RESEARCH ON THE REDUCTION OF INDICATORS OF ORE LOSS AND DILUTION IN A COMPUTER MODEL

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Abstract. *The effectiveness of mining minerals and ensuring the profitability of the enterprise is always one of the pressing issues, and this problem cannot be solved without new technologies, innovations. It involves the modernization of technical means, the automation of all production processes or the development of new, modern methods of their organization. Including, computer technology, Mathematical, Physical Modeling is one of the most effective solutions in the present day in preventing the consequences of economic, social and environmental risk that may arise, providing the opportunity to predict the processes of mining, extraction, transportation of ore. This article explores the computer model of reducing loss and dilution.*
Keywords: *ore, enclosing rocks, recovery, loss, dilution, underground mining, sublevel caving, blastholes, model, economic damage.*

Introduction

The economic efficiency of the extraction of mineral reserves largely depends on the degree of loss and dilution, the normalization and planning of which is one of the most difficult tasks for rational and effective use of the subsurface[1]. Raising the potential of the mining and metallurgical industry is carried out at the expense of increasing the technical and economic indicators of mining enterprises.The effectiveness of the extraction of mineral deposits depends on several factors, the analysis and management of which has a positive effect on the activities of the mining enterprise [2,3]

The loss directly affects the activities of the mining enterprise, expressing the degree of rational use of the earth crust. Funds allocated for the search for a mine, mining, construction of a mining enterprise, the creation of infrastructure, capital investments are spent a certain amount inefficiently as a result of the loss. Alternatively, the destruction causes a decrease in mine's productivity, a decrease in balance reserves, as well as the operational endurance in the plan. With increasing loss, the profit that a mining enterprise receives decreases inversely proportional to it (B~1/P). All of the above negatively affects mine's ability to compete in the world market, leading to an increase in the cost of final product. Dilution is considered one of the main sizes that characterize the indicators of mineral extraction [4-6].

The dilution, along with the ore, causes an increase in excessive unproductive costs for the extraction, transportation and processing of the waste rocks to the enrichment factory, as well as mining work to achieve the amount of metal in the plan, causing significant economic damage. The profit received by the mining enterprise will disproportionately decrease to it as the quality of ore increases. Reducing the dilution by 1% will lead to a decrease in the cost of ore by 3.8%. According to the calculation work, the damage seen from 1% dilution is greater than the damage seen from 1% loss, varying differently according to mining systems [5].

Most of the currently existing methods of normalizing loss and dilution do not allow a reliable assessment of the level of mining indicators. 3D modeling in mining-geological information systems allows you to increase the level of reliability of the value of mining indicators[7]. As a solution to such problems, the results of the study before designing the technology for mining one of the blocks of the Kyzylolma mine are presented(Figure 1). The main factors affecting ore loss and dilution in the Kyzylolma mine are: the state of the enclosing rocks; ore extraction; ore drawing[8]. In ore mining, there is the possibility of predicting the indicators of loss and dilution generated by the contact of ore and enclosing rocks through a computer model, and the profit and economic damage of the enterprise can be assessed in advance[9,10].

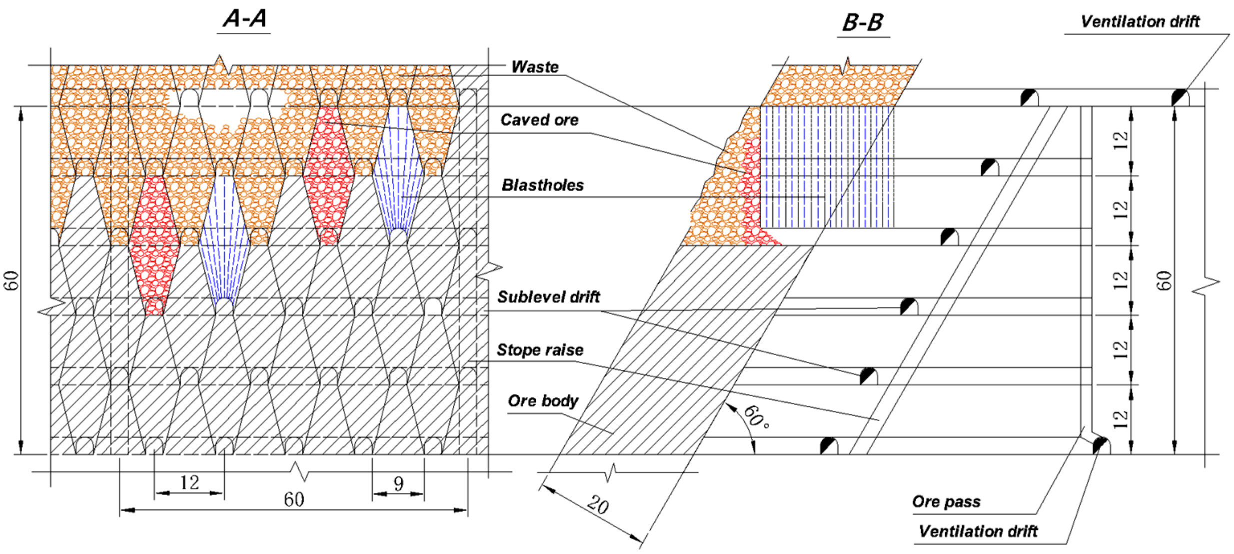

Figure1. Sublevel caving method with a diamond shaped slice and front draw

Methods

A computer model for determining contact loss and dilution in ore mining was developed in the AutoCAD 3D program. The model analyzes changes in extraction indicators when drilling and blasting work is carried out in 3 different cases. Below are the necessary initial data for the development of a computer model of determining the indicators of loss and dilution that form in the contact of ore and enclosing rocks(Table 1).

Table 1.

Indicators of the mining block

Indicators	Value
Block height, m	60
Slice height, m	24
Sublevel height, m	12
Burden interval, m	2
Dip angle of ore body, ° grade	60
Ore density, t/m^3	2,55
Enclosing rock density, t/m^3	2,50

Several trapezoidal shapes are formed, which have a complete volume if the amount of ore loss and enclosing rocks on the hanging wall and footwall of the ore body is combined, respectively, leading to dilution.

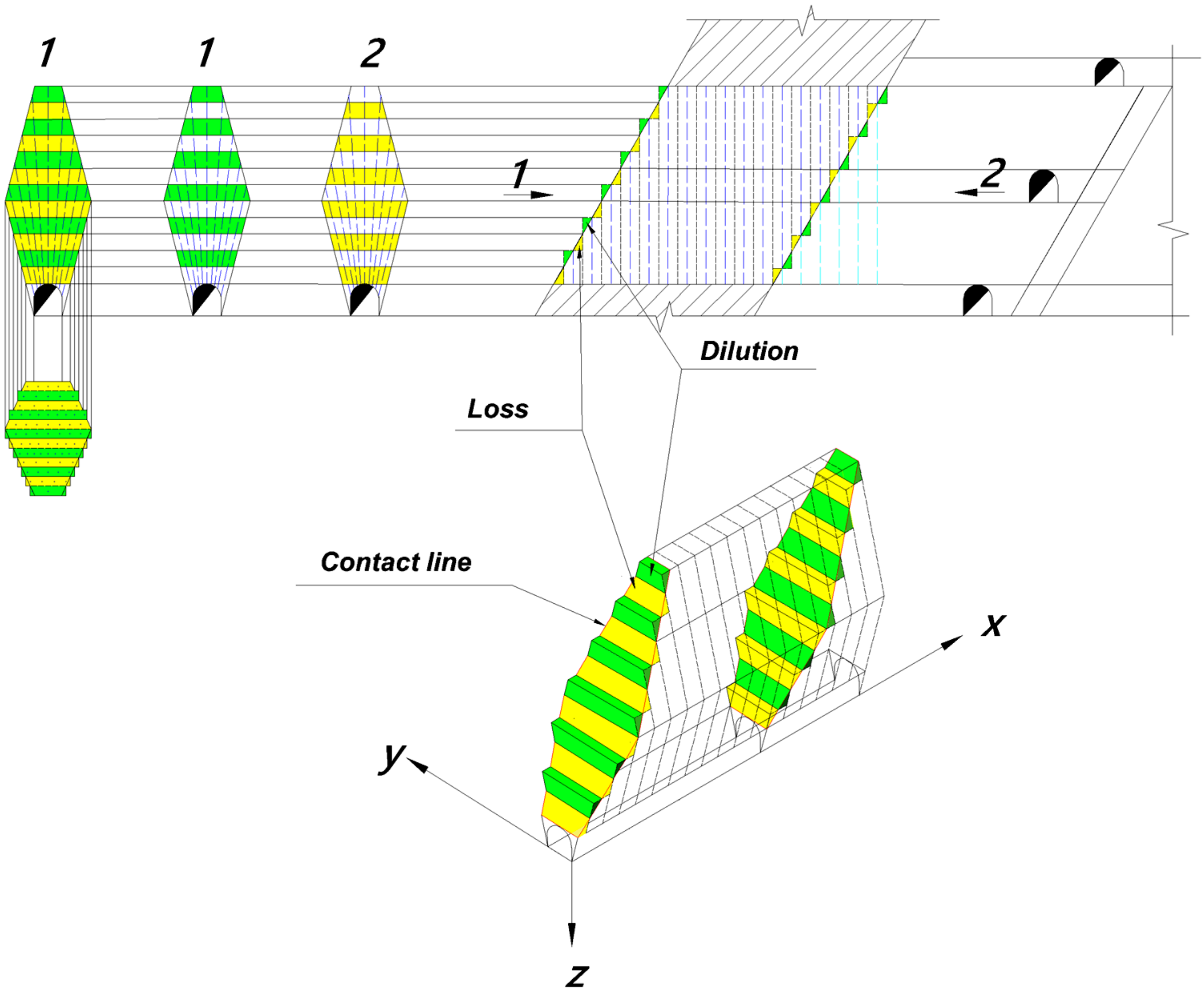

Figure 2. Ore loss and dilution in contacts on the hanging wall and footwall of the diamond shaped slice for option I

The enclosing rocks leading to dilution and the volumes of ore loss are determined by these formulas:

$$V_{\text{В}_n} = S_{\text{В}_n} \cdot m_{\text{в}},$$
$$V_{P_n} = S_{P_n} \cdot m_{\text{п}}$$

here $S_{\text{В}_n}$, S_{P_n} is the surface of the enclosing rocks that cause dilution and ore loss trapezoids; $m_{\text{в}}$, $m_{\text{п}}$ is the thickness of the enclosing rocks that cause dilution and ore loss trapezoids.

The amount of enclosing rocks that cause dilutin on the hanging wall and footwall B_{hw} and B_{fw} is determined by the following formulas:

$$\text{B}_{\text{hw}} = \frac{S_d \cdot L_{\text{hw}} \cdot \gamma_{\text{т}}}{2}$$
$$\text{B}_{\text{fw}} = \frac{S_d \cdot L_{\text{fw}} \cdot \gamma_{\text{т}}}{2}$$

here S_d – surface area of diamond shaped slice, $L_{\text{hw}}, L_{\text{fw}}$ – horizontal projection length of the hanging wall and footwall contact, m.

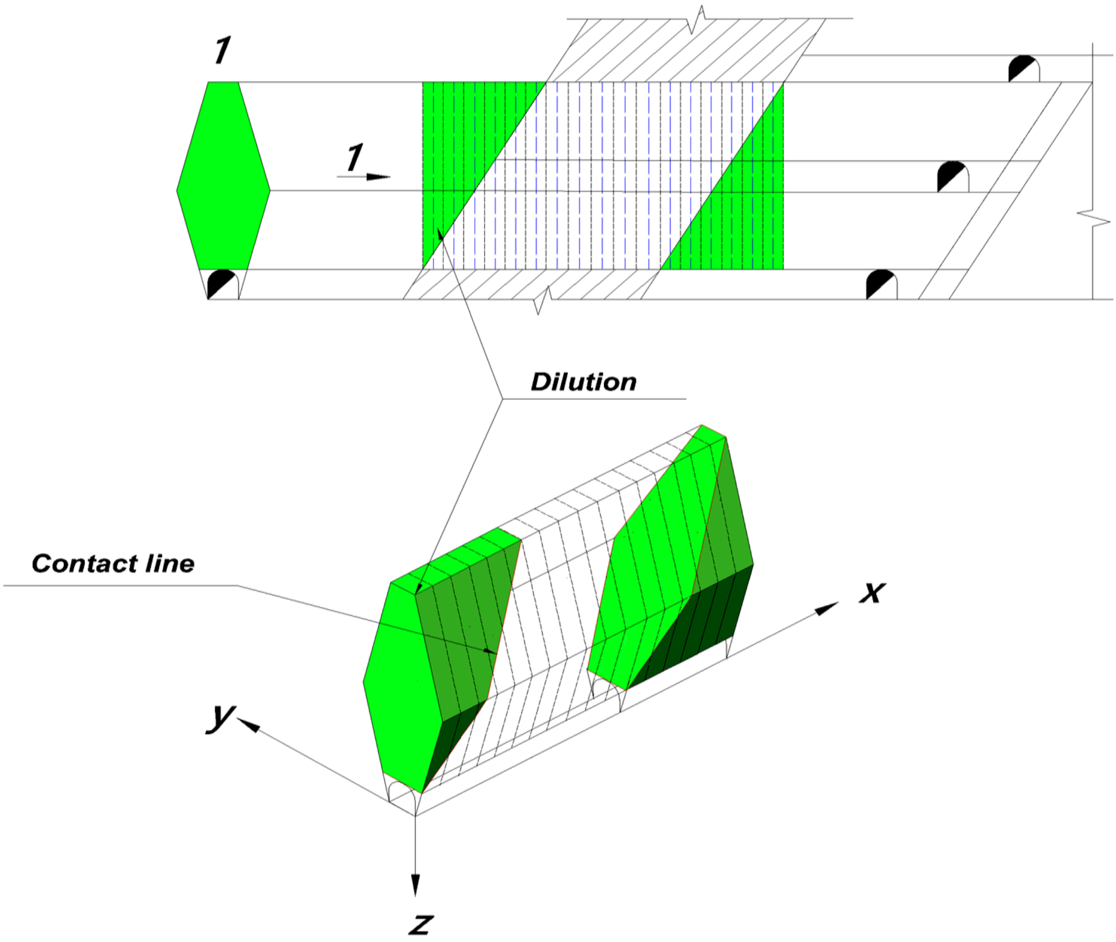

Figure 3. Ore loss and dilution in contacts on the hanging wall and footwall of the diamond shaped slice for option II

In all models, the direction of drilling and blasting work is taken as a basis in managing the quality of ore. In model I, on the hanging wall and fo otwall of the ore body, the boreholes are drilled and charged from the workings to the contact line of the ore body and enclosing rocks(Figure 2). In Model II, boreholes are drilled and charged on the hanging wall and footwall of the ore body up to the panel ceiling in the workings(Figure 3). In Model III, on the footwall of the ore body, the boreholes are drilled and charged from the workings to the upper side of the slice(Figure 4).

The indicators of loss and dilution on the presented models were determined by computational work(Table 2).

Table 2.

Mining indicators by models

Indicators	Model I	Model II	Model III
Amount of balance reserves in block, t	212003	212003	212003
Ore loss, t	4255	-	2127

Enclosing rocks, t	4075	108 750	58450
Mined ore, t	207748	212003	209876
Ore loss, %	2	-	1
Dilution, %	1,9	51	27
Recovery factor, %	98	100	99

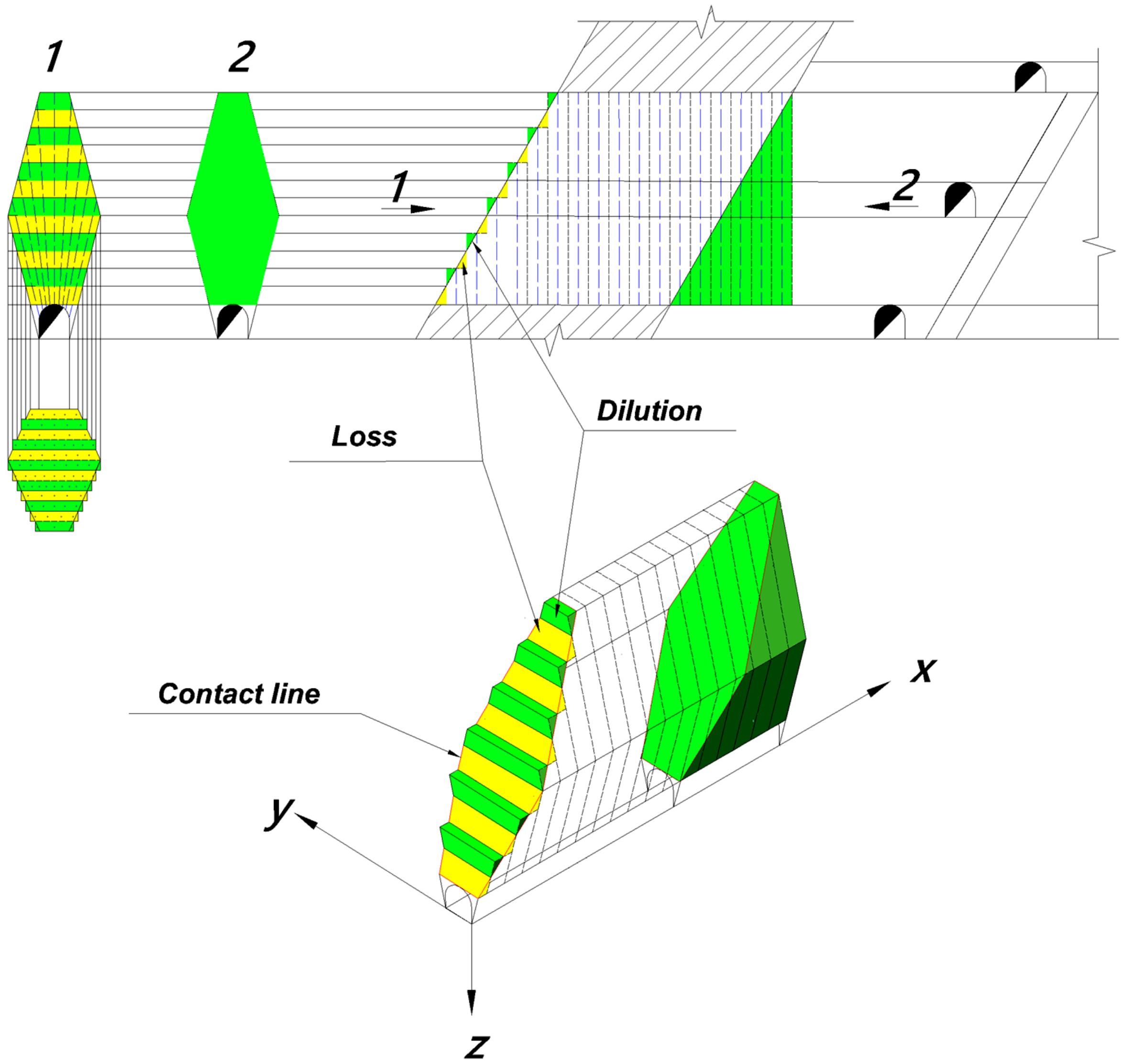

Figure 4. Ore loss and dilution in contacts on the hanging wall and footwall of the diamond shaped slice for option III

Results

The specific damage caused by ore loss is determined as follows

$$u_l = L(1-L)\varepsilon`\left(\sum_{i-1}^{n} \alpha_i p_i - \sum C_{etp}\right), \$./t$$

here L – is the coefficient of ore loss during mining; α_i – is the content of the i-th component in the ore(%); p_i – the price of the i-th metal, \$./t; ε' – is the metal extraction coefficient during ore processing; ε'=0.65-0.9; C_{etp} – the total cost of extraction, transportation and processing of 1 ton of ore.

Total damage from the loss of part of the ore reserves

$$U_l = u_l\ Q_b,\ \$.$$

here Q_b – is the amount of balance ore reserves to be excavated, t.

The damage caused by the dilution of ore, in essence, characterizes the additional costs of processing production caused by the deterioration of its quality. To compensate for the decrease in the metal content in the extracted ore mass, it is necessary to increase the cost of mining, transportation and processing of additional ore[11-13]. As a result, the total costs for the entire mining and metallurgical complex of production are also increasing.

The specific economic damage from ore dilution can be represented by the sum of additional (unproductive) costs of extraction, transportation and processing of enclosing rocks and lean ores mixed with the balance ore, reducing the quality of the extracted mineral product:

$$u_d = \Sigma C_{etp}\ D,\ \$.$$

The total damage caused by ore dilution is determined as follows

$$U_D = u_d\ Q_c,\ \$.$$

here Q_c – the amount of rocks clogging the ore, which determines the decrease in its quality.

Discussion

Among all the models, the choice and justification of their option, which is optimal for a mining enterprise and has high efficiency indicators, is carried out by comparing their technical and economic indicators(Table 3). This takes into account not only the indicators of mining, but also the economic damages caused by losses and dilution.

Table 3.

Technical and economic indicators of models

Indicators	Model I	Model II	Model III
Ore loss, %	2	-	1
Dilution, %	1,9	51	27
Damage from the loss, $	1263537,88	-	657209,3
Damage from the dilution, $	3625,25	2591673,07	726 385,87
Total damage from the loss and dilution of ore, $	1267163,13	2591673,07	1388595,17

The results of the analysis of the above models show that despite the fact that the mining indicators for the II and III models are slightly higher than for the I model, the overall damage caused by losses and dilution in them is much higher. In order to increase the economic and quality indicators of the mining enterprise, it is recommended to apply model I.

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