The International Journal of Engineering and Science (IJES)
|| Volume || 8 || Issue || 12 || Series I || Pages || PP 01-08|| 2019 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

# Optimization and Estimation of Kipese-Lunsanu Mine Reserves

Banzewa Mutombo A*.,Mosengo N'sole R**,Kabatuswila Panu***,Kanda Nkula ****

** Lecturer at ISPT-Kin /Kinshasa, ** Reseacher at CRGM / Kinshasa *** Professor in faculty of Polytechnic at UNILU, ****Ordinary Professor at Unikin,KabatusuilaPanu, Professor at UPN-Kinshasa.*
*Corresponding Author: Banzewa Mutombo Alex*

**ABSTRACT**

*This survey tackling on optimization and evaluation of resources has been carried forKipese- SMKK and Lunsanu-Surya Minesthanks to its project on the layer of Kipese-Lunsanu copper. The aimis to provide a reportof resources and estimated mineral reserves of this project, the conception of the resulting factory, the financial assessments and subsidiary surveys related to the development of a processing plant by SX/EW/HMS producing ingots of black copper getting up to 95% of copper.*
*For the analysis, Whittle (version 4.4.1) has been used to determine the economic limits of mining exploitation. Whittle used a complete set of technical and financial information mainly the information of the model of the blocks,such as: Information on the slope of the mine, Mining dilution and loss of ore, Costs of extraction,Recuperation of treatment units, Mining exploitation, treatment and production of metals, Costs in capital.*

***Key words**: Optimization, Evaluation of the mineral reserves, Whittle,Kipese-Lunsanu.*

Date of Submission: 27-11-2019 Date of acceptance: 09-12-2019

## I. INTRODUCTION

Kipese and Lunsano's"P.E495&PR 754" perimeters of this article are located in Kambove territory in the province of Haut-Katanga, in the Democratic Republic of Congo, more or less 103 kilometers (as the crow flies) to the northwest from the city of Lubumbashi and more or less 23 kilometers southwest of the city of Likasi.

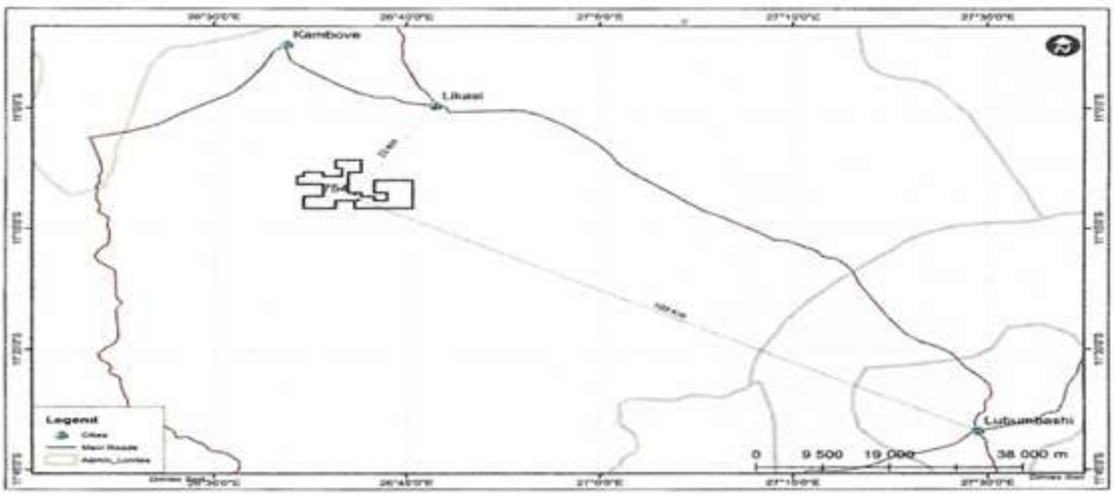


**Figure 1:** Map of PR 754 showing mining squares and summits


**Figure 2:** Map of P.E495 showing mining squares and summit

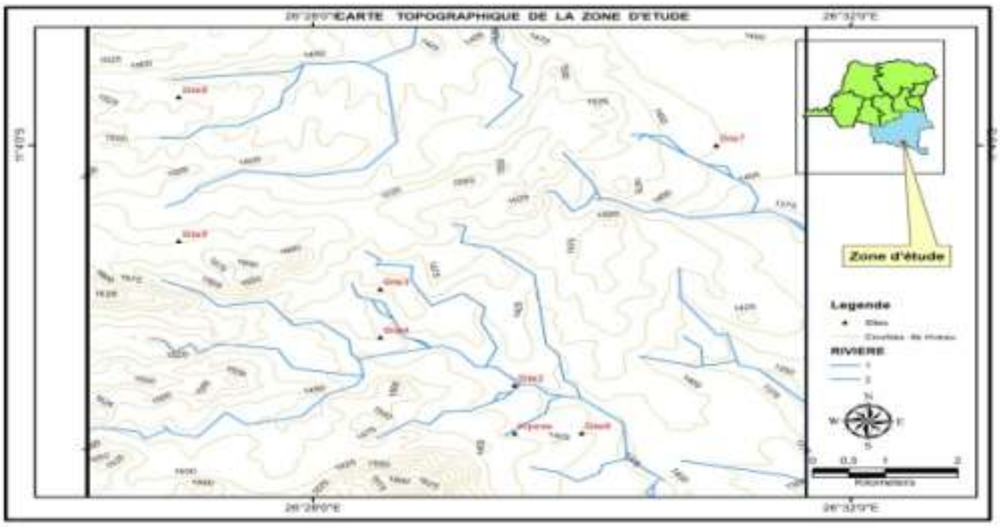


**Figure 3:** Kipese Topographic Map of P.E495

## II. FIELD OF STUDY, MATERIAL AND METHODS

### 2.1. Field of study

The P.E 495 and 754we study in this article shares its borders with the following mining companies MUYA RESOURCES with the PR 758 project in the South, DA FEI MINING with the project PR 12361 in the North and SMKK AND SURYA MINES with the PR 757 project in the East.

### 2.2. Equipment

To carry out this survey, we used the following equipment: GPS, computer tools,whittle software (version 4.4.1) a rope, a decameter, the field book and aerial photos, Surpacsoftware6.6.2 andLeapfrogGeo4.0.The above resource model was prepared in a Whittle compatible version using the latest GEOVIA Surpac exploration software (Version 6.6.2). In addition to density (sg) and metal content attributes; total copper (tcu), the following attributes have been added to meet Whittle's requirements: A. Type of material ("Rock") Whittle requires a character attribute that classifies quality model blocks as waste, ores, or air.

### 2.3 Methodology

#### 2.3.1optimization of the Kipese-Lunsanu open sky mine

The Whittle open pit optimization software (version 4.4.1) was used to determine the economic boundaries of mining. For the analysis, Whittle requires a complete set of technical and financial information. This information includes: Block model information, Information on the slope of the mine, Mining dilution and ore loss, Extraction costs, Recovery of treatment units, Mining, processing and production of metals, Capital costs, Operating costs, including fixed or variable costs ,Metal prices and discount rates for cash flow analysis.

**2.3.2 Resource Model**

The resource block model used in optimizing the open pit is shown below colored on the total copper attribute (% tcu).

Figure 2: Resource Model

A. An attribute called "Rock" has been created and the values assigned are as follows: "ORE", all resources measured and indicated with% tcu> 0.5 "WASTE", all modeled wastes, inferred resources, indicated and measured resources% tcu<0.5 "AIR", all blocks above the topographic surface.

**Table 1:** Block Model abstract

| Attribute Name | Y | X | Z |
|---|---|---|---|
| Minimum Coordinates (m) | -1,300 | -100 | 900 |
| Maximum Coordinates (m) | 300 | 1,900 | 1,380 |
| User Block Size (m) | 12.5 | 12.5 | 5 |
| Min. Block Size (m) | 6.25 | 6.25 | 2.5 |
| Rotation(degrees) | 0 | 0 | 0 |

B. Adjustment Factors for Extraction and Treatment Costs The attributes of the extraction and processing cost adjustment factors were created and assigned to the block model under the attributes "MCAF" and "PCAF" respectively.

The factors take into account the increase of the mining cost with the depth and any additional processing cost based on the types of rocks. The estimated factors are included in the cost modeling worksheets in the Appendix.

C. Slopes an integer attribute "slopes" was created and values assigned according to the different slope regions provided by the geotechnical study. The attribute was used to assign slope angles in whittle.

**2.3.3. Technical parameters**

A. Density Specific gravity has been modeled in the resource model by rock type, as detailed in the resources section of the report.

B. Slope angles there has been no detailed slope analysis of the Kipese-Lunsanu Trough to date. The values used are based on the existing on-site preliminary study.

C. Mining and recovery of processing units Oxygen recoveries through the HMS plant were based on plant performance, while mixed and sulphide recoveries are based on "definitive" test results in SMKK and Surya Mines' own laboratory and Expected recoveries in the Roaster and leach plant. The table below shows the derivation of the overall process recovery for each component of each ore type, calculated from the individual recoveries.

**Table 2:** Process recoveries for different types of minerals

| TYPE | | HMS | Fonderie |
|---|---|---|---|
| **Oxyde** | Cu | *40%* | *80%* |
| **Sulfure** | Cu | *90%* | *85%* |
| **Mixte** | Cu | *90%* | *85%* |

Note that some of these values were subsequently refined for use in the final production model, including the assumption that oxide concentrates could be routed directly to the leach facility. Mine dilution and recovery were assumed at 5% each in the absence of reliable historical data.

D. Limits of production Plant throughputs were based on the capacity of each plant at 90% availability. The mining boundary, as advised by SMKK and Surya Mines, is based on 410 000 BCM of total materials in the rainy season (November to April) and 700 000 BCM during the dry season (May to October). The values used for the above parameters are given in the following table:

**Table 3**: Technical Optimization Parameters

| PARAMETRES UNITES | | | VALEURS | | |
|---|---|---|---|---|---|
| | | | *OXYDE* | *MIXTE* | *SULFURE* |
| **DENSITE** | | t/m3 | Inclue dans le modèle | | |
| **OVERALL SLOPE ANGLES** | | Degré | 35 | 35 | 35 |
| **RECOVERIES** | | | | | |
| Dilution | | % | 5 | 5 | 5 |
| Pertes | | % | 5 | 5 | 5 |
| Taux de récupération totale | Cu | % | 35 | 23 | 7 |
| **PRODUCTION LIMITS** | | | | | |
| Exploitation (Min & Stérile) | | tpa | 15 700 000 | | |
| Traitement (HMS) | | tpa | 2,920,000 | | |
| Traitement (Fourneau) | | tpa | 900 000 | | |

**2.3.4. Economic parameters**

A. Income assumptions
B. The analysis of the evolution of copper prices in the international market over a decade enabled SMKK AND SURYA MINES to retain an average of US $ 5,000 for calculating the revenues and profitability of mining operations.
C. Mining costs estimated unit costs and price assumptions are presented below in the table.

**Table 4:** Financial Optimization Parameters

| PARAMETRES | UNITES | VALEUR | | |
|---|---|---|---|---|
| **COUTS D'INVESTISSEMENT** | | | | |
| | US$ | 47 190 277.00 | | |
| Total | US$ | 47 190 277.00 | | |
| Taux de réduction | % | 12 | | |
| **COUTS D'EXPLOITATION** | | | | |
| Couts variables | | | | |
| Sous-traitant (Chargement et transport) | Stérile | US$/BCM | 5.26 | |
| | Min. | US $/BCM | 5.48 | |
| Forage | | US$/BCM | 0.27 | |
| Cout differentiel du Diesel | | US$/BCM | 0.33 | |
| Explosives | | US$/BCM | 0.64 | |
| Séléctivité | | US$/BCM | | |
| Couts fixes et variables | | | | |
| Supervision de l'exploitation | | US$/annum | 2,820,000 | |
| Exhaure | | US/annum | 2,000,000 | |
| **COUTS DE TRAITEMENT DE MINERAIS** | | OXIDE | MIXED | SULPHIDE |
| Variable | | | | |
| Cout d'opération usine de flottation | US$/t Ore | | 13.63 | 8.77 |
| Cout d'operation HMS | US$/t Ore | 3.92 | | |
| Surya Mines Processing Cost | US$/t Cu | 1,187 | 423 | 423 |
| **COUTS DE VENTE (marketing, shipping, logistics, export taxes)** | | | | |
| | US$/t (Cu) | 539 | 539 | |
| **PRIX DE VENTE** | | | | |
| Base Cu cathode | US$/t | 5000 | 5000 | 5000 |

## III. ANALYSIS AND INTERPRETATION OF THE RESULTS

After the preparation of the block model in Surpacmining, the model was imported into the latest version of the Whittle 4 x Multi-Element Optimization Software (Version.4.4.1) using a minimal practical block size of 25 x 25 x 5m. The imported Whittle block model had a tonnage of 6 290 859 tonnes of ore, which compares very well with the original Surpac model with 6 290 950 tonnes of ore. The metal content attributes imported into Whittle for economic analysis study total copper (tcu). The weighted values of the average grades were exactly the same between the Surpac and Whittle models: 3.49% tCu. A range of revenue drivers has been used to generate a series of nested optimized pits.

An analysis of optimal pit sinks was undertaken, using copper reference prices as presented above. The figure shows the results of the NPV analysis of the updated project at 10% for the best cases, the specified cases and the worst cases. The best case of mining refers to a mining program where each shell is drilled, loaded, mined and slaughtered completely before the next. This is generally impractical since push-backs are usually too narrow.

Worst case refers to a calendar where each bench of the pit is mined completely before starting the next one. This case generates the minimum NPV for the project. The specified case attempts to generate an NPV

(Net Present Value) or VPN (Net Present Value) of the optimal project in an emergency by stipulating a practical pushback program. This means that the first push-back can only take place once at least four benches in the inner pit have been exhausted. Similarly, the second push-back can only begin once four benches of the first push-back have been completed, and so on. With a production limit of 6.2 million tonnes of ore to feed the mill, Whittle's term provides for a production schedule of 10.7 full years. The total exploitable reserve is 6.2 Mt tonnes, at 3.49% Cu, with an overall stripping rate of 4 tonnes of waste for each tonne of ore. The payback period is estimated at around 4 years. The NPV is estimated at US $ 575.2 million.

### 3.1. Optimum Pit Sheil Selection

There are two criteria primarily used for selecting the ultimate pit shell from the range of nested well shells.

1) Maximization of Net Present Value (NPV): This is achieved by selecting the hull of the pit with the highest NPV.Using the case specified above, shell n°21 at the maximum NPV of 575.2M SUS. This criterion is mainly used because the main objective of private companies is to maximize profits.

2) Maximization of mine life: In this scenario, a company may be interested in maximizing the life of a mine as long as possible, provided that a minimum profit margin objectives such as seizing market opportunities and keeping people employed. This is achieved by selecting the shell of the pit at a factor of income of 1. The shell of the Optimum pit with respect to the slope model is illustrated below in Figure 3and 4. DESIGN OF THE MINEThe Whittle pitshell 21 was reimported into the original Surpac block pattern and served as the basis for designing a final pit. The design parameters of the pit used for the final pit are presented below:

**Table5:** Pit by Pft optimization Results

| Pit | Minimum Rev Ftr | Rock Tonnes | Ore Tonnes | Strip Ratio | TCU Grade |
|---|---|---|---|---|---|
| 1 | 0.60 | 13571054,41 | 6004891,33 | 2.26 | 3.37 |
| 2 | 0.62 | 16436600,96 | 6042868,00 | 2.72 | 3.35 |
| 3 | 0.64 | 16989176,76 | 6089310,67 | 2.79 | 3.33 |
| 4 | 0.66 | 17342206,04 | 6127988,00 | 2.83 | 3.32 |
| 5 | 0.68 | 19029565,18 | 6158435,33 | 3.09 | 3.30 |
| 6 | 0.70 | 19130630,84 | 6191142,67 | 3.09 | 3.29 |
| 7 | 0.72 | 19244956,72 | 6228141,33 | 3.09 | 3.28 |
| 8 | 0.74 | 19366882,13 | 6247381,33 | 3.1 | 3.27 |
| 9 | 0.76 | 19481902,51 | 6264277,33 | 3.11 | 3.26 |
| 10 | 0.78 | 19660072,53 | 6281173,33 | 3.13 | 3.26 |
| 11 | 0.80 | 21092826,10 | 6296366,00 | 3.35 | 3.25 |
| 12 | 0.82 | 21517700,16 | 6310176,00 | 3.41 | 3.24 |
| 13 | 0.84 | 22094026,67 | 6330666,67 | 3.49 | 3.23 |
| 14 | 0.86 | 22204317,33 | 6344090,67 | 3.5 | 3.23 |
| 15 | 0.88 | 22306159,98 | 6355031,33 | 3.51 | 3.22 |
| 16 | 0.90 | 22474756,93 | 6366786,67 | 3.53 | 3.22 |
| 17 | 0.92 | 22535352,91 | 6383952,67 | 3.53 | 3.21 |
| 18 | 0.94 | 23951089,65 | 6404034,67 | 3.74 | 3.20 |
| 19 | 0.96 | 24111486,29 | 6412629,33 | 3.76 | 3.20 |
| 20 | 0.98 | 24333305,89 | 6420397,33 | 3.79 | 3.20 |
| **21** | **1.00** | 24353360,05 | 6425688,67 | **3.79** | **3.20** |
| 22 | 1.02 | 24365242,96 | 6428824,00 | 3.79 | 3.19 |
| 23 | 1.04 | 24695308,80 | 6431070,00 | 3.84 | 3.19 |
| 24 | 1.06 | 24698360,32 | 6431864,67 | 3.84 | 3.19 |

| Paramètres | Valeurs |
|---|---|
| Hauteur du talus | 5m |
| Banquette | 3m |
| Angle de talus | 60° |
| Largeur de la route | 12m |
| Degré de la route | 8% (1 in 12.5) |

**Table 6:** Open Pit final parameters

## VI. ILUSTRATIONS

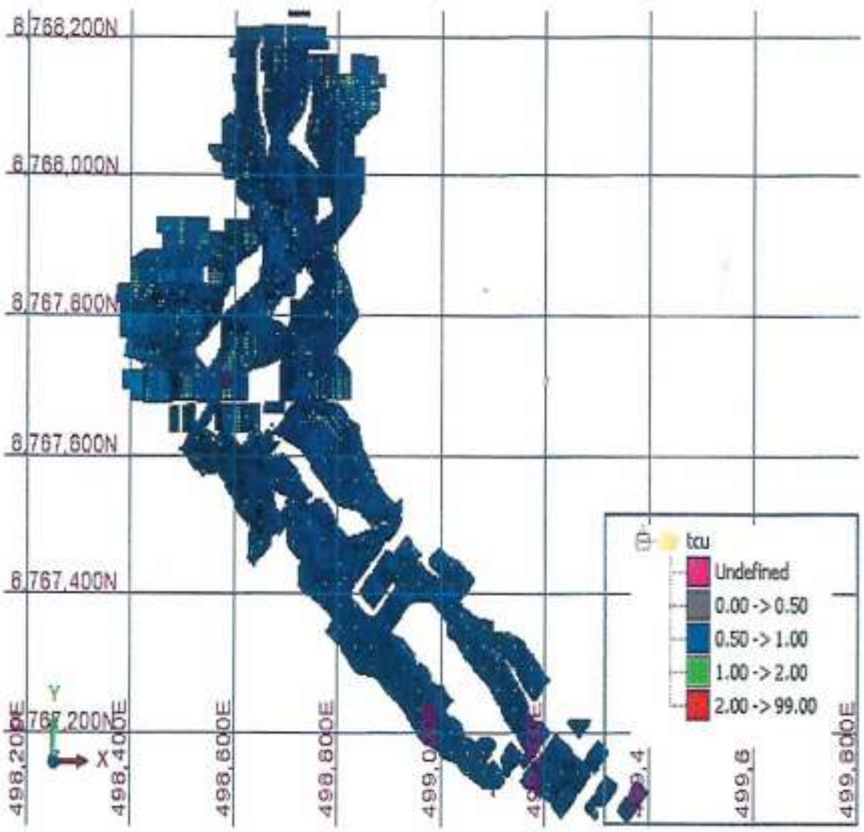


**Figure 2:** Resource model

**Figure 3**:Overview of Kipese-Lunsanu's Optimal Pit and the configuration of the orebody

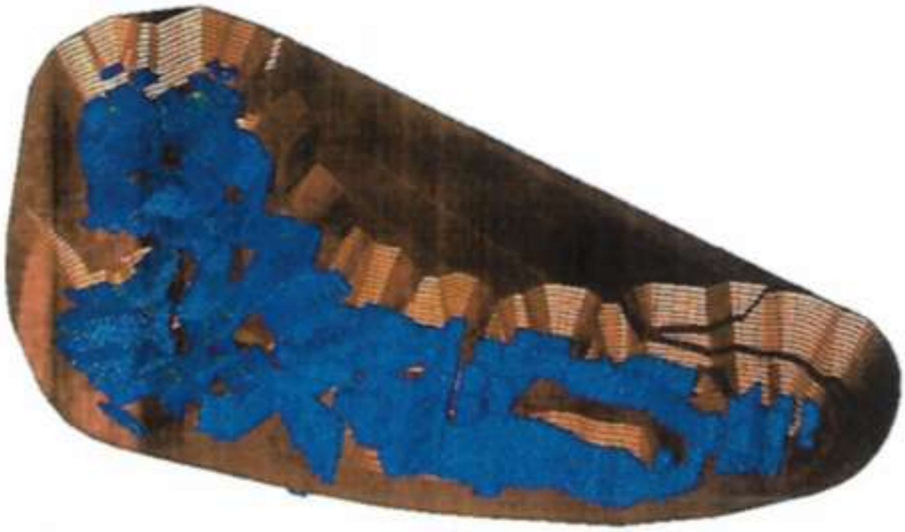

**Figure 4**:Perspective and perspective view of the optimal Lunsano mine

## VI. CONCLUSION

In this paper we optimize and estimate the copper reserves of Kipese-Lunsanu open pit mine, located in Kambove territory, Upper Katanga province in its P.E495-PR754 for SX / EW copper production and HMS. To achieve this, we used Whittle (version 4.4.1) and Overpacmining optimization software to determine economic boundaries, taking into account technical and financial information, the mineral resource model, mining, mining and quarrying.

Recovery of treatment units, production limit, ore density, slope and slope slopes, bank angle, economic parameters. The analysis of the results reveals that: After the preparation of the block model in Surpacmining, the model was imported into the latest version of the Whittle 4 x Multi-Element Optimization Software (Version.4.4.1) using a minimal practical block size of 25 x 25 x 5m. The imported Whittle block model had a tonnage of 6 290 859 tonnes of ore, which compares very well with the original Surpac model with 6 290 950 tonnes of ore.

The metal content attributes imported into Whittle for economic analysis study total copper (tcu). The weighted values of the average grades were exactly the same between the Surpac and Whittle models: 3.49% tCu. A range of revenue drivers has been used to generate a series of nested optimized pits. An analysis of optimal pit sinks was undertaken, using copper reference prices as presented above. The figure shows the results of the NPV analysis of the updated project at 10% for the best cases, the specified cases and the worst cases. The best case of mining refers to a mining program where each shell is drilled, loaded, mined and slaughtered completely before the next. This is generally impractical since push-backs are usually too narrow. Worst case refers to a calendar where each bench of the pit is mined completely before starting the next one. This case generates the minimum NPV for the project.

The specified case attempts to generate an NPV (Net Present Value) or VPN (Net Present Value) of the optimal project in an emergency by stipulating a practical pushback program. This means that the first push-back can only take place once at least four benches in the inner pit have been exhausted. Similarly, the second push-back can only begin once four benches of the first push-back have been completed, and so on. With a production limit of 6.2 million tonnes of ore to feed the mill, Whittle's term provides for a production schedule of 10.7 full years.

The total exploitable reserve is 6.2 Mt tonnes, at 3.49% Cu, with an overall stripping rate of 4 tonnes of waste for each tonne of ore. The payback period is estimated at around 4 years. The NPV is estimated at US $ 575.2 million. Finally, the Whittle pitshell 21 was reimported into the original Surpacmining block pattern and served as the basis for designing a final pit.

## REFERENCES


[1]. SCHOFIELD, N. ET P. ROLLEY [1997]. Optimization of ore selection in mining: Method and case studies. 3rd International Mining Geology Conference Mining", Unpublished PhD Dissertation, FREMPONG-BOAKYE, V. [2004]. "Application of Surpac and Whittle Software in Open Pit Thesis, University of Mines and Technology,Tarkwa, pp. 99-100. Design: A Case Study", Unpublished MSc

[2]. OSTERHOLT, V. AND DIMITRAKOPOULOS, R. [2007]. Channel Iron Ore Deposit, WA and Planning Uncertainty and Risk Management Models, Dimitrakopoulos, R. (ed.), second edition,Implications for Resource Uncertainty"Orebody Modelling and Strategic Mine Australasian Institute of Mining and Metallurgy, Spectrum Series No. 14, 51 pp.

[3]. "Simulation of Orebody Geology with Multiple-Point Geostatistics Application at Yandi

[4]. DIMITRAKOPOULOS, R., C. T. FARRELLY ET M. C. GODOY [2002]. "Moving forward from traditional optimization: Grade uncertainty and risk effects in open-pit design." Transactions of the Institutions of Mining and Metallurgy, Section A: Mining Technology 111(Compendex): A82-A88.

[5]. DIMITRAKOPOULOS, R., L. MARTINEZ ET S. RAMAZAN [2007]. "A maximum upside / minimum downside approach to the traditional optimization of open pit mine design." Journal of Mining Science 43 (Compendex): 73-82. Dowd, P. A. (1997).


Banzewa Mutombo Alex "Optimization and Estimation of Kipese-Lunsanu Mine Reserves" The International Journal of Engineering and Science (IJES), 8.12 (2019): 01-08