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Peculiarities in Setting Norms of Extraction in Underground Ining of Diamond Ore

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Abstract Methodological approach is considered in this article which refer to evaluation of reasonable ore loss and dilution in mineral extraction in underground mining of kimberlite ore deposits in mine “International” and “Mir” of OJSC “ALROSA” concerning to the of descending mining in slices and consolidating stowing in worked-out areas with mechanized (continuous) mining. This work shows us the condition of conformation loss and dilution in mining and also computation algorithm

Keywords Losses, Dilution, The Technique, Classification, Rationing, Planning, Extraction Indicators

1. Introduction

According to Article 23 of the Subsoil Law of the Russian Federation, basic requirements for the rational use and conservation of subsoil include rational use and protection of mineral resources; the most complete extraction of subsoil resources and occurring minerals; reliable recording of recoverable reserves and reserves left in the depths of basic and occurring minerals and associated components in the development of mineral deposits.

2. Topicality

It should be noted that the loss rate and dilution factor in extraction of mineral resources affect the performance of mining enterprises. These factors mark the completeness and quality of mineral extraction from subsoil; they depend on technological process of mining operations and reasonability of technical solutions used in the development of the deposit. The amount of actual loss and dilution of minerals reflects the complex of geological, technological, economic and organizational factors in mining.

Evaluation of reasonable ore loss and dilution is of current concern in setting norms of mineral extraction in underground mining of kimberlite ore deposits.

This is connected with transfer from open pit mining of diamond ore to underground. The kimberlite ore mines in Yakutia are good example of modern underground mining.

In 2011 the authors carried out investigation of rational amount of loss and dilution in the underground mining of kimberlites in the mine “International” of OJSC “ALROSA”.

3. Mining-and-geology Characteristic

Diamond-bearing kimberlite ore represents a subvertical elliptic pipe with characteristic dimensions of axes approximately 100 and 65 m. The depth of the explored reserves is 1220 m.

The ore body is monotonous in its composition, and consists of 93 % of porphyritic kimberlites and autolith kimberlite breccia with unevenly distributed pillars of unaltered massive kimberlites (7 %) which are characterized by medium fracturing degree.

Kimberlites in the pipe "International" are unstable, liable to flaws, peeling off and collapse of walls and roof when they are unsupported during a long period of time. The hardness coefficient is 2-10, according to M.M. Protodjakonov scale.

4. The Mining Method

The system of descending mining in slices and consolidating stowing in worked-out areas with mechanized (continuous) mining is used for excavation of ore in the pipe. Extraction equipment consists of Sandvik Hardrock Miner MN620 and a load-haul dumper EST-6C. Broken ore is delivered by the incline to the chamber for loading into trucks or to the ore passageway.

Ore reserves are divided into excavation layers by height, which are oriented by the long axis of the pipe body.

Excavation of ore layer is performed by pillar mining; a pillar equal the width of two strips is left between the strips, in the main and connecting layers - equal the width of one strip. Pillar recovery is performed if there is one or two edges.

If the height of a strip is 4 m, mining is performed in one stage in continuous face. In the stope the height increases (6-8 m) and there are two stages. In this case, at first a working of 4-5 m high is developed along the entire length of the strip, and after that the reserves of the lower bench of 2.0-2.5 m high are extracted.

Before stowing, on the strips there is formed a fine ore pad 0.15- 0.50 m thick. It reduces seismic impact of the working body of miner on stowing, the risk of joining adjacent strips, and eliminates undercutting of concrete of the base layer during breaking the underlayer.

5. Loss and Dilution Defined

A set of experiments was carried out to determine and evaluate location and sources of ore loss and dilution. The study included a field observation and measurement, a full-scale experiment and statistical processing of obtained data.

The results of the research at the mine "International" showed that the main source of ore loss and dilution during extraction in stope drifts and strips is the loss in "locks", "baseboards" and "terminals" (lock is the place of mineral loss of not broken ore in the roof of the drift along its side; baseboard and terminal is the place of mineral loss of broken ore on the floor of the drift along its side and in areas of adjacent strips).

The analysis of reserves development showed that the quantity and quality of ore loss is determined by the technological process of stoping.

The process of breaking ore directly affects the amount of loss in the rock ore and dilution by rock or stowing material and indirectly it affects the loss of broken ore in formation of baseboards along the strip edges and dilution of ore with stowing material. This is explained by the fact that the contour of stoping strips is wavy.

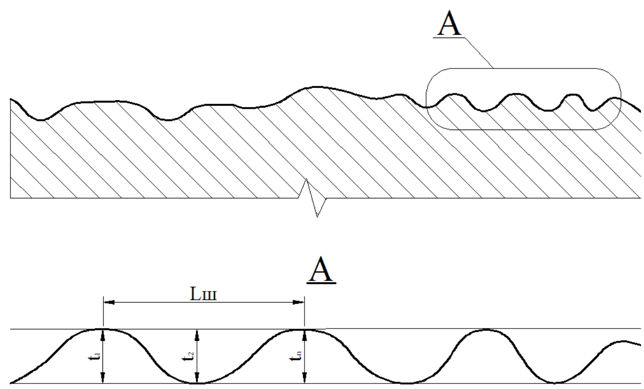
The formation of an ore pad (an upfilling with broken ore on the floor of the working before stowing material) determines the loss of broken ore in baseboards along the working edges.

There is a loss of broken ore in baseboards along the edges during discharge of broken ore and cleaning-up.

In addition, the loss and dilution of ore is determined by mining and geological parameters (slope angle of the ore body, ore-rock contact, etc.), technical parameters of equipment for breaking ore (shape and size of miner's jib, length and width of miner) and its discharge (width and bucket capacity of load-haul dumper), and such process parameters as order of mining layers and stoping strips, location of cutting drifts, parameters of strips and drifts.

6. Theoretical and Empirical Results

Research has shown that the form of edges of stoping strips becomes curving during breaking ore by cutting heads of selective heading boom-ripping machines (Fig. 1a). The complexity of contact and its sinuosity is determined by the area of stochasticity. This area is defined by the distance between lines drawn tangent to the "projectures" and "hollows" in the ore body. The width (t) and wave length (*Lu*) was measured by the control points of sinuosity area (Fig. 1a).



a

b

Figure.1. Edge sinuosity: a – diagram of edge sinuosity; b- example of actual edge sinuosity (photo

Subsequently the outline of the ore edge is repeated by stowing material (Fig. 1b), which is exposed in mining of the adjacent strip.

The calculated parameters of the stochasticity area help to determine the loss and dilution of ore in mining reserves on the technogenic contact ore-stowing.

To calculate parameters of the stochasticity area, we used experimental data obtained from surveying in the mine "International".

The results of mathematical treatment of statistic data are given in Table. 1.

Table 1. Parameters of stochasticity area

№	Parameter	Values	
		Width of the stochasticity area (*t*)	Wavelength (*Lш*)
1	Number of measurements	152	307
2	Average, m	0,305	0,493
3	Standard deviation	0,107	0,107
4	Coefficient of variation, %	35,35	21,78
5	Excess kurtosis	3,75	6,38
6	Mode	0,375	0,555
7	Parameters adopted for setting norms of ore loss and dilution, m	0,3	0,5

According to data given in Table 1 we can predicate that there are mostly average or close to average values of width of stochastic area t = 0,3 m and the wavelength $Lш$ = 0.5 m. Therefore, we can use the obtained values for setting norms of extraction.

Loss of broken ore in baseboards is formed along the working edges during formation of ore pad by a load-haul-dumper (Fig. 2). The main cause of such loss is adherence of technological gaps for safe movement of a load-haul-dumper along the working.

The experimental assessment of the loss in baseboards included measurements of width and height of baseboard in the strips prepared for stowing, the natural angle of slope in baseboard and subsequent mathematical treatment of obtained data (Table 2).

Figure2. Experimental measurement of ore loss in baseboards

Ore loss at the end of the first and stop workings is characteristic for the considered working method. The loss depends on the angle between the working and geological contact surface and the slope angle of the ore body.

To determine the characteristics of the geological contact surface, we made conformance evaluation of design and actual contours of geological contact of layers. Contour of geological contact along the design working layer was determined from geological sketches of actual contact of overlying soil layer on a scale of 1:200 made by Geological Survey of the mine “International”.

Table 2. Measurement of baseboards of broken ore along the concrete edge

№	Parameter	Value		
		Width, m	Height, m	Natural angle of slope, degree
1	Number of measurements	178	178	178
2	Average, m	0,403	0,447	47,98
3	Standard deviation	0,084	0,082	-
4	Coefficient of variation, %	20,97	18,49	-
5	Excess kurtosis	3,29	2,90	-
6	Mode	0,522	0,412	-
7	Parameters adopted for setting norms of ore loss and dilution, m	0,4	0,45	48,00

It was found out that the design parameters of the geological contact contour in the layers - the incidence angles of the geological contact (α) and the impact angles of geological contact (ε), which are taken for feasibility study of normative quantities of ore loss and dilution, are significantly different from actual angles, detected only after working of ore reserves in some strips and split drifts in the geological contact.

Analysis of the results showed that the average difference between the angles of design and actual values is 4.83°±0.34°. The average angle of working with geological contact is 50÷55°.

A significant difference of the measured angles (≈ 5°) affects extraction values and that is shown in calculations (Table 3). In the table the ore loss (L) and dilution (B) are defined by criterion of maximum profit of a ton of gotten balance reserves, for working the layer.

Table 3. Extraction values during changing the impact angle of working and geological contact

№	Impact angle of working and geological contact (ε), degree	Loss in optimal contour (П), t	Dilution in optimal contour (В), t	Deviation, %	
				П	В
1	50	19,21	57,73	25,88	13,35
2	55	15,26	50,93		

Objective uncertainty of the geological contact on design stage of mining operation determines mismatch of the design quantities of ore loss and dilution, calculated from the technical and economic criteria [1,2] and the values of actual mining on geologic contact surface in the end of the working. It is explained by the fact that it is impossible to ensure technical and technological accordance with calculated planning amount of ore loss and dilution.

This can result in exceeding actual degree of extraction compared with the target, i.e. the formation of excessive ore loss and, consequently, penalty in accordance with provision 1.1.18 “Branch regulations ...” [2].

7. Methodology

Based on the above and provision1.3.6 of “Branch regulations ...” [2], the loss and dilution standards must conform technical standards, the mining operations must be at the ore-rock contact in the end parts of working without ore loss in the solid ore, which ensures a high degree of mineral extraction from subsoil and safety of mining operation.

In this case, the specified value of undermining from the end of the working is defined from the expression:

$$B_{n(m)} = \frac{b_в \cdot R^2 \cdot ctg\alpha + b_в^2 \cdot ctg\varepsilon \cdot \left(h_в^2 + \left(h_в^2 ctg\alpha \right)^2 \right)^{0.5}}{2}$$

$$-0{,}43 \cdot \left(h_в \cdot (1 + ctg\alpha) + b_в \cdot (1 + ctg\varepsilon) \right) R^2, м^3,$$

where $b_в$ – width of working, m; ε – impact angle of working with geological contact surface, degree; α – angle of slope of ore body, degree; R – radius of corner of working contour, m; $h_в$ – height of working, m.

In addition, the results of studies showed that the contour of working made by selective heading miner with cutting head (jib) has a curvature in the angular parts of the workings. These curvatures are made by the front part of the jib during turning the boom of the miner and that significantly affect the loss of mineral in the “locks”.

The experimental research included a full-scale measurement of the curvatures in the workings where a miner with a jib diameter 1050 mm is used, and the base layer - with a jib diameter 1400 mm. The research resulted in dependence of radius of corner in the angular parts of workings and parameters of miner and the width of working:

$$R = R_{cmp}^{0,5} \left(d / b_в \right)^{0,75} - 0{,}08 R_{cmp}$$

where R_{cmp} – turn radius of a miner boom, m; d – diameter of a miner jib, m.

8. Conclusion

1. Standards of ore loss and dilution are the basis for planning extraction rate and quality criteria of mining. The actual ore loss and dilution reflects the complex geological, technological, economic and organizational factors in mining enterprises.

2. In the result of their research the authors found that the amount of loss and dilution of kimberlite ore is mainly influenced by stopping operations: breaking, loading, cleaning-up and forming an ore pad.

3. Irregular course of ore walls in chambers characteristic for the stochasticity area, affects greatly the loss of minerals in the solid ore. The width of the stochasticity area in mine “International” is 0.3 m and the wavelength is 0.5 m.

4. Loss of broken ore in baseboards depends on irregular course of the wall and the angle of internal friction of mined rock.

5. The working contour of continuous mining has rounded corners. The ore lost in these rounded corners is the loss in “locks”. The amount of loss in the locks increases with increasing the radius of curvature, which depends on diameter of a miner jib, turning radius of a miner boom and width of working.

REFERENCES

[1] Vokhmin S.A. Planning of extraction rate in underground mining of mineral deposits / S.A.Vokhmin, U.P.Trebush, V.L.Ermolaev // Monograph – Krasnoyarsk, KSAoNFM&G. - 2002. - 160.

[2] The branch regulations on setting the norms for determination and recording of loss and dilution of ore and sand in mines of the USSR Ministry of Metallurgy. - M.: Gosgortechnadzor, 1975 - 127.