorway project in Bellanica. XV International Conference of the Open and Underwater Mining of Minerals, 46-53. Varna. http://eprints.ugd.edu.mk/22629/1/VTOR%20TRUD-VARNA%202019.pdf

Brahimaj F, Dambov R, Brahimaj A, (2019) The optimal parameters determination of drilling in the Kosovo motorway project in Bellanica. XV International Conference of the Open and Underwater Mining of Minerals, pp. 39-45. Varna. http://eprints.ugd.edu.mk/22629/1/VTOR%20TRUD-VARNA%202019.pdf

Brahimaj Sh, (2013) Opening and preparation of trenches on the highway Morine – Merdare. Msc. thesis. Mitrovica.

Dambov R, (2011) Method's of blasting. Stip: University "Goce Delcev. https://www.researchgate.net/profile/Risto-Dambov-2

Dambov R, (2013) Drilling and blasting. Stip: University "Goce Delcev". https://www.researchgate.net/profile/Risto-Dambov-2

Dambov R, (2015). Special Blastings. Stip: University "Goce Delcev", Faculty of Natural and Technical Sciences. https://www.researchgate.net/profile/Risto-Dambov-2

Kennedy BA, (1990) Surface Mining, USA. ISBN-13:978-0873351027

Milenko S, (2000). Blastings in surface exploitations. Bor: Institut of Bakar. http://www.mining.org.tr/en/download/article-file/1392768

Nako I, (2001) Nonel initiation system. Tirana: Polytechnic University of Tirana.