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Organization of Blasting Operations in the Karta Mine. SMD Lefa Concession (Republic of Guinea)

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Fodé Mohamed CAMARA[1], Daouda KEITA[2], Kandas KEITA[3]

[1]*Department of Mining Services, Institut Supérieur des Mines et Géologie de Boké (Republic of Guinea)*

[2]*Department of Mining Services, Institut Supérieur des Mines et Géologie de Boké (Republic of Guinea).*

[3]*Processing-Metallurgy Department, Higher Institute of Mines and Geology of Boké (Rep. of Guinea).*

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ABSTRACT

This paper summarizes the work carried out to improve drilling and blasting parameters at the Lefa gold mine in Guinea. This is done with the aim of finding parameters that not only ensure technical and economic performance but also comply as closely as possible with the requirements of other activities downstream from those of drilling and blasting. For this study constraints were taken into account. These constraints relate to the requirements on the degree of fragmentation and the operating costs. Some mathematical formalisms have been used to model the degree of fragmentation that can be obtained with respect to the parameters used. The Kuz-Ram fragmentation model was used to determine the ideal particle size distribution that could improve the performance of mine activities. The use of this proposal has a good impact on the drilling and blasting budget. As a matter of fact, despite an increase of $ 0.03 /t or 4% in drilling and blasting costs, there is a reduction in the quantity of large blocks from 7% to 3.4%, either 5%. This additional cost of drilling and blasting is reasonable insofar as it will be offset by the gain that will result from other activities throughout the production chain.

1. INTRODUCTION

The primary aim of mining is to make a profit [1]. Mining companies are therefore constantly seeking to improve production costs in order to increase the profit margin of their activities.

One of the key activities during the exploitation phase is the proper orientation of ore preparation and blasting operations, the improvement of which promotes good ore recovery and a reduction in the associated operating costs [2].

Indeed, the rock blasting operation is very important insofar as the fragmentation obtained affects not only the performance of the loading equipment but also the costs of the whole range of related mining activities, such as transport, crushing and, to a certain extent, grinding. C'est pourquoi, durant la période allant de juin 2022 à novembre 2022, nous avons réalisé une étude sur l'"Organisation des opérations de dynamitage dans la mine de karta de la concession de SMD Lefa".

2. MATERIAL

The equipment used to carry out our study consisted of field tools such as safety equipment, data acquisition equipment and office tools.

2.1 Field material

Our study area lies 730km east of the capital Conakry, in north-eastern Guinea, between 11o30'-12o00' north latitude and 9o45'-10o15' west longitude, straddling the Dinguiraye and Kankan north-east sheets, and belongs administratively to the Siguiri prefecture [4]. The prefecture of Siguiri lies in the flat zone of the region, with an average altitude of between 315m and 350m. The lowest altitude is 308m, in the Niger valley to the east of the town. To the south of the town, a terrace stretches out on either side of the Niger on a flat strip of land 1.5km long - the flood zone. The region has a tropical climate of the Sudanian type, with two seasons: the longer dry season from November to May, characterized by the influence of the harmattan, during which a hot, dry wind blows from the desert towards the dominant region from November to February, with temperatures reaching 42°C in March-April. The rainy season runs from June to October and is characterized by low rainfall, varying from 1200mm to 1700mm per year, i.e. less than

1500mm/year [5 The study area is criss-crossed by several rivers with irregular flow regimes, including the Yro, Siguiriniko, Karta and Boukha, all of which have their source in the centre and flow southwards [6].

The latest census in 2018 estimated the population of Siguiri at around 347,612, made up mainly of young people. 70% of the population farm, and the main crops are food crops (maize, fonio, rice, millet, etc.), cereals and vegetables.

Gold panning has existed since the time of the empires, and is now the main activity in the bourré and sègues regions. In addition to the study area, these materials include:

a. Personal protective equipment

b. Shooting equipment: there are two groups: accessories and fireworks:

- Shooting accessories

- Fireworks:

c. Data acquisition material

2.2 Office material

a. Production reports

b. Computer material

3. METHODS

To achieve our objective, we began by carrying out documentary research. This choice is justified by the fact that any evaluation and improvement cannot be made without knowledge of the existing system [7].

We then went out into the field to make our own observations of the primary crusher loading and feeding process and to collect the data needed for our study. This field work consisted of assessing the fragmentation quality of the felled material, which could potentially have an impact on the loading and feeding process of the primary crusher**.** To do this, we first checked the state of fragmentation of the blasted blocks, by simulating the blasting parameters with the Kuz-ram model and then by determining the particle size distribution of the rocks at the end of a blast with the wip-frag software. Fragmentation was further verified by analyzing its effect on the shovel's cycle time during loading of the felled material into the pit and also for the primary crusher [8].

a. Documentary research

The aim of the documentary research carried out was to acquire significant knowledge about blasting and the feeding of the primary crusher.

The approach also focused on fragmentation, i.e. ensuring that the shots fired produce at least 80% of fragments smaller than the mesh size of the hopper located above the crusher's inlet opening, which is 500 mm.

b. Evaluation of fragmentation

Several methods can be used to predict and assess the granulometry of blasts. The most effective and most widely used methods are based on modelling fragmentation with blast parameters using theory (Kouznetsovo, Rammler) and processing and analyzing photos of rock piles blasted using software such as wip-frag etc.

However, there are other methods that can also be used to assess the quality of shot fragmentation (granulometry, compactness and shape of the shot heap):

- ✓ The shovel cycle time analysis method. This time is linked not only to the quality of the fragmentation but also to other factors such as the operator's skills, climatic conditions and work organization;
- ✓ The method of visual observation, in the field, of heaps of felled rock. This is a simplistic method, based on assessing the grain size of the felled material.

In our study, we combined the method of analyzing the constraints on fragmentation that could enable the processing plant to achieve its maximum output, the analysis of photos of the rock piles felled using the wip-frag software and the Kuz-Ram model for predicting the desired fragmentation.

Kuz-ram model

a. Theory

There are fields where the prediction of the course of a phenomenon is too complex to be approached using conventional calculation schemes. In the blasting sector, computer-aided blast design has been developed over the last few years, enabling numerous simulations to be carried out by varying the input parameters in order to find the optimum solution (performance, safety, cost). There are several calculation methods depending on the expected results [10].

For the purposes of our study, we refer to the empirical Kuz-Ram model. This is a theory that is currently widely used in the field of evaluating the results of mine blasts.

The model is expressed in terms of two (02) fundamental equations from which other equations follow, formulated as follows:

$$Xm = AK^{-0,8}Q^{\frac{1}{6}}\left(\frac{115}{RWS}\right)^{19/20} \quad (1)$$

With:

- Xm: average particle size;

- A: the rock factor;

- K: the powder factor or specific energy of the explosive (Kg/m3);

- Q: quantity of explosive used per hole (kg)

- RWS: the detonating power of the explosive compared with that of ANFO;

The rock factor is expressed using the equation of Lilly (1986) according to the following formula:

$$A = 0,06x(RMD + GF + RDI + HF) \quad (2)$$

With:

- A: the rock factor, varying between 0.8 and 22;

- RMD: Rock Mass Description Index;

- JF: Joint factor;

- RDI: Rock Density Index; - HF: Rock Hardness Factor.

The particle size distribution of the rock can be predicted using the Rosin-Rammler equation [11], which is formulated as follows:

 Rosin-Rammler equation

$$R_x = 100x(1 - e^{\left(-\frac{x}{xc}\right)^n} \quad (3)$$

Where:

- Rx: the percentage of material whose size is smaller than x;

- X: the size of the fragments (cm);

- Xc: the characteristic size of the distribution (cm);

- n: the uniformity coefficient.

- Finally, we need to calculate the uniformity coefficient n to be able to describe the distribution completely distribution, hence the following equation:

$$X_c = \left(\frac{X_m}{0{,}693^{\frac{1}{n}}}\right) \qquad (4)$$

$$n = \left(2{,}2 - 14 \times \frac{B}{D}\right) \times \sqrt{\frac{1 + \frac{S}{B}}{2}} \times \left(1 - \frac{W}{B}\right) \times \left(\frac{L}{H}\right) \qquad (5)$$

With:

- B: the bench (m);

- D: hole diameter (mm);

- S: spacing (m)

-W: vertical deflection of the hole (m);

- L: the length of the load (m); - H: the height of the step (m);

The vertical deflection of the hole is expressed using the following formula:

$$W = \frac{2 \times D}{1000 + 0,035 \times (H + Sf)} \qquad (6)$$

With:

- D: the diameter of the hole (mm); - H: the height of the step (m); - SF the oversize in (m).

b. Practical work

In practice, we programmed all these equations in Excel, thus producing a standard spreadsheet. This model has been approved by several studies [11]. Our task will therefore be to fill in the input parameters, which include the mesh size, the specific charge, the quantity of explosive per hole, the type of rock, the behavioral parameters of the rock mass, and so on. The result is a granulometric curve that we will interpret later.

The spreadsheet interface looks like this :

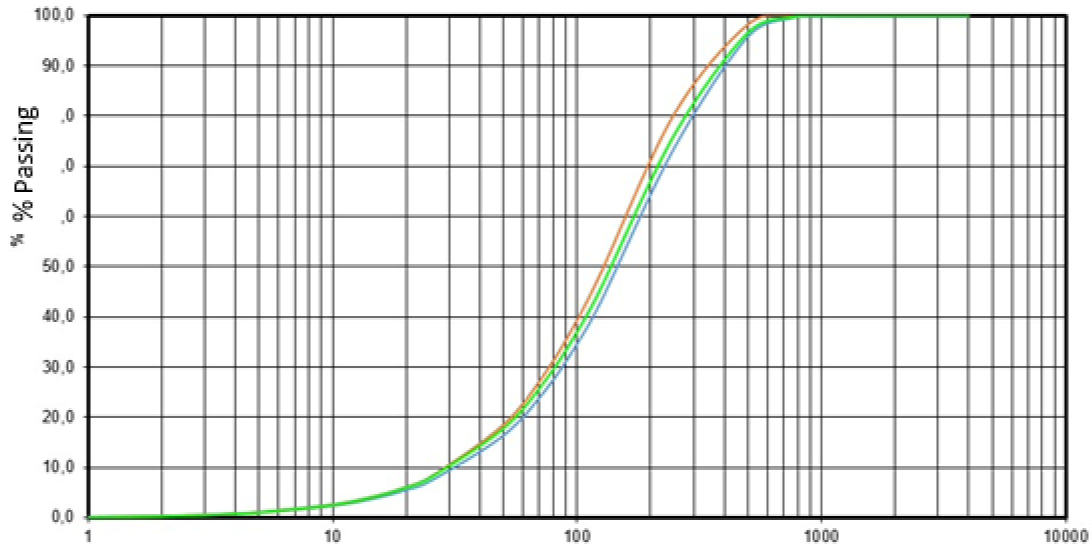

Figure 1 : Spreadsheet interface based on the Kuz- Ram, (source, according to the from Kuz-ram)

▪ Checking blasting parameters in the field and monitoring loading operations

To gain a better understanding of the quality of the fragmentation of the material that will result from blasting, we visited the various flights to carry out quality control of the boreholes and the explosive used. This quality control focused firstly on checking the depth of the boreholes using a tape measure, then on loading the holes with explosives and finally on ensuring that the blast plan was followed in the field.

Determining the particle size characteristics of a shot using WIP-FRAG

The particle size distribution after a shot is easily determined in a succession of simple steps using the Engineering split desktop software [13], which analyses the images taken after the shot. It compares the size of the blocks with two reference elements used as a comparison scale, analyses them, and generates a curve of Particle size distribution shown in the figure below:

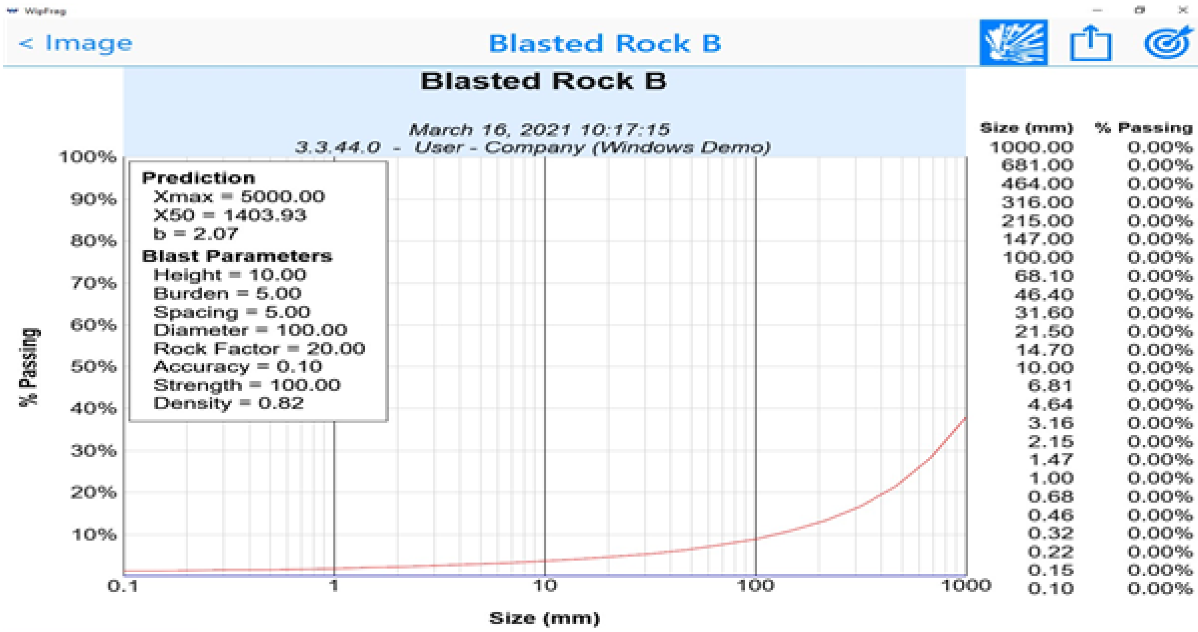

Figure 2: Particle size distribution curve

4. RESULTS AND INTERPRETATION

4.1 Analysis of existing blasting parameters

The blasting parameters used at the Lefa gold mine are based on empirical models [14].

These parameters are summarized in the table below:

Table 1: Summary of existing blasting parameters

No	Parameters	Unit	Values	No	Parameters	Unit	Values
1	Rock density	**(t/m^3)**	**2,6**	11	Hole length	**(m)**	**8**
2	Young's modulus (E)	**(GPa)**	**100**	12	Driling gap	**(m)**	**0,61**
3	UCS	**(MPa)**	**150**	13	Tramping lenght	**(m)**	**3,6**
4	Rock factor A		**5,7**	14	Load lenght	**(m)**	**5,7**
5	Hole diameter	**(mm)**	**165**	15	Banquet	**(m)**	**4.1**
6	Explosive density	**(g/cc)**	**1,15**	16	Spacing	**(m)**	**4.7**
7	RWS		**100**	17	Tonnes	**(t)**	**400**
8	Explosive mass/metre	**(kg/m)**	**24,6**	18	Volume	**(m^3)**	**154**
9	Height of bench	**(m)**	**8**	19	S. B		**1,14**
10	Sub-drilling	**(m)**	**1,3**				
7	Parameters		**100**	17	Tonnes	**(t)**	**400**
8	Rock density	**(kg/m)**	**24,6**	18	Volume	**(m^3)**	**154**
9	Young's modulus (E)	**(m)**	**8**	19	S. B		**1,14**
10	UCS	**(m)**	**1,3**				

As a result, we can see here that the mesh ratio is relatively good for the explosive, even though it is slightly tighter. This explains the high specific explosive consumption. It should also be noted that the tighter the mesh, the higher the specific explosive consumption. This specific consumption of explosive should make it possible to obtain very good results, i.e. good fragmentation of the extracted material.

4.2 Fragmentation results

In view of the results shown in figure 7, it is clear that from a theoretical point of view, the parameters used meet the expectations in terms of fragmentation, i.e. 60% of fragments with a diameter of 250 mm or less, and 40% with a diameter greater than 250 mm**.**

a. Theoretical fragmentation Emulsion

The theoretical firing parameters entered in the Kuz-ram model were used to obtain the following:

The particle size distribution is as follows (Figure 8), based on the results of Table I

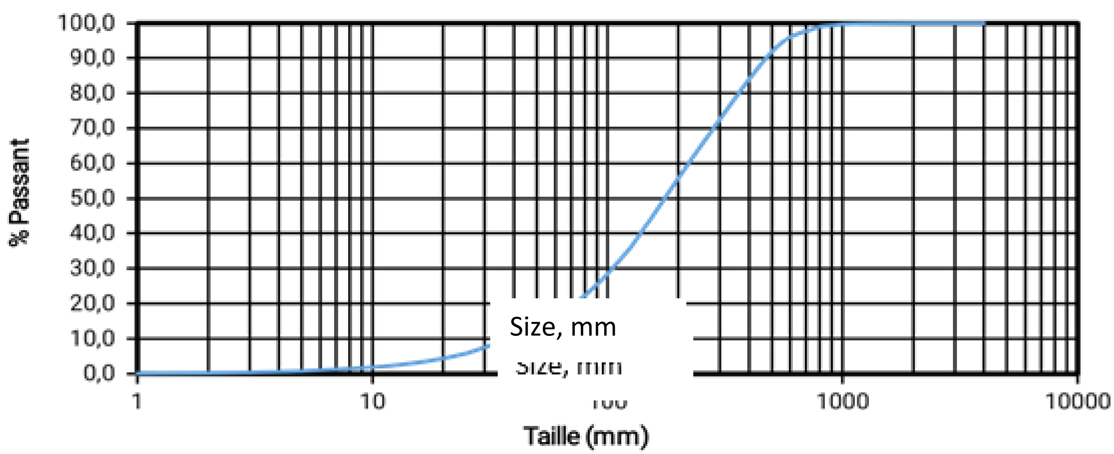

Figure 3: Particle size distribution (according to the Kuz -ram. emulsion(SDM lero)

Analysis of the granulometric curve generated by the Kuz-ram model reveals two granulometric classes: 35% of large boulders (size greater than 250 mm) and 65% of rock fragments whose size is less than or equal to 215 mm.

Given the results, it is clear that, from a theoretical point of view, the parameters used meet expectations in terms of fragmentation, i.e. 60% of fragments with a diameter of 215mm or less and 40% with a diameter greater than 250mm.

However, this model has its limitations, in that it does not take into account the firing sequence. This factor has a considerable influence on the fragmentation of the shot. Let's now analyses the results obtained in the field. b. Results relating to Quality Assurance / Quality Control (QA / QC).

The QA/QC results can be summarized around four (4) points, namely checking the depth of the holes, the quantity of explosively loaded per hole, the density of the explosive and the collar (tamping height).

The tables below show the results of the AQ/QC of one blast.

C. Checking the density of the explosive

Table 2: Control of emulsion density (blast SMD lero)

No Sample	Time(min)	Density (g/m3)
1	0	1 , 33
	5	1 , 32
	10	1 , 3
	15	1 , 32
	20	1 , 31
	25	1 , 3
	30	1 , 3
Time(min)	Time(min)	Time(min)
	5	1 , 32
	10	1 , 3
	15	1 , 33
	20	1 , 3
	25	1 , 33
	30	1 , 32

The table above shows some samples used to check the density of the explosive used during the loading of a flight.

The table shows that we obtained this density after 10 minutes. So we had to pack the different holes after 10 minutes.

The collars were also respected with a height of more or less 1 metre in relation to the initial collars.

All these factors will contribute to obtaining large blocks in the field.

The photo below is an example of large boulders resulting from failure to comply with the planned parameters.

Figure 4: Illustrative photo of the presence of large blocks (blast SMD lero)

4.3 Study of Fragmentation

Determining the particle size distribution after a blast is carried out is easily done in a succession of simple steps using the Engineering split desktop software. This software analyses the images taken after the shot. It compares the size of the blocks with a reference element used as a comparison scale**.** Photographs taken after blasting 5 flights enabled us to determine changes in the particle size distribution, as shown below.

Given these results, it is clear that the parameters and methods used do not meet expectations in terms of fragmentation, i.e. 60% of fragments with a diameter of 250mm or less and 40% with a diameter greater than 250mm.

Fragmentation of the lower level (Emulsion)

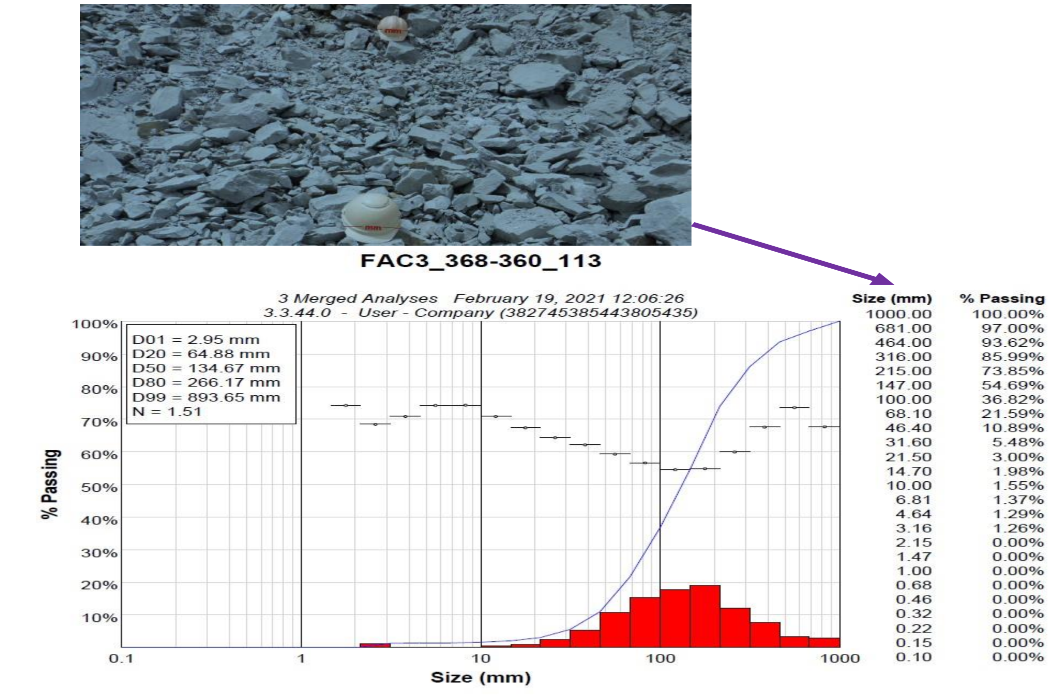

Figure 5: Sieve size curve for shot 1 (emulsion) **(blast SMD lero)**

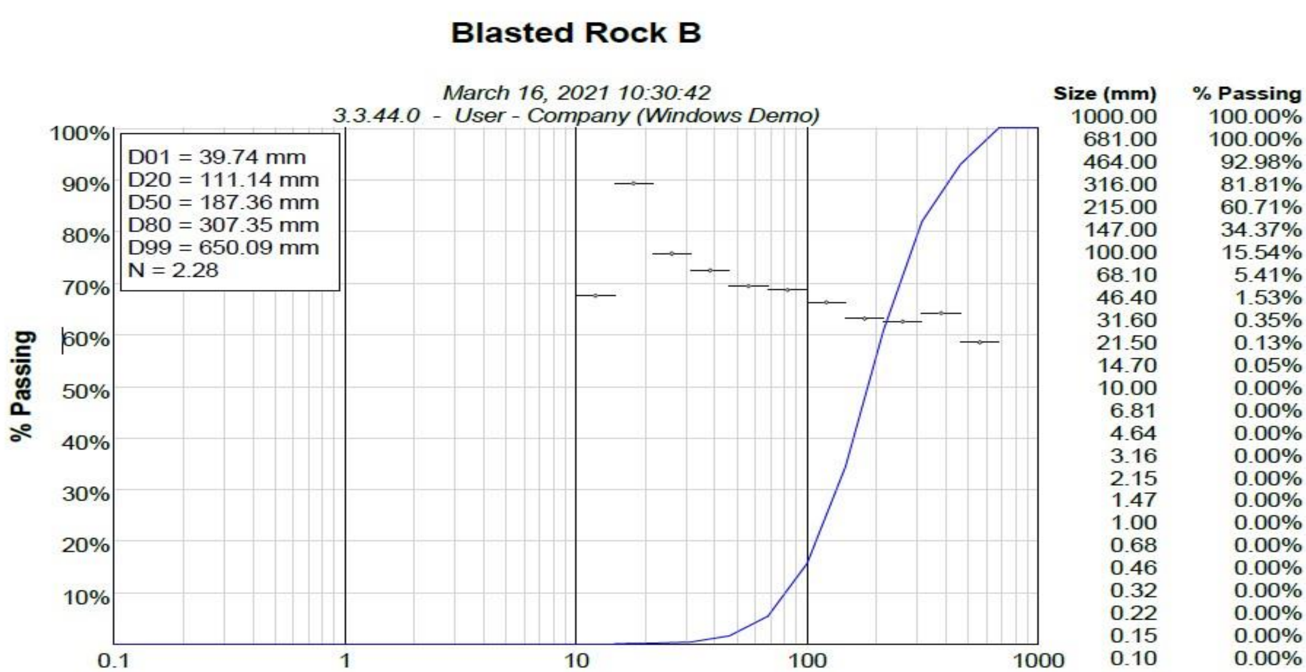

Figure 6 : Sieve size curve for shot 2 (emulsion)

Analysis of the particle size distribution curve in Figure 9 reveals two particle size classes, namely 46% of blocks larger than 215 mm and 54% of blocks smaller than 215 mm. rock fragments less than or equal to 250mm in size. The following image shows the physical dimensions of the blocks after blasting.

Analysis of the grading curve in Figure 10 reveals two grading classes: 52% of boulders larger than 250 mm and 48% of rock fragments smaller than or equal to 250 mm.

Given these results, it is clear that the parameters and methods used do not meet the fragmentation targets, i.e. 60% of fragments with a diameter of less than 215 mm and 40% with a diameter greater than 215 mm.

However, we note that the use of emulsion brings us closer to the objective of 60% of blocks smaller than 215mm.

4.4 Proposed improved practices and parameters

4.4.1 Proposed improved parameters

In order to improve fragmentation to reduce production costs and improve the feed to the primary crusher, we have drawn up a proposal based on the evaluation carried out. The parameters of this proposal were selected according to two key criteria: technical performance and economic benefits.

Technical performance is understood to mean not only good fragmentation and lower specific explosive consumption (powder factor), but also vibration and noise levels below the recommended thresholds for the shots considered. As for the economic aspect, it was essentially necessary to see whether the parameters chosen produce operating costs per tonne, from drilling and blasting to feeding the primary crusher, and whether they are lower than those currently in use.

The ideal parameters are therefore those that meet both of these criteria. However, as this is not always feasible in practice, we have opted for the solution(s) that come closest to meeting the above selection criteria.

The parameters of this proposal are summarized in the table below:

Table 3: Proposed improved parameters

No	parameters	Units	Values	
			Existing calculated	Existing calculated
1	Rock density	(t/m^3)	**2,6**	**2,6**
2	Young's modulus (E)	(GPa)	**100**	**100**
3	UCS	(MPa)	**150**	**150**
4	Rock factor A		5,7	5,7
5	Hole diameter D	(mm)	**165**	**165**
6	Explosive density	(g/ m^3)	**1,15**	**1,15**
7	RWS		**100**	**100**
8	Explosive Mass/meter	(kg/m)	24,6	24,6
9	Bench height	(m)	**8**	**8**
10	On drilling	(m)	**1,3**	1,0
11	Hole length	(m)	**9,3**	**9,0**
12	Drilling deviation	(m)	0,66	0,65
13	Stemming length	M	**3,6**	3,2
14	Load length	(m)	5,7	5,8
15	load design	(m)	**4,1**	**4**
16	Spacing design	(m)	**4,7**	5,0
17	Total load weight	(kg)	**140**	143
18	Tonnes	(t)	401	416
19	Volume	(m^3)	154	160
20	S.B		1,15	**1,15**
21	HD: Burden		25	24
22	Quantity	**t/m**	**43**	**46,2**
23	Powder factor	(kg/m^3)	0,909	0,891
24	Powder factor	(kg/t)	0,350	0,343
25	Medium size x 50	(mm)	153	156
26	Oversized	**>1000mm**	**1,1**	**0,6**

Based on the data in the table above, it can be seen that, if the alternative proposal made for the shots were adopted, the powder factor would fall from 0.90 Kg.m-3 to 0.89 Kg.m3 [15], i.e. a reduction of around 5%. On the other hand, the average fragmentation would be increased from an initial value of 153 mm to 156 mm [16]. This is reasonable insofar as the increase in size is well in line with the needs of the production chain. Drilling and blasting costs would also be affected, falling from $1.93/t to $1.89/t, a reduction of $0.03/t, which represents a reduction of around 4% on the initial amount. However, if we were to adopt this proposal, the total quantity of large blocks would fall from 7% to 3.4%, a reduction of 51% [17].

This is justified by the fact that we will have a better loading time and a better quality feed for the primary crusher, which will its energy expenditure.

4.4.2 Suggestions for improved practices

Blasting suggestions

About blasting, we would ask the drilling and blasting supervisor:

- Be much more vigilant in assessing the quantities of explosives to be pumped into the various holes. He must adjust the quantity of explosives to be loaded according to the actual depth of the holes in the field;
- Ensure that the density of the explosive is 1.3 (g/cm^3);
- Ensure that the tamping height is respected to prevent energy escaping during blasting**.**

5. CONCLUSION

The objective of this study was to determine blasting parameters that would not only improve the performance of the blasting section's activities but would also meet the requirements of the production chain. To achieve this objective, we first analyzed the current blasting parameters applied in the mine; then we assessed the quality of fragmentation theoretically and after blasting; and finally, we analyzed the excavation time.

Analysis of the parameters studied revealed that fragmentation quality has a direct impact on all the other activities in the production chain.

The parameters used resulted in 69% of rock fragments being less than 1000 mm in size. This is not acceptable, as it does not meet the operating criteria, i.e. 80% of fragments with a diameter of 1000 mm or less and 30% with a diameter greater than 1000 mm.

However, with a view to improving the latter in order to further reduce the size of the rock fragments, a proposal (mesh size: 4m x 5.5m) was made. This proposal results in a [reduction in drilling and blasting costs of $0.03/t. These proposed parameters are those currently used at the Lega gold mine. They allow a 20% increase in rock fragments smaller than 1000 mm compared with the old parameters.

These new parameters used in the drilling and blasting section will meet expectations in terms of fragmentation while reducing operating costs.

Overall, therefore, the process is relatively satisfactory, but could be improved if the recommendations made at the end of this study are taken on board.

6. Acknowledgements

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7. Conflicts of interest

The authors are keen to have this article published in your journal and there are no conflicts.

8. BIBLIOGRAPHY

[1] Camara, M. Kabinet, Kourouma, Kemon (2011). Geology and detailed prospecting project for the firifirini gold deposit SMD concession. Institut Supérieur de mines et Géologie de Boké, République de Guinée, .57p.
[2] Delille f (2012). Search for a charge-by-charge fragmentation prediction for open pit blasting. Ecole des Mines de Paris, France,304p.
[3] YACE I, (1993). Precambrian volcanic-sedimentary complexes in West Africa. Symposium on the Lower Proterozoic, CIFEG.25p.
[4] Dramou, O. (2009). Improved blast drilling parameters at the Lefa mine in the Republic of Guinea. Institut National Polytechnique Félix Houphouët Boigny, Republic of Ivory Coast, 67p.
[5] Bessoles B. (1977). Geology of Africa. Le Craton Ouest-Africain. Exploration of the Deep Continental Crust, France.402p.
[6]. Doumbouya, I. kalil, Fofana, M., Kanté, L (2011). Improvement of the priming method to ensure proper fragmentation of the felled mass during exploitation of the N'Dangara and Boundou-wade CBG plateaus. Higher Institute of Mines and Geology of Boké, Republic of Guinea,.62p.
[7] Bangoura & al (2010) Bangoura, alpha Mano, Camara, M. Cahim, Conté, Y., Planning of felling works with a view to achieving an annual production of 14,132,000t/year at the SMD concession of the Sangarédi mine. Higher Institute of Mines and Geology of Boké, Republic of Guinea.67p.
[8]Cunningham CVB (1993). The Kuz Ram model for prediction of fragmentation from blasting. In: Proceedings of the first international symposium on rock fragmentation by blasting. Sweden,54p.

[9] Noureddine Bendid, (2019). Analysis and prediction of shot quality using the Kuz-Ram method: Application to the career of Kef Azerou Seghir (W-BBA). Abderrahmane Mirade Bejaia University, Algerian Republic.85p.
[10] Coulombez, C. (2007) Coulombez, C. Analysis and optimization of blasting practices in an aggregates quarry. School of Mines of Paris, France., 111p.
[11] Sampou, M., Kanté, M., Mansaré, F (2010). Analysis of the specific consumption of the explosive during blasting work at the Sangaredi mine. Higher Institute of Mines and Geology of Boké, Republic of Guinea., 61p.
[12] Bavogui, V., Camara, G., Traoré, F (2011). Study of the problem of large blocks resulting from blasting in the Rusal/Friguia quarries. Higher Institute of Mines and Geology of Boké, Republic of Guinea.,.51p.
[13] Jaeger, J., Cook, N.G (2009). Fundamentals of rock mechanics. Cambridge university press 117.,.86p.
[14] Kamulete, M. N. (2011). Exploitation of open-cast mines. Democratic Republic of Congo., 2010.254p Leno, P.S., Patrice, B.K. Study of the parameters of the drilling and blasting works at the Siguiri mine with a view to achieving the planned production of the SAG concession. Higher Institute of Mines and Geology of Boké, Republic of Guinea, 67p.
[15] Bah, Abdoulaye Cherif (2010) Organization of the calendar plan for exploitation works on the Parawi bauxitic deposit for a production of 1,000,000t in 2010. Higher Institute of Mines and Geology of Boké, Republic of Guinea.
[16] Doumbouya, A., Traoré Mamadi Sika, Camara Mamadou Bintou. (2011). Sampling and control of geological samples at SAG. Higher Institute of Mines and Geology of Boké, Republic of Guinea,
[17] Minéral info, n.d. Overall overview of the world gold market