Justification of underground gold placer development parameters for the Konevinsky deposit

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Justification of underground gold placer development parameters for the Konevinsky deposit

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Abstract. The Konevinsky deposit is located in the Eastern Sayan highlands in a poorly developed area of the Far North. The deposit is being developed by Khuzhir Enterprise LLC. The deposit is a thin steeply dipping vein characterized by the extremely irregular metal content and a low ore-bearing coefficient. Ore is extracted using the underground method at a depth of 300 m in the permafrost zone. Steeply dipping ore deposits with a complex morphology and a discrete distribution of metal are developed using the ore shrinkage system which involves longwall stoping without supporting enclosing rocks. Longwall stoping with a small extraction space eliminates rock cleavage along the cracking system that results in high dilution of ore (up to 67%). Due to this fact, the existing mining geotechnology of balance reserves development has become unprofitable and production has been suspended. The purpose of this article is to identify new parameters of the balance reserve extraction method that will improve quality of ore and increase profitability of metal production. Studies of geological environment and analysis of causes of ore quality deterioration showed that along with the excessive sticking of wall rocks under the minimal excavation width of 1m, ore dilution is affected by inrushes from block sides with an increased rock fracturing and an internal chocking with low-grade ores. These disadvantages can be eliminated using sublevel drifts, the breast-and-bench method and a descending order of reserves excavation. The article substantiates and develops parameters of the system which can increase ore production quality without increasing production costs.

1. Introduction

The Konevinsky deposit is located in the highlands of the Eastern Sayan Mountains in the poorly developed area of the Far North. The Konevinsky mining company is developing the gold placer in hard geological conditions.

Vein-type ore deposits are represented by steeply falling (the average falling angle is 75 °) thin quartz veins with a thickness of 0.01–0.07 m in the zone of ore berezites; their average thickness is 0.4 m; they are characterized by unstable thickness and extremely uneven metal content. The deposits have a pillar-like distribution along the length - up to 300 m and the falling - up to 450 m.

The rocks are represented by gneiss-shaped berezites, berezitized granodiorites, and schistose microdiorites. In the rocks, two systems of cracks are dominant: a system of steeply falling cracks subparallel to the contacts of the ore deposit and a system of sloping shallow cracks. The concentration of cracks is discrete.

Mining operations are carried out in the permafrost zone, the temperature of the rock mass varies from minus 4 °C at the horizon of +2365 m to 0°C at +2165 m. There is no water inflow in the mine.

Ore and host rocks are of medium stability. According to the Protodyakonov's scale, their strength is 10-15.

Ore balance reserves were mined using the ore storage system, and reserves below the horizon of +2315 m – field preparation and self-propelled equipment [9]. The use of the latter is more productive. The main positive factor is a self-flowing ore delivery to dump trucks. An analysis revealed that when the extraction space is less than 1 m, it will inevitably become jammed from the oversized secondary dilution, and the resulting ore freezing increases costs for its elimination. At freezing temperatures, ore freezes which leads to its loss and reconfiguration of the mining system. The inability to maintain the sides with fasteners and pillars while maintaining the minimum extraction capacity and the continuous extraction of balance reserves deteriorated ore quality. The total dilution of ore reached 67%.

It is necessary to improve the deposit development method. For this purpose, researchers of Irkutsk National Research Technical University have studied the geological environment and the geomechanical state of the rocks while conducting ore mining operations and developed parameters of the effective mining method.

2. Methods

Studies of the geological environment revealed that the distribution of metal content in ore is uneven and discrete. Low-grade ores account for 14.5%.

At development depths of up to 300 m, the stress-strain state was determined using the slot unloading method. Calculations using mathematical modeling established parameters of permissible exposure of the sides of excavation which showed that the rock was stable and not prone to collapsing during overflow spans up to 100 m (two levels) with a block width of 50 m which has been confirmed by the mining experience at negative temperatures and depths of up to 300 m. At a depth of more than 300 m and in areas of increased pressure, the distance is 50 m, the width of the block is 20 m. The study of fractures revealed that the intense fracturing areas are discretely located and do not exceed 60% of ore mining balance reserves. After blasting, the near-contact host rocks are destroyed to an average depth of 0.3 m due to the subparallel and secant fracturing. Permafrost does not resist this type of disturbance due to stable lateral rocks; moreover, it affects ore freezing in the wedged rock outfalls. These areas contribute to the increased dilution. The ore storage system is ineffective due to the involvement of low-grade ores and 24% excess of the standard dilution. The short shrink stopes at depths of more than 300 m will have a negative effect on the productivity.

3. Technology

As a result of research and experimental works carried out by Irkutsk National Research Technical University and Khuzhir Enterprise LLC, a sub-level ore breaking system with a descending order and a support anchoring system was developed for balance reserves of thin steeply dipping gold-bearing veins.

When mining an ore deposit with a thickness of 0.4 m, only hole blasting can be applied. To reduce the seismic effect of explosion and the ability to control ore deposit direction deviation, the length of the hole was less than 1.5 m. Ore is broken on the slopes with heights of no more than two meters (Figure 1). The height of the slope has been chosen to maintain stability of the sides. This type of blasting is productive and makes it possible to carry out drilling operations without excessive blasting of lateral rocks [1-14].

The number of slopes above the sub-level is no more than two. The advance of ore excavation on the lower slope should be at least 3–3.5 m, and the advance of the sub-level should be at least 3 meters. Such an advance is required to ensure safety of the driller and monitor stability of the zone of drilling operations. The advancement is carried out from the ore pass to the blasting flank border. The left sub-level pillar with a height of 1.6 m is cut by windows for ventilation. It is mined in a backward order, taking into account off-balance areas.

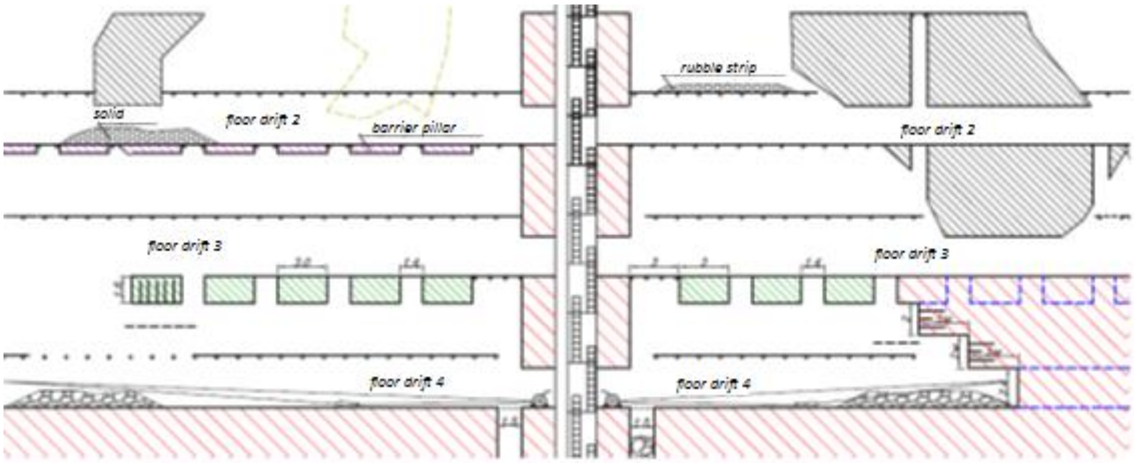

Figure 1. Balance reserves excavation using the breast-and-bench method.

The minimum extraction capacity is 0.6 m; when excavating the pillar, it is 0.5 m. This minimum extraction space will allow you to make working places safe, drill holes using portable punchers and move the block.

Ore is delivered using a scraper installation. The size of the sub-level drift cross-section is determined by the size of a passage for the staff, the size of the scraper bucket, the ore capacity after breaking off the sub-level. The length of the sub-level drift depends on the conditions of optimal productivity of a scraper delivery, the ore deposit curvature and host rock stability. For example, with a drift length of 30 m, permissible stresses are reduced by 1.4 times compared to a length of 50 m.

Reserves are extracted in a descending order. The total sub-level height is 8 m. This maintains stability of the side rock exposure with minimal maintenance costs and localizes the extraction space from the working area. After the excavation, the waste space is localized from possible collapses by storing safety platforms above the sub-level drift. In addition, by blasting the lateral rocks, regular rubble strips that will protect against the air wave and serve as artificial malleable pillars are formed. A barrier against possible collapsing is created as well. In the cryolite zone, the rubble strip is spilled with water, after which the rock freezes and an artificial pillar is formed; in thawed rocks, it is spilled with cement milk. The rubble strip can be replaced with a strip of barrier pillars and closed windows. Calculations show that it is enough to erect a rubble strip through three sub-levels, i.e. at a distance of 24 m. Rock stresses do not exceed permissible values at the ore mining sections of 30 × 24 m in size, and the sides remain stable at depths of more than 300 m with positive temperatures of the rock.

Mining operations are carried out on both sides. Depending on the geological environment, this order allows for changes in the length and height of mining, rock and off-balance pillars, and selective ore extraction in places with a deposit capacity of less than 0.3 m. The method eliminates a possible penetration of rocks. In addition, this excavation order makes it possible to control the rock pressure [11].

Before breaking fractured host rocks prone to collapsing, the roof is fastened with mineral-based metal anchors through the strips (Figure 2).

Based on the rock stability, the equipment operation, the staff and cargo movements, a level height of 70 m is recommended [10].

Ore is loaded through a hatch with a sector lock to a dump truck.

The pillars remaining after the extraction are extracted in a descending order in pairs from the bottom up.

Preparatory works are carried out using the tunneling system. At the horizons, there are ore and field drifts.

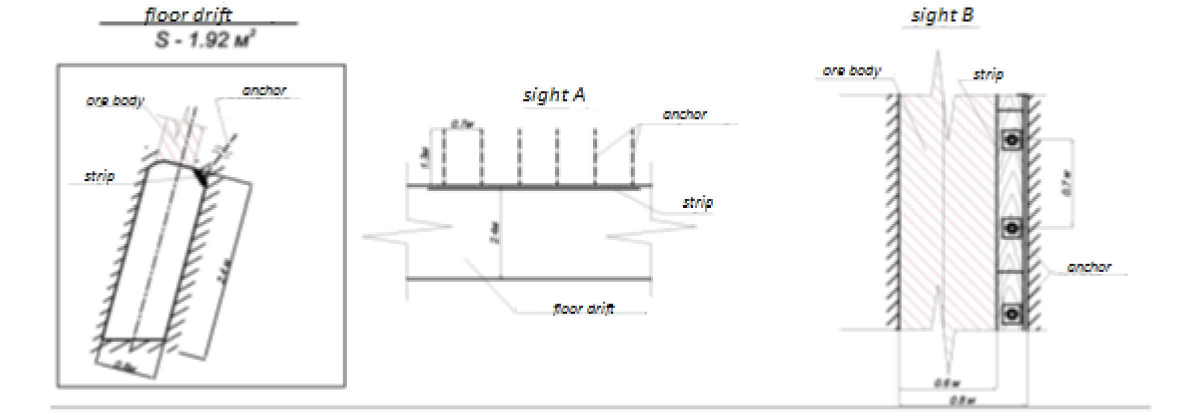

Figure 2. An anchor support for the sublevel drift top rock before breaking.

Figure 3. Working suspended platforms.

Figure 4. Wooden working and safety platforms.

4. Conclusion

The performance of the system in comparison with the ore storage one is due to

– the reduced volume of mining and preparatory works per 1000 tons of balance ore;

– a flexible mining system that contributes to leave rock and off-balance pillars, as well as to conduct selective mining, and change the size of the sub-level;

– reduced mining capacity by 1.9 times;

– application of mechanized raising excluding walling;

– loading of ore from ore passageways without loaders;

– the reduced volume of rock transportation and ore processing per gram of metal mined.

The system can improve ore quality, productivity per shift and reduce metal production costs.

References

[1] Agoshkov M I and Malakhov G M 1966 *Underground mining of ore deposits* (Moscow: Nedra) p 663

[2] Agoshkov M I, Mukhin M E and Nazarchik A F 1960 *Development systems for vein deposits* (Moscow: Gosgortekhizdat) p 376

[3] Baklashov I V 2004 *Geomechanics: Textbook for universities* (Moscow: Moscow State Technical University) p 208

[4] Bolikov V E and Konstantinova S A 2003 *Forecast and ensuring stability of mining* (Ekaterinburg: Ural Branch of the Russian Academy of Sciences) p 374

[5] Brink A 1983 Research on prediction of rock bursts at Western Deep *Levels Journal of the South African institute of mining and metallurgy* **l** pp 1–10
[6] Coates D F 1966 Predictions and measurement of pillar stresser Ignatieff *Canada Mining* **J.87(1)** pp 50–56
[7] Galchenko Yu P 2005 Highly efficient technology for the development of steeply dipping gold vein deposits *Gold mining industry* **5 (11)** pp 18–23
[8] Glotov V V 2007 Technology of development of vein deposits with variable capacity *Mountain news and analytical bulletin* **4** pp 70–74
[9] Kaimonov M V, Khokholov Yu A and Kurilko A S 2010 Development of measures to prevent freezing of chipped ore in treatment blocks of cryolithozone mines *Mountain news and analytical bulletin* **9** pp 223–228
[10] Neganov V P 1995 *Technology for the development of gold deposits* (Moscow: Nedra) p 336
[11] Pavlov A M 2013 *Improving the technology of underground mining of vein gold deposits: monograph* (Irkutsk: ISTU) p 128
[12] Vlokh N P 1994 *Control of rock pressure in underground mines* (Moscow: Nedra) p 208
[13] Voronov E T and Bondar I A 2007 Improving safety and efficiency of underground mining in the mines of the North M*ountain informational and analytical Bulletin* **4** pp 92–96
[14] Zubkov A V 2001 *Geomechanics and Geotechnology* (Yekaterinburg: Ural Branch of the Russian Academy of Sciences) p 335