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MINING SYSTEMS WITH SHRINKAGE STOPING AND THE FORMATION OF ARTIFICIAL PILLARS TO SUPPORT UNSTABLE ROCKS OF VEIN DEPOSITS

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ANNOTATION

The characteristic of the occurrence of ore bodies of the Zarmitan gold ore zone, the Navoi Mining and Metallurgical Combine (NMMC) is given. The results of the analysis of the systems used for the mining of steeply-falling vein deposits with insufficiently stable host rocks are presented. For the mining of vein deposits with a capacity of up to 2.0 m in unstable massifs, variants of a system with the stock of broken ore in combination with a spacer (spacer-frame) and metal rod support, variants with short or narrow shrinkage, with intervening and inter-floor pillars are considered. The main disadvantages of the development systems applied in unstable massifs and complex geomechanical conditions are given, which include the consumption of expensive materials, labor costs, a significant increase in the volume of preparatory and cutting operations and the loss of ore in the pillars. Variants of systems are proposed for the development of ore with an open cleaning space for the development of reserves of weakly stable massifs and in zones of stress concentration, providing for combined methods of managing a rock mass with stock of broken ore, ore pillars and hardening backfill, which makes it possible to gradually develop both chamber reserves and pillar reserves.

Keywords: mining-geological and geomechanical conditions, quartz veins, ruptures and displacements of veins, capacity, depth of mining, falls, cracking, strength, stability, safety of workers, stress concentration, massif control, support, spacer (spacer-frame), rod support, "short shrinkage", backfill, open spaces, cleaning chamber, floor, block, preparatory rifling, ore pillars, cutting raising, backfill material, hardening backfill, ventilation, polyvinyl chloride (PVC) pipes.

INTRODUCTION

The main rocks composing the mineral reserves of the Zarmitan gold ore zone are represented by granosienites of different granularity, horn shales and rounded carbonaceous-clay shales, granosienites account for 80-85% of the total volume.

Industrial ore bodies of the deposit are morphologically divided into several types,from which, quartz veins with ruptures and displacements or weak ore sites constitute the main value of the ore body.

The veins lie at steep angles of 70-85 and more, are characterized by variable thickness, both along the dip and along the strike, and have an uneven distribution of mineral resources.

The length of ore bodies of this type ranges from the first tens to 1000-1200m, the thickness from centimeters to 8m. Individual ore bodies have been traced to a depth of up to 1000 m by wells.

The strength coefficient of ore-containing rocks on the scale of M. M. Protodiakonov is 9-15, the ore density is 2.65 t/m3- 2.96 t/ m3, the moisture content of ores and rocks is up to 1%, ores are prone to caking in places.

Strongly fractured zones with longitudinal and diagonal cracks, unstable and relatively stable engineering-geological areas are distinguished at the deposit. Groundwater, confined to fractured rocks and crushing zones, rocks are weakly watery.

Material and method

During the period of reconstruction of the existing and construction of new mines on the basis of the Zarmitan deposit, the authors carried out many design and scientific research works [3,8,10,13,14,15] aimed at increasing production, reducing ore losses, dilution and improving the organization of labor. Work was carried out both on the introduction of new development systems and on the modernization of the applied development systems.

An assessment of the changes in the stress-strain state of the mining massif was carried out. The results obtained cannot exclude the possibility of accidental local rock falls even in the upper horizons.

It is also possible that the stress-strain state of the massif may change as mining operations deepen and the possibility of high stress concentrations at the lower horizons of the mine[5,9,16,17];

The analysis of sources [1,2,4,6,7,11, 12] shows that, depending on the conditions of occurrence and properties of the massif of steeply falling vein deposits, numerous variants of development systems characterized by different technical and economic indicators are used in practice.

When developing low-power steeply falling veins with insufficiently stable enclosing rocks, variants of the system are used in combination with spacer (spacer-frame) and rod support, "short shrinkage"

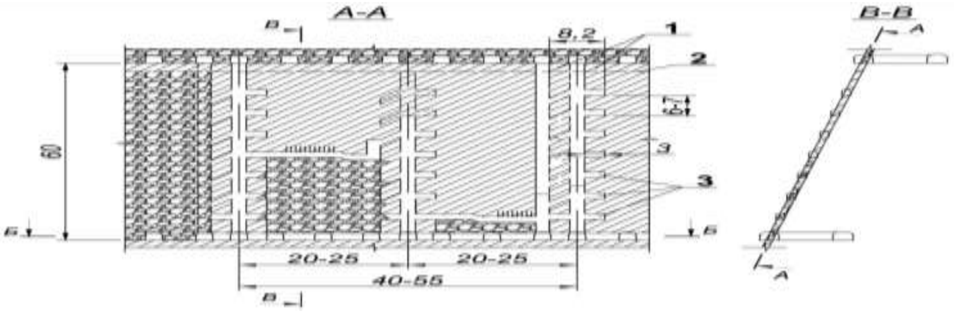


Fig. 1. Development system with ore storage (development system with "short" shrinkage): 1- intervening pillar; 2 - ceiling; 3 – access drifts(trips to the block); 4 – scram drift;

5 - block raise; 6 – loading crosscut; 7 – haulage drift; 8 - cut-off raising.

A mining system with ore shrinkage and ore stripping by small diameter wells from drilling chambers is also used (Fig.2)

Systems with a backfill of the developed space due to the high complexity of the work and the imperfections of the known options have limited use. But in connection with a decrease in the depth of development and the complication of mining and geological conditions, the proportion of their use began to increase.

From the most common in modern practice variants of the system with a backfill from external sources, the variants with self-propelled equipment are effective. But, as can be seen from the above information, even in combination with small-sized self-propelled equipment, they can be successfully used only when excavating vein with a capacity of more than 2-2.2 m. Their use for the development of thin and very thin vein is associated with an increase in dilution and, for economic reasons, is usually impractical.

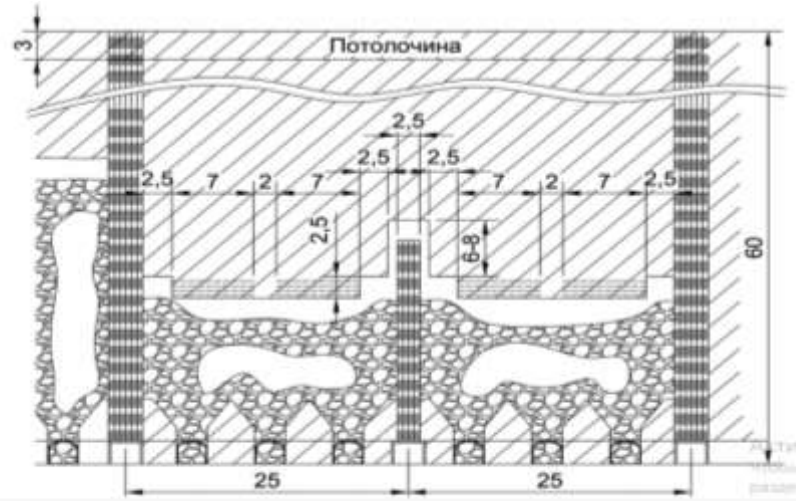


Fig. 2. Development system with ore shrinkage and ore stripping by small diameter wells from drilling chambers.

It should be noted that, in all the considered variants of the development system, the floors are divided into blocks, which, in turn, are divided into cleaning chambers and supporting pillars, the dimensions of which are interconnected and depend on many factors.

In any case, the dimensions of the cleaning chamber and the supporting pillars in specific conditions should be sufficiently reliable to maintain the cleaning space of the block in a safe condition and economically feasible.

Result

To determine the optimal dimensions of the cleaning chamber and ore pillars for the conditions of the Zarmitan gold ore zone, according to the VNIMI method [1] using the Excel computer program, the width of the inter-chamber pillars was determined for stable, unstable and relatively stable massifs by fracturing (a), at different values of the depth of mining operations (H), the angle of incidence of the ore body (α), the chamber lengths 20m and 60m (Lк), the limit of the strength of rocks to compression σcq. Based on the obtained results of the calculated data, graphs are constructed for choosing the safe width of the inter-chamber pillars with different camera lengths (Fig. 3, 4).

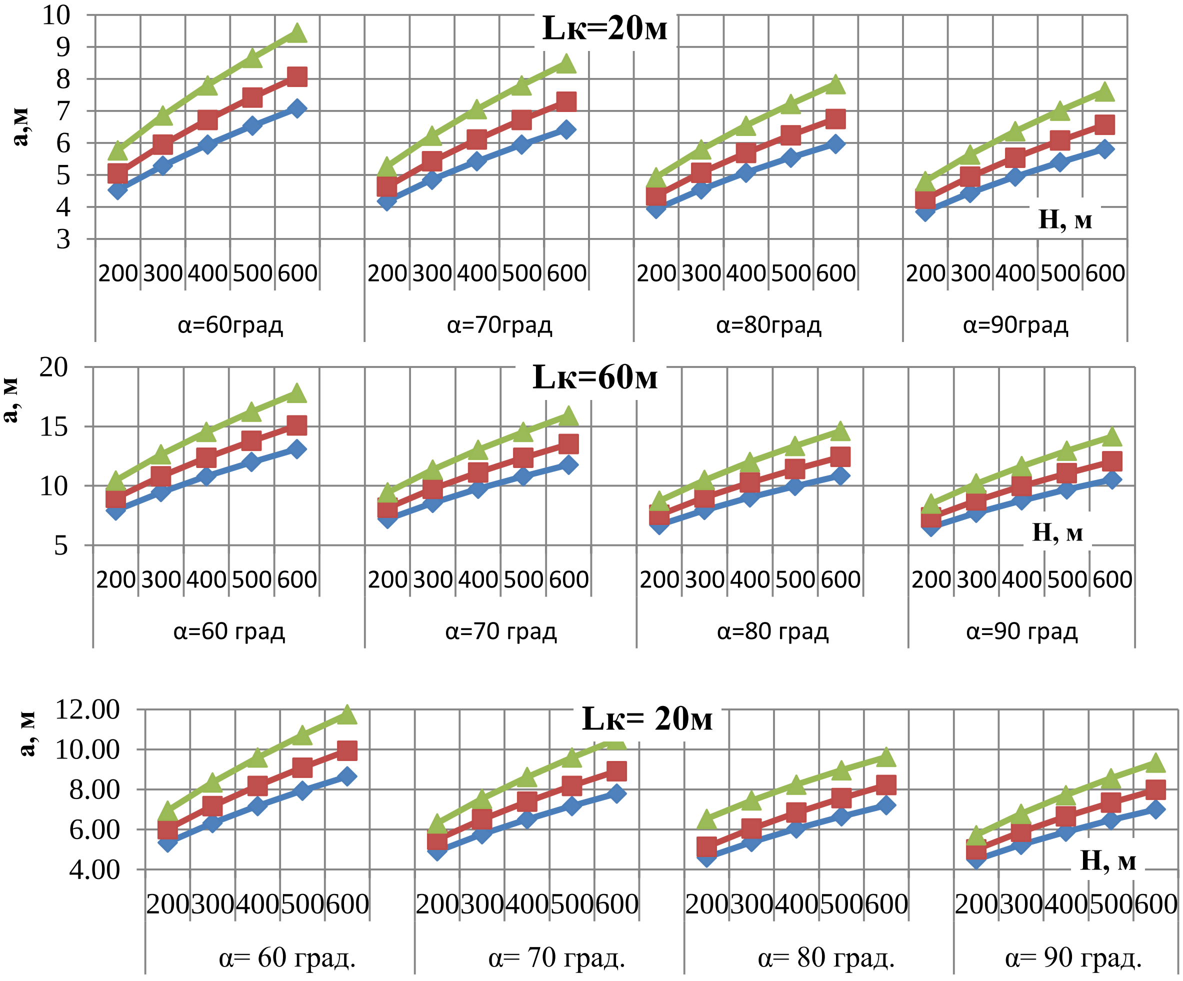


Fig.3. Graphs for choosing the safe width of the intervening pillars at different chamber lengths (σcq =110 Mpa)

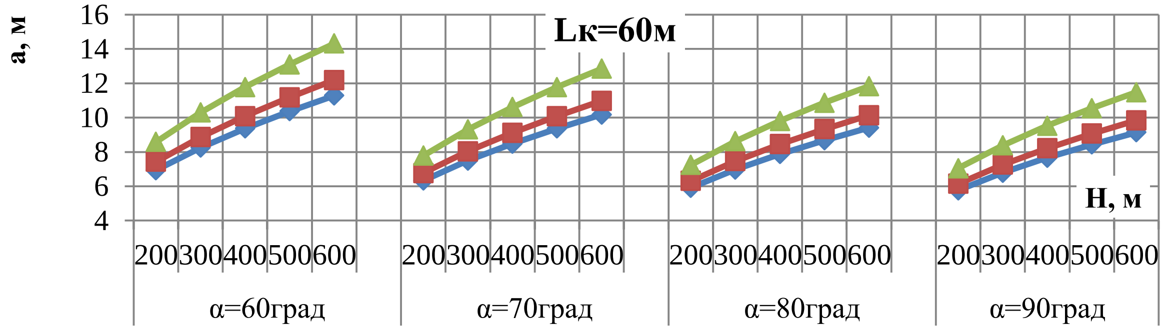


Fig.4. Graphs for choosing the safe width of the intervening pillars at different chamber lengths (at σcq =170 Mpa)

DISCUSSION

The analysis of the graphs shows that the stable dimensions of the pillars, depending on the above factors, vary in the range from 4.5 m to 20 m, the formation of pillars with such dimensions, in addition to large volumes of drilling preparatory-rifled workings, leads to significant losses of ore in the pillars, since their development in weakly stable massifs and complex geomechanical conditions is almost impossible.

For the purpose of safe and complete mining of ore reserves in weakly stable massifs and stress concentration zones, a development system with ore storage and the formation of artificial pillars from a hardening backfills is proposed in two variants of ore development with an open clearing space (Fig.5).

In Fig.5a presented a variant of the development system, which provides a combined method of controlling a rock mass with the storage of chipped ore, ore pillars and artificial pillars from a hardening backfill. This option allows you to gradually develop both chamber stocks and stocks in the pillars.

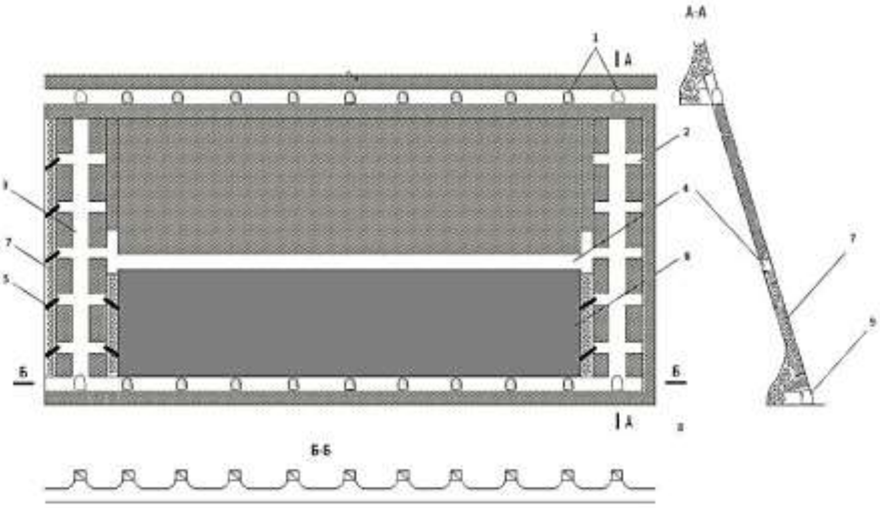
CONCLUSION

The proposed version of the development system with shrinkage stoping and the formation of artificial pillars (Fig.5b), the ceiling-like shape of the location of the faces of the cleaning works, increases the stability of the cleaning chambers due to the inclined orientation of the work front.

The preparatory work in the proposed schemes consists in developing an ore haulage drift, from which, after 50-60m, develop the access raise with access drifts up to the ventilation horizon. The haulage drift, passed during the preparation of the overlying floor, usually serves as the ventilation horizons. Along the length of the haulage drift, every 5-6 m there are loading cross-cuts, towards the recumbent side of the ore body with a length of 3-5 m.

Ore chutes are formed, and the cleaning chambers are left above the haulage drift with a ceiling thickness of at least 2.0 m, and a cleaning chamber with a height of 2.0-2.5 m is located above the mouth of the chutes along the entire length of the block.

a)



b)

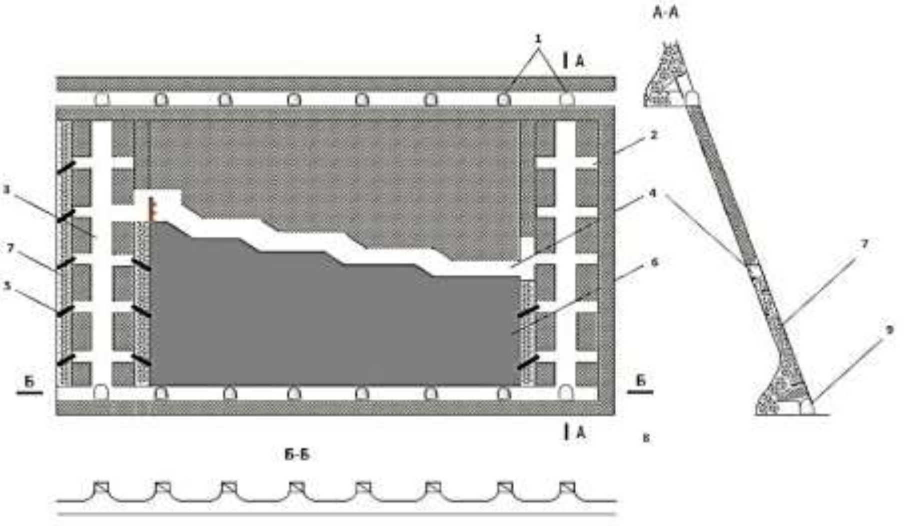


Fig.5. Development system with shrinkage stoping and formation of artificial pillars: a) continuous breaking with horizontal layers; b) ceiling-sagging breaking with inclined layers; 1-loading crosscut; 2-access drifts: 3- raise; 4- room in the stage of drawing the ore from the shrinkage stope; 5 - PVC ventilation pipes. 6-broken ore; 7-hardening(cemented) artificial pillar; 8- solid ore; 9- haulage drift with ramps.

Mining works are carried out from the room in the stage of drawing the ore from the shrinkage stope in layers in the direction from bottom to top. The height of the layer is 1.5–2.0 m. Breaking is carried out by uphole drilling with continuous horizontal layers (look at Fig. 5a), or the ceiling with a ledge notch in obliquely oriented layers (look at Fig. 5b).

After breaking the next layer, a partial release of the broken ore is carried out so that the distance from the surface of the broken ore to the face plane is 2.0-2.5 m and the cycle is repeated.

The technological scheme for the development of intervening pillars provides for the ventilation of the face(workplace) with the help of polyvinyl chloride (PVC) pipes laid in the access drifts of raise. With this scheme, fresh air is supplied to the face from the developed space of the block through PVC pipes.

Before backfilling, the open sides of the backfill room are covered with cinder blocks, stones or a shaft of waste ore. In this case, the shaft of the broken ore is arranged in such a way that this ore does not jam and is not subject to an obstacle during its further release under its own weight.

The proposed version of the mining system is simple, ensures the safety of workers during the development of intervening pillars in weakly stable rock massifs and in conditions of increased stress concentration, prevents ore losses in the pillars, and reduces labor and material costs for mining excavations.

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