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PRACTICE OF USING THE CHAMBER AND PILLAR MINING SYSTEMS IN EXTRACTING SMALL ORE BODIES AT THE KOCHBULAK MINING DEPOSIT WITH UNBALANCED MINERALIZATION

Abstract. The paper presents details about the experience of using the chamber and pillar mining system in small ore bodies mining with irregular mineralization in the Kochbulak gold mining deposit. The article includes a short description of the geological and mining conditions of the deposit and provides information on the development systems used for ore bodies extraction having different mining and geological properties. It refers to the conditions in which it is possible to apply the chamber-and-pillar development systems. The essence of the system, the procedure of ore bodies mining, the main features of it, its advantages and material disadvantages are also noted. It also summarizes the findings of the research carried out in the Kochbulak mine. The purpose of the study was to increase extraction indicators without the cost of ore going up.

Key words: *ore mining deposit, chamber-and-pillar mining system, ore body, capacity, angle of incidence, loss of ore, enclosing rocks, ore extraction, preparation, cleaning excavation, mining system characteristics, ventilation, ore dilution.*

Әркелкі кенденумен Көшбұлақ кен орнының аз қуатты кен денелерін өңдеу кезінде игерудің камералық-бағаналық жүйесін енгізу

Аңдатпа. Бұл мақалада Көшбұлақ алтын кені кен орнын әркелкі кендендірумен қуаты аз кен денелерін өңдеу кезінде камералық-бағаналық игеру жүйесін енгізу тәжірибесі туралы мәліметтер, сондай-ақ кен орнының қысқаша тау-кен-геологиялық жағдайлары келтірілген, әртүрлі тау-кен-геологиялық сипаттамалары бар кен денелерін игеру үшін қолданылатын игеру жүйелері туралы мәліметтер берілген. Камералық-бағандық игеру жүйесін қолдану шарттары баяндалған, жүйенің мәні, кен денелерін өңдеу тәртібі, игеру жүйесінің негізгі параметрлері, оның артықшылықтары мен елеулі кемшіліктері келтірілген. Көшбұлақ шахтасында кеннің өзіндік құнын арттырмай жер қойнауынан алу көрсеткіштерін арттыру үшін жүргізілген зерттеулердің нәтижелері келтірілген.

Түйінді сөздер: *кен орны, камералық-бағандық игеру жүйесі, кен денесі, қуаты, құлау бұрышы, кенді жоғалту, сыйымды жыныстар, кенді ұсақтау, дайындау, тазалау ойығы, игеру жүйесінің параметрлері, желдету, кенді құнарсыздандыру.*

Опыт внедрения камерно-столбовых систем разработки при отработке маломощных рудных тел Кочбулакского месторождения с неравномерным оруденением

Аннотация. В данной статье даны сведения об опыте внедрения камерно-столбовой системы разработки при отработке маломощных рудных тел с неравномерным оруденением Кочбулакского золоторудного месторождения, а также приведены краткие горно-геологические условия месторождения, даны сведения о применяемых системах разработки для отработки рудных тел с разными горно-геологическими характеристиками. Изложены условия применения камерно-столбовой системы разработки, приведены сущность системы, порядок отработки рудных тел, основные параметры системы разработки, его достоинства и существенные недостатки. Приведены итоги исследований, проведенных в шахте Кочбулак для повышения показателей извлечения из недр без увеличения себестоимости руды.

Ключевые слова: *рудное месторождение, камерно-столбовая система разработки, рудное тело, мощность, угол падения, потери руды, вмещающие породы, отбойка руды, подготовка, очистная выемка, параметры системы разработки, вентиляция, разубоживание руды.*

Introduction

The practical significance of the work involves the fact that it will be possible to combine certain mining conditions in the mines of Angren ore management JSC AGMK. Applications given in the study can be successfully repeated.

The specificity of Kochbulak gold ore deposit is that it has a high content of the balanced resources. Thanks to this we can strive to use the wealth of natural resources more reasonably, reduce the loss of valuable minerals and improve the quality of the extracted minerals. However, it determines the mines' direction towards the chamber and pillar systems as one of the most productive and technologically simple solutions.

The chamber-and-pillar system can be used for ore bodies mining with a capacity of up to 18 m and an angle of incidence of up to 35°. Generally, the chamber-and-pillar system has to be used for the extraction of low-value ores. This system can be used only if ribbon pillars are left between the chambers, taking into account their future excavation[1].

Room and pillar or pillar and stall is a variant of breast stoping. It is a mining system in which the mined material is extracted across a horizontal plane, creating horizontal arrays of rooms and pillars. To do this, «rooms» of ore are dug out while «pillars» of untouched material are left to support the roof overburden. Calculating the size, shape, and position of pillars is a complicated procedure, and is an area of active research [1]. The technique is usually used for relatively flat-lying deposits, such as those that follow a particular stratum. Room and pillar mining can be advantageous because it reduces the risk of surface subsidence compared to other underground mining techniques [2]. It is also advantageous because it can be mechanized, and is relatively simple. However, because significant portions of ore may have to be left behind, recovery and profits can be low [1]. Room and pillar mining was one of the earliest methods used, although with significantly more man-power.

The room and pillar system is used in mining coal, gypsum, iron and uranium ores, particularly when found as manto or blanket deposits, stone and aggregates, talc, soda ash, and potash. It has been used worldwide from the Czech Republic to China [3] to the US.

The main advantage of the chamber-and-pillar mining is its simplicity. Namely, its simplicity makes it flexible and helps to develop ore deposits in

[1]*Rules of technical exploitation of mines, shafts and pits, which develop deposits of colored, rare and precious metals. – Tashkent, 2019. – 119 p. (in Russian)*

various mining and geological environments. All technological alternatives are basically the same as leaving ore pillars in the mined-out space or constructing artificial blocks that support the underlying thickness [4-6].

One of the major disadvantages of the chamber-and-pillar system is the necessity for shaftmen to work directly in the excavation zone. And there is a relatively high probability of them being injured by the detached cover rocks. In fact, we can more correctly determine the rock and ore hardness characteristics that affect the reliability of the basic mining system estimates, namely the cross-sectional area of the ore pillars and the size of the mining chamber spans. This helps to improve the level of mining safety, because we are making it more reliable [4].

One of the main problems of the chamber-and-pillar mining system is the high loss of ore in the pillars. The deeper the mining is carried out, the greater the size of the pillars and the probability of ore loss (about 40-60%). This is why the extensively used variants of the chamber-and-pillar mining system at shallow and medium depths with sinking of mining operations to great depths become technically and economically non-efficient [7].

The technologies of mining with the chamber-and-pillar system are being constantly improved. Currently, a variety of methods have been created which help to avoid mining losses. These techniques are successfully applied. For example, the extraction of interchamber pillars from the excavated area. However, we cannot apply many of these methods when mining, because they are quite expensive. Therefore, we address the issue of reducing production mineral losses without adding expenses to mining activity [8].

Materials and Methods

At the mine «Kochbulak» of JSC «Almalyk mining and metallurgical works» a number of investigations were carried out in order to establish activities allowing to increase the indicators of extraction from the ground without increasing the cost of production in 2019-2022. One of the tasks of the project is to determine the locations and sources of ore losses and dilution under the chamber-and-pillar mining system.

The «Kochbulak» mine is developing the Kochbulak mine gold deposit by underground operation: Central, Uzun and Semguran sections. The Kochbulak gold-silver ore deposit is localized in quartz lodes and in silicified enclosing rocks that form complexly constructed lodes and mineralized zones in tectonically disturbed and hydrothermally modified rocks. A group of similarly positioned parallel or curved quartz lodes, streaks, and rings, arranged in a single tectonic structure of flat interformational or steeply dipping radial, radial-concentric formation, and extending from 1.5 to 2.5 km in length. Over the period of exploration activities, 23 ore-bearing zones were revealed, confined to 32 tectonic structures and grouping over 200 quartz, lodes and silicification zones; 115 of them were included in various levels of mining and production, including: 58 – central section, 37 – tokberda section, 15 – western section, and 5-sharak section [9].

Ore body №15 is localized in the soft-lying Uzun ore-bearing zone. It is represented by quartz lodes and a zone of ore metasomatic lode silicification with sulfide mineralization. Ore minerals are in the form of pyrite, chalcopyrite, galena, and bright ores in the form of phenocrysts, nests, and streaks and account for 3% to 5% in total.

The zone of mineralization, which has a depth of 3-8 m, lies at the junction of two lithological volcanic variations. There are acidic tuffs in the ore-bearing area, and the hanging side is represented by andesite-dacite porphyrite lava-breccias. The ore body is not located in a particular geological framework and is identified by surveying the entire area. The capacity of the ore body varies from 0.4 m to 3.40 m, the average one is 1.43 m. The ore body extends sublatitudinally with dip angles of 10-20° in the northern bounds. The length of the ore body along the extension is from 35 m to 170 m. The height of the ore body along the pitch is 115 m.

The intervening rocks and ores are damaged by multidirectional tectonic cracks, which leads to their instability and potential breakdowns. The rock and ore thickness ratio is 10-14. The volumetric weight of ores is 2.63 t/m^3. Ore dilution is weak, represented by sparse dripping in some parts.

The system of underground drifts is taken at the mining site, depending on the angle of incidence of ore bodies. As well as systems with ore storage, namely continuous with not regular remaining pillars and also chamber-pillar. Since the mining site has poor resistance of local rocks, especially within ore zones 1 and 2, there is extensive dilution, which amounts to 40-50% on separate blocks [10].

Each of the following extraction systems can be applied given the following mining and geological situations:

- if the ore bodies with sharp falling rocks and stable underlying rocks are mined, the application of a system of block storage is recommended;
- if the stability of enclosing rocks interferes with the application of the block storage system, the combined option of ore storage and spacer shields is recommended;
- in order to mine ore bodies over 3 m thick with low-stability enclosing rocks, the system of sub-floor drifts (orts) is recommended;
- falling ore bodies are mined by the chamber-and-pillar mining system.

Currently, drilling and blasting technique is used at Kochbulak mine. When sinking preparatory mine and cut-and-fill openings, the blasting is carried out through borehole charges. For clearing excavation, borehole blasting is applied.

Chamber-and-pillar systems are used to develop horizontal and inclined (maximum 45°) ore bodies (Figure 1). The ore body capacity is between 1.2 m and 2.5 m. Ore and surrounding rocks should be strong and resistant, enabling wide areas of exposed[2].

It should be prepared in the following way: first goes the pulling drift, entering by the pulling machine like PPN-1S or a scraper ort (when pulling the chipped

[2]*Akbarov T.G., Nishanov A.Sh., Urazov J.D. Rational technologies of underground gold deposits exploration in Angren district: Monograph. – Tashkent, 2022. – 212 p. (in Russian)*

rock mass with scraper winches through the installed loading shelves), two ascending excavations, which pass simultaneously with the knocking down between each other by manways. Then there should be equipped one of the ascending excavations as a walking section, and the other will be used for lowering the rock mass to the level of the pulling level.

The upper mine pulling drift dislodges the traversed ascending excavation with a ventilating manway, which passed on the level of the upper mine surface layer. The sinking of the sub-floor drift is carried out towards the passed manway from the ascending excavation to the block outline. After that, the sinking of drifts is realized in order to create chambers, in front of the drifts they cut grooves under the scraper winches. Before they are laid, cyclic passage of bays is carried out. Chambers are displaced between each the other by the manways. They are separated by a series of pillars. Their height is 3-4 m. Temporary protective pillars 3-5 m wide are also placed between the drifts.

In sections where the sub-floor drifts are conjugate to the drifts, as well as in places where there are tectonic defects, cracks and dripping of the mining excavation – a frame is fixed with the walls and the roof boards tightened. The mining excavation is carried out by a continuous excavation along the dip of the ore body along the entire length of the block, with temporary ore protective pillars deposited between the drifts and the underground drift. Ore is mined with a light borehole method. Chambers are mined from top to bottom.

Ore pillars that are still remaining when the block is excavated to artificially maintain the cover are removed if the particular sections are hammered out one after the other. The back-up pillars with their irregular placement, as a rule, are not extracted.

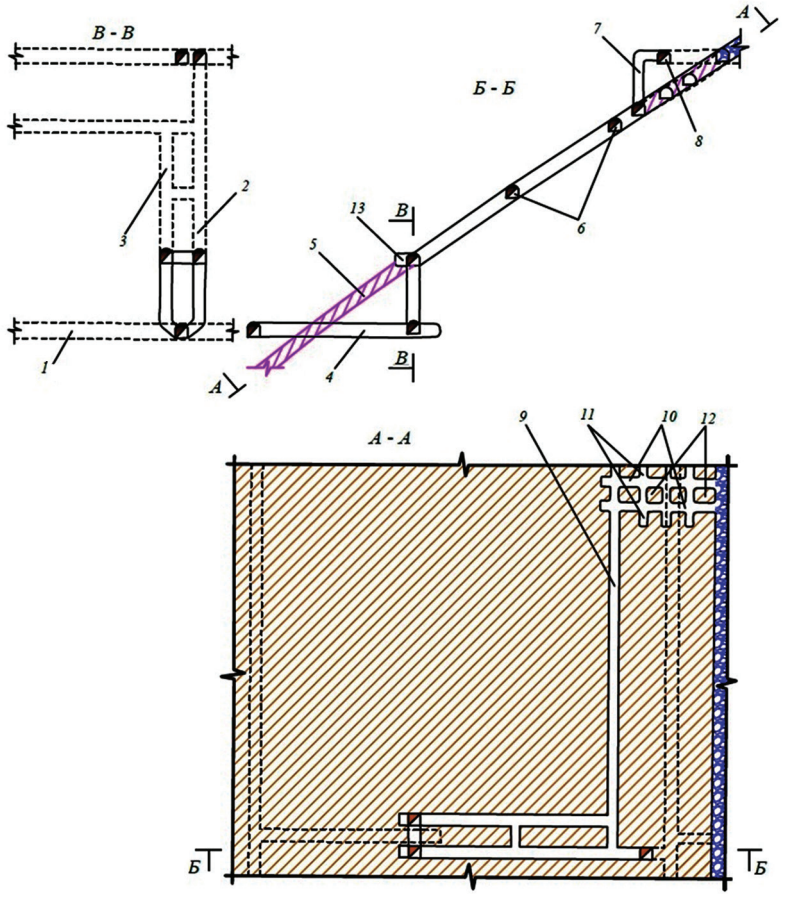
The mining space is controlled, if necessary, with the spacer cluster mount. Average parameters of the system in the mine are as follows: extension block length – 50-60 m, vertical height – 50 m, dip block length – 60-90 m, ascending chamber length – 15 m, sizes of irregular pillars – varying from 3 m^2 to 6 m^2.

Ventilation is achieved by a fresh air stream entering the chambers from the lower pulling drift through the ascending manway and bottom drift. Then the air stream flows to the upper sub-stage drift and is directed to the ventilation channel through the upper pulling drift across the lower pulling drift of the mining layer.

According to safety standards, the diameter of the pillars should be minimum 3 meters. It is not acceptable to use pillars of a smaller size, because their surface is destroyed by blasting, and pillars of a smaller diameter may not be completely stable. When the shift comes on, the cover, the bottom-hole and the surface of the pillars in the chambers where the mining work is done must be skimmed. Ore fragments that are not firmly held at the sidewall or at the top are capped with a crowbar. Usually, the top and the bottom-hole are tapped with a crowbar and the sound is used to determine which section or fragment needs to be cut so that if it falls unexpectedly, it will not harm the workmen involved.

Workers' productivity varies widely and depends on the rock strength, deposit capacity, type of the system and the equipment applied.

The loss of ore may be only for one reason – if the pillars are being left in place. After all, chamber reserves are extracted with minimal amounts of loss, which does not exceed 2-3% in



1 – lower pulling drift; 2 – manway ascending excavation; 3 – ore deposit;
4 – shipping lane; 5 – ore body; 6 – manways; 7 – ventilating ascending excavation;
8 – upper pulling and supplying drift; 9 – underground drift; 10 – stopes;
11 – manways; 12 – poles (pillars); 13 – begging for a scraper installation

Figure 1. Sample of chamber-and-pillar mining system with small borehole and scraper ore extraction.
Сурет 1. Ұсақ түйіршікті ұсақтау және кенді скрепермен жеткізу арқылы камералық-бағаналы қазу жүйесінің нұсқасы.
Рис. 1. Вариант камерно-столбовой системы разработки с мелкошпуровой отбойкой и скреперной доставкой руды.

difficult environments. Total losses may reach 10-15% (25-30% in the worst cases). It depends on mining conditions and mainly on the deposit's thickness and ore specificity. Ore dilution, if they do not contain hollow rock, does not exceed 3-7%.

The main advantages of the system: simple operation; high efficiency of the work; wide production area; low cost of fixing materials; low cost of ore extraction.

The main disadvantages of this system are the high risk of working in the chamber under the bare top and the serious loss of ore in the pillars.

Results

The results of the study showed that the major losses of uncut minerals are formed by keeping regular backup pillars in the excavated space, at the top of the chambers. The most of the losses of ore is formed on the soil of the chambers.

The priority is to reduce the quantity of mineral losses. We carried out a number of activities that could help to reduce losses in the chamber pillars. The objective was reached. Losses in the top of the layer are formed by remaining at the top of the chambers a layer of ore with a thickness of not more than 1 m with the inclusion of bare rock in the ore, with an increase in the height of the chambers, due to the safety regulations.

The following ore bodies were mined using the pillar-and-castell mining system: ore bodies 15 and 70 of the Uzun plot by mining blocks 1715-1, 1715-4, 1715-5, 1715-7, 2570-1, 2570-2; ore bodies 120, 24, Chetgi, 58, 59, 255 and 262 at the Central mining area by mining blocks 720-1, 720-2, 720-724, 810-r, 858-1, 858-2, 859, 8255, 862-1, 862-3, 862-5; ore body 15 at Semguran mining area by mining blocks 9215, 9215-5.

Discussion

That model of chamber-and-pillar system, which was applied, provided a significant reduction in quantitative and qualitative ore losses and ensured selective extraction of ore during mining in the chamber. Moreover, it was possible to significantly increase the safety of shaftmen' work by means of retaining the substandard ores in the pillars. That was due to the reduced cross-section of excavations and free access to the mining area. Overall, the efficiency of underground mining at the Kochbulak mine was improved.

However, during the mining operations, a number of problems were revealed, especially the resistance of the protective pillars and the maintenance of the mining space in the chambers after the ore has been extracted. It is necessary to support the mining area with a cluster wooden lining, increasing the consumption of timber, and in some cases leaving the inter-chamber pillars uncut, which significantly increases the losses. These phenomena are typical for ore bodies with irregular mineralization.

Conclusion

The experience of using the chamber-and-pillar mining system at the Kochbulak mine showed its high economic efficiency, despite the fact that in some cases there were significant losses. It should also be noted that the use of chamber-and-pillar system for mining of small ore bodies of Kochbulak deposit with irregular mineralization, showed the possibility of dilution ore control with parameter changes of passable excavation in the block.

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