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Features of Underground Mining of the Kochbulak Gold Ore Deposit

Akbarov Takhirzhan Gulyamovich
Candidate of Technical Sciences, Associate Professor, Professor of the Department of Geotechnology of Coal and Reservoir Deposits, Tashkent State Technical University, Tashkent, Republic of Uzbekistan

Nishanov Akmal Shermatovich
PhD student of the Department of Geotechnology of Coal and Seam Deposits, Tashkent State Technical University, Tashkent, Republic of Uzbekistan

Urazov Jakhongir Dilshodovich
PhD student of the Department of Geotechnology of Coal and Seam Deposits, Tashkent State Technical University, Tashkent, Republic of Uzbekistan
e-mail: urazov.jahongir@gmail.com

Ashirov Yunus Nematovich
district surveyor of the Mine Construction Department of "Almalyk Mining and Metallurgical Combine" JSC
Angren, Republic of Uzbekistan

Abstract:- This article is devoted to the analysis of development systems for the Kochbulak gold deposit. A detailed review of losses and dilution for the applied systems of underground field development is considered. The analysis of the applied development systems is carried out. As a result, an integrated approach to the development of the Kochbulak deposit reserves was determined, development systems for various mining and geological conditions were substantiated, and a rational procedure for mining the ore bodies of the deposit was determined.

***Keywords**:- Gold Ore Deposit, Ore Body, Opening, Preparation, Ventilation, Development System, Stope Excavation.*

I. INTRODUCTION

The operation of the Kochbulak gold ore deposit, located in the foothill part of the northern slope of the Kuramensky ridge, in the interfluve of the Nishbash and Gushsai, left tributaries of the Angren River, has been conducted since 1966 by open and underground methods.

The Kochbulak mine was commissioned in 1966 on the basis of proven reserves, as a pilot operation enterprise with a design capacity of 50 thousand tons. ore per year. Since 1975, in order to replenish the knock-out production capacities and maintain the capacity of the Kochbulak mine at the level of 200 thousand tons. per year, capital mining operations were started to uncover the reserves of the lower horizons of the deposit with the "Blind-Capital" shaft. The Kochbulak mine became part of the Angren mining administration of AGMK JSC since October 2002. At present, underground mining operations are carried out by the mine at the Tsentralny, Uzun, Semguran and partially Uzun-1 sections of the Kochbulak deposit by open cut.

In general, the hydrogeological conditions of the field, due to the low water cut, are considered favorable for development by both open-pit and underground methods.

Ore bodies are morphologically characterized by complexly constructed zones of silicification, quartz veins, veinlets among metasomatically silicified rocks and are subdivided into three types:

Steeply dipping (50-80º), intersecting ore bodies with a thickness of 0.5-3 m, submeredial and northeastern construction, the length along the strike from 50 to 300 m, along the rise up to 350 m;

Gently dipping consonant bodies (10-30º) of sublatitudinal construction, controlled by interstratal tectonic disruptions, the thickness of the bodies is 1-2 m, the length along the strike is from 150 to 200 m, along the rise up to 400 m;

Steeply dipping (75-80º), pipe-like formations confined to exclusive ore-bearing structures, the thickness of the ore bodies is 1-20 m, the length along the strike is from 15 to 20 m, along the rise up to 390 m.

The thickness of the ore bodies varies from 0.5 to 20 m, the dip angle is from 10 to 80°, the host rocks (andesite porphyries) are characterized by low stability, especially in the contact zones and vary from unstable to medium stability, the ores are characterized by medium stability with a deviation to the side stability and instability.

Fortress category of host rocks XII and ores XIV according to the scale of Professor M.M. Protodyakonov. Average volumetric weight 2.63 t/m^3. Loosening ratio 1.5-1.7.

II. INFORMATION REVIEW

The upland topography of the surface determined the adit method of opening the deposit. The lower horizons of the Tsentralny section were opened with a blind vertical shaft, which was passed from the horizon +1082 m of the Kapitalnaya adit to the horizon +880 m. Every 50 m in height, cross-slugs were passed, dividing the mine field into 5 floors. At the industrial site of the Kapitalnaya adit, there is a main fan unit (HVU) operating in a pumping mode.

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The shaft of the mine "Blind-Kapitalnaya" is passed five hundred meters from the mouth of the adit "Kapitalnaya" and is used for discharging rock mass, lowering and lifting people, equipment, materials, as well as for draining and supplying compressed air. In the section of the trunk, there is a counterweight cage, a ladder and a pipe-cable compartment.

The main concentration horizons are: section "Uzun" - adits No. 17 and No. 25, section "Semguran" - adits No. 90 and No. 92, section "Central" - adit "Capital". Underground transportation of ore to the place of unloading at the adit site is carried out by contact electric locomotives of the 3KR, 4KR, 7KR and 10KR types with a gauge of 600 mm using mine trolleys of the VO-0.8 and VG-2.2 types. On the surface, the ore is loaded by a DRESSTA loader into ISUZU and MAN dump trucks, and delivered to the ore warehouse of the gold-recovering plant (ZIF).

The main mining systems are the chamber-and-pillar system and the ore storage system using hand-held rock drills. The mining of ore bodies with a thickness of not more than 3 m with enclosing rocks of low stability is carried out by a system of sublevel drifts.

At present, mining operations in the Tsentralny area are being carried out at horizons of + 980-880 m, which are connected by ventilation-running risers.

The development systems and mining equipment used at the mine correspond to the mining and geological conditions of the deposit and make it possible to mine it with sufficient efficiency.

III. RESEARCH METHODOLOGY

Proceeding from the need to involve new horizons of the deposit into operation [1,2], the production capacity of the mine in terms of mining potential was determined - 150 thousand tons. ore mass per year. The mine disposes of the necessary human resources and technical equipment necessary to fulfill the provision of this annual production. However, the significant scattering of geological blocks (ore bodies), a large number of mining blocks with small ore reserves, as well as a change in the transportation (haulage) scheme and mining depth, the commissioning of the lower horizons of the Tsentralny site made it necessary to change (modernize) the existing mine ventilation scheme ...

Another feature of the development of the deposit is the largest volume of mining operations (GPW) and rifling operations (RR), especially taking into account the development of operational exploration (ERR), as well as a high level of quality loss of ore during mining, due to the complex morphology of ore bodies (geological blocks), their small thickness of gold-bearing veins. So, the design value of dilution is 39.3%, and the actual value is 24%.

According to the degree of opening and readiness of reserves for stope excavation and the order of their development, the field is divided into two parts: the upper (above the 930 m horizon) and the lower (below the 930 m horizon).

When optimizing the mine ventilation scheme, the following main tasks were solved: ensuring safe reworking of reserves in the upper part and improving ventilation when opening the lower horizons.

The possibility of creating a significant depression to overcome the natural draft, providing normal ventilation of the underlying and overlying horizons, as well as the availability of the necessary areas on the industrial site of the adit for the placement of the HLG, was of significant importance in choosing the method and scheme of ventilation.

Having considered the options, the combined ventilation scheme of the mine was recognized as optimal, with the installation of a main ventilation fan (HVU) at the mouth of adit No. 90, operating on suction, and leaving the operating HVU at the mouth of the Kapitalnaya adit unchanged.

Opening scheme of the Kochbulak field. The reserves of the field above the horizon of 930 m have been mostly recovered and largely prepared. A certain difficulty of driving development workings below the horizon of 930 m lies in the fact that they can only be passed after the upper part has been worked out. It is necessary to pass more than 1 km of drifts (GKR) on the horizon of 880 m. At a rate of penetration of 40 m / month, the period for full opening of the lower part of the field will be about 2.5 years. Therefore, it is necessary to first develop reserves above the 930 m horizon (with parallel stripping of reserves below the 930 m horizon), and then below the 930 m horizon. ore mining, thirdly, allows after the extraction of reserves of the floor, the corresponding workings are closed and to simplify the ventilation scheme.

IV. ANALYSIS AND RESULTS

Based on the analysis of mining and geological (physical and mechanical properties of ores and enclosing rocks, angle of incidence and thickness of ore bodies) [3] and mining (floor height, opening scheme, transportation scheme) [4] conditions, taking into account the experience of the Kochbulak mine for mining The following mining systems are adopted for ore bodies:

- system with ore shrinkage (SM);
- system of sublevel drifts (PSH);
- chamber-and-pillar system (CC).

Taking into account the wide variation in the values of mining and geological factors, for the adopted development systems, the areas of application for the thickness (m) and the angle of incidence (α) of ore bodies were determined, their average weighted parameters were determined, the share of application of development systems relative to the balance reserves of the deposit was determined (table 1).

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Table 1. Field of application and the proportion of mining systems used and average indicators of the thickness and angle of incidence of ore bodies.

Indicator	**m<3 м**		**m≤3 м**
	α≥45°	**α<45°**	**α≥45°**
	SM	**CC**	**PSH**
Power, m	2,0	1,8	2,2
Incidence angle, degree	65	40	75
Development system share, %	11	22	67

The system with ore shrinkage is used to mine thin and thin (m<3 m) steeply dipping (α≥45°) ore bodies with stable ores and host rocks [5].

As the block's reserves are cleared (blast hole), the ore is released through the beams with scraper delivery to the loading point and loading by loading machines into the mine blind trolleys. Clearing excavation is carried out with a ledge face with a ledge length of 2.5 m along the entire length of the block. The access of people to the clearing space is carried out along the ventilation-running risers, near which pillars are left from the underlying horizon. The abandonment of other pillars in the system with shrinking is not provided due to field preparation (driving of workings). The void formed after the block is mined is (partially) extinguished by the collapse of the enclosing rocks. The share of the system with ore shrinkage is not more than 11%.

The system of sublevel drifts is used to mine thin ore bodies (m≤3 m) with a dip angle α≥45° for stable ores and host rocks [6]. In accordance with the experience of the Kochbulak mine, the stable outcrop area of the hanging side is 1000-1500 m^2. The system of sublevel drifts is used in two versions: for the development of small ore bodies - without leaving interstorey and interchamber pillars; for the development of ore bodies of significant size - with the temporary abandonment of the formed inter-chamber pillars.

The height of the sublevel in most cases is 6-8 m. The sublevels are interconnected by vertical elevators, which are used to move people, lift materials and release broken ore. Breaking is carried out by means of a ceiling-ledge blast-hole method to an open treatment space, the height of the ledge is 2.5 m, and the length is 3 m. The block is mined from top to bottom, work is carried out on one sublevel drift. The broken ore is delivered to the ore pass by means of scraper units, from there the ore by gravity of its own weight gets to the loading run. With the help of PPN-1s, it is loaded into mine trolleys from the loading entrance.

After the extraction of the chamber reserves, the formed voids are not extinguished. The abandonment of interfloor pillars is necessary when there is an active mine working at the boundary of the movement. After the extraction of the main stocks of the chamber, the inter-chamber pillars are collapsed.

The chamber-and-pillar mining system is used to mine thin (m<3 m) horizontal and inclined (α<45°) ore bodies with stable ores and host rocks that allow large areas of exposure.

In all cases, the option is used of mining the ore bodies of the deposit with chambers of the correct shape, located parallel to each other along the uprising, leaving pillars between them in the form of separate columns-pillars to maintain the roof.

Clearing excavation is carried out by a continuous face along the fall of the ore body along the entire length of the block, with the abandonment of temporary ore guard pillars between the entryways (chambers) and the sublevel drift. Breaking is carried out using a fine-bore method. Delivery of ore to the loading place is carried out using scraper installations.

The ore pillars remaining during the excavation of the block to artificially support the roof are removed by sequential blasting of individual sections.

Treatment space management is carried out with the installation of spacer cluster support. The void formed after excavation of the block bottom is not absorbed.

V. CONCLUSION AND RECOMMENDATIONS

Comparison of the applied mining systems shows that the most effective is the system of sublevel drifts, which provides a sufficiently high productivity with the best ore recovery rates [7]. The pillar-room system with high productivity is characterized by an increased level of losses. The scheme for the preparation of mining blocks allows, in the event of a decrease in the stability of the outcrops of the enclosing rocks, to quickly, without unnecessary costs, switch from a system with ore shrinkage to a system of sublevel drifts.

With all the considered variants of the applied development systems, the use of the same electrical equipment, machines and mechanisms for the release, loading, delivery and transportation of ore and rock is envisaged.

The standard losses and dilution for the applied development systems and for the mine as a whole, taking into account losses during the handling of ore on the surface and its transportation to the gold processing plant, are shown in table 2.

Table 2. Standard losses and dilution

Development systems	**Losses, %**	**Dilution, %**
System of sublevel drifts	12,1	28
Storing ore system	17,8	39,7
Chamber-and-pillar system	24,3	35,9
Total	18	39,3
Losses during transportation to the mill and transshipment	1	-
Total	19	39,7

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An increase in the use of a system of sublevel drifts for the extraction of ore bodies can significantly reduce dilution.

Thus, an integrated approach to the development of the Kochbulak deposit (mine) reserves, including the choice of the optimal method and ventilation scheme, the substantiation of the development system for various mining and geological conditions, the determination of a rational procedure for the development of ore bodies provides:

- timely and efficient access to all developed reserves of the field;
- optimal ventilation of mining operations;
- safe development of reserves in the upper and lower parts of the deposit;
- sufficiently high indicators of ore mining productivity;
- high indicators of ore quality due to the differentiated application of mining systems in various conditions;
- increasing the share of sublevel driveway systems;
- reliability of the transport system of the mine due to compliance with mining technical conditions;
- maintaining and increasing the production capacity of the underground mine due to the simultaneous development of reserves in the upper and lower parts of the deposit.

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