Assessment and selection of a rational option for the opening of near-contour reserves during open-underground mining of upland deposits

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Abstract. The article considers a combined method of mining the Karakutan deposit and substantiates two systems of opening the contiguous reserves by the open-underground method. The development of short-circuit reserves provides for the use of the worked-out space of the quarry for the opening of ore zones by horizontal, vertical or inclined workings with the combination of open and underground mining cargo flows into a single cargo flow. The transition to underground mining is expected at the last stage of completion of the open pit. Due to the fact that there are more reserves behind the contours of the quarry, deposits that it is advisable to work out in an open-underground way.

1 Introduction

There are scientific papers devoted to the issues of evaluation and selection of rational opening options. [1]. At the stage of open works, the method of opening depends on the conditions of occurrence of the deposit, the mode of mining operations and their economic efficiency. Opening design is a complex multivariate complex technical and economic task, in which many determining factors cannot be quantified [2]. The problem is solved by quantitative and qualitative assessments of technically possible options.

Previously, a number of particular problems are singled out and solved from the general complex problem. The task is complicated by its dynamic nature. The opening system develops during the entire development period and is usually subjected to more than one reconstruction. When designing, the tasks are solved in the following sequence.

Based on the transverse and longitudinal profiles, a quarry plan is drawn up in the final or intermediate and prospective contours. The contour lines of the horizons and the terrain are applied to the plan. The rational direction of mining development is determined. The locations of the dumps and the main surface structures and the entry of the route into the quarry are established. The parameters of the route are determined: the slope, the radii of turns, the shape of the junction, the length of the trenches, the length of the junction sites, the length of the elementary sections of the exits. The shape of the route, its stationarity and the boundaries of placement within the quarry field are established. Preliminary tracing is performed for the initial and final contours of the quarry [3-5].

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2 Materials and methods

If several opening options are considered, then the specified structures are made for each of them. Then the objects of transport works are determined, calendar schedules of stripping and mining operations are built, and the indicators necessary for the technical and economic comparison of the options for the method of opening and the system of cargo transportation communications are calculated. For the selected method of opening, a detailed tracing of trenches and the construction of quarry plans are carried out at the time of its commissioning, for the 1st, 2-1 and subsequent years of operation, as well as at the end of working out in the final and intermediate circuits.

Thus, in [6], when choosing the method of opening, it is recommended to proceed from the following provisions:

1. Based on the nature of the deposit and the conditions of its operation, technically possible, but economically unequal options are established, discarding obviously unacceptable and irrational ones.
2. When evaluating the compared options, special attention is paid to the size of the capital and operating costs depending on the method of opening for the compared options, excluding the same costs. In general, the following are taken into account: capital costs for the opening and construction of surface structures; operating costs for the maintenance of opening workings, underground and surface rollback, lifting, drainage; damage from the abandonment of security targets; reduction of financing of capital costs due to associated ore extraction at the location of mining and capital workings in the ore body.
3. Usually significant costs and expenses are taken into account, and minor and minor ones, as insignificant for comparative evaluation, are not taken into account.
4. The capital costs and operating costs calculated for each option are tabulated and calculated for 1 ton of production for 5. The accuracy of economic calculations is taken for final conclusions within ± 10%, with a smaller difference, the options are considered equivalent.
5. When comparing options, factors that are difficult to value are also taken into account, such as, for example, the time of opening and construction of the mine, the prospects for its development, as well as economic considerations.

As a criterion for choosing the optimal option, a minimum of comparative costs per 1 ton of production is used.

On the basis of the above-discussed increase in the efficiency of the use of the geo-resource potential of the nagorny deposits of the Karakutan Ziaetdinsky ore field is the basis for the development of a strategy for its development.

Methodological foundations [7] for the development of a strategy for the development of the nagorny Karakutan deposit include:

- a technological strategy providing for the development of the deposit by an open-underground method with the development of a quarry to a depth of 80-100 m based on road transport;
- an economic strategy that determines the conditions for the transition from the operation of the quarry according to the scheme with profit maximization to work according to the scheme with maximization of the use of the raw material potential of the deposit;
- a raw materials strategy that provides for a cyclical reduction in the content of processed ore and the involvement of previously unpromising raw materials in processing.

3 Results and discussion

The possibility of such adaptation is based on the presence of significant reserves of gold-bearing ores that are not currently involved in development. Based on the interests of the state, the region and the enterprise, a strategy for the development of the Karakutan gold mining deposit is proposed, which provides for maximizing the extraction of mineral raw materials as a result of:

- the introduction of an open-underground method for mining reserves outside the quarry;
- completion of reserves by underground method below the bottom of the quarry.

The development of the adjacent sections provides for the use of the worked-out space of the quarry for the opening of ore zones by horizontal, vertical or inclined workings with the combination of open and underground mining cargo flows into a single cargo flow. At the same time, the condition for switching to an open-underground mining method is the need to prevent the fall in gold output below a certain level. The transition to underground mining is expected at the last stage of completion of the open pit.

Due to the fact that there are more reserves behind the contours of the quarry, deposits that it is advisable to work out in an open-underground way.

In addition to the main purpose, underground opening workings are used for auxiliary purposes: ventilation of an underground mine and ventilation, descent-lifting of people, materials and equipment.

Thus, the following favorable combinations of elements of open and underground mining operations are the basis for the formation of technological schemes for the development of instrument reserves:

- joint use of transport and opening mine workings, as well as quarry space as opening workings;
- a single cargo flow of open and underground works.

There are two ore zones outside the quarry: ore body 7 and 51. The productivity of the mine can be at the level of 200-400 thousand tons of ore per year.

Having considered 5 variants of the opening system - with the use of a quarry space, without the use of a quarry space as the main opening mine, as well as a combined opening system for mining the on-board and sub-quarry reserves of the Karakutan upland deposits, taking into account the terrain and the location of reserves, two optimal variants of the opening system aimed at increasing the efficiency of using the geo-resource potential of the deposit were selected.

The first option is a scheme for opening the terminal (instrument and sub-barrier) reserves of Karakutan using a combined opening system, i.e. opening the instrument reserves by tunnels passed in the space of the quarry, and opening the sub-barrier reserves by an inclined transport exit, passed behind the contours of the quarry (Figure 1).

When applying the first opening scheme, it is necessary to perform the following basic mining and capital works:

1. Carrying out the tunnel from the quarry space on the eastern side of the mountains. 530.00 m and the western side of the mountains.540.00 m with a total length of 1500 m;
2. Carrying out an inclined transport exit outside the contour of the quarry from mountains. 540.00 m to mountains. 240.00 m, length 000 m;
3. Carrying out pumping-out coulages from concentration horizons, with a total length of 3600 m;
4. Chamber workings in the amount of 30% of the total volume of opening mine workings.

5. Penetration of ventilation rising from the mountains. 600,00 m. to the mountains. 420,00 m.

When using this option, opening tunnels passed from the quarry space and an inclined transport exit, which is intended for mining of sub-quarry reserves, are used to issue ore from the instrument reserves.

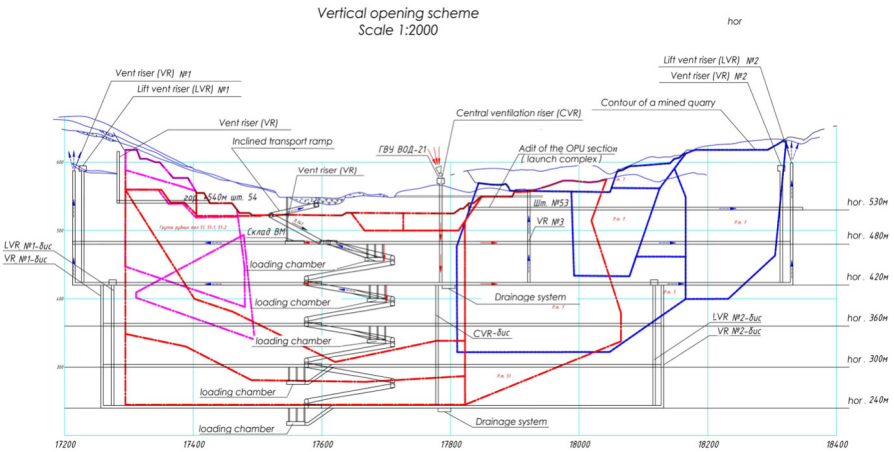

Fig. 1. Diagram of the opening of the Karakutan stocks with the use of the system of opening the tunnels passed in the space of the quarry, and an inclined transport exit outside the space of the quarry.

The second variant of the scheme of opening the terminal, instrument and subcarrier reserves of Karakutan with the use of a combined opening system, i.e. opening part of the instrument reserves by tunnels traversed in the quarry space, part by vertical trunks, and opening the subcarrier reserves by three vertical opening trunks traversed outside the contour of the quarry (Figure 2).

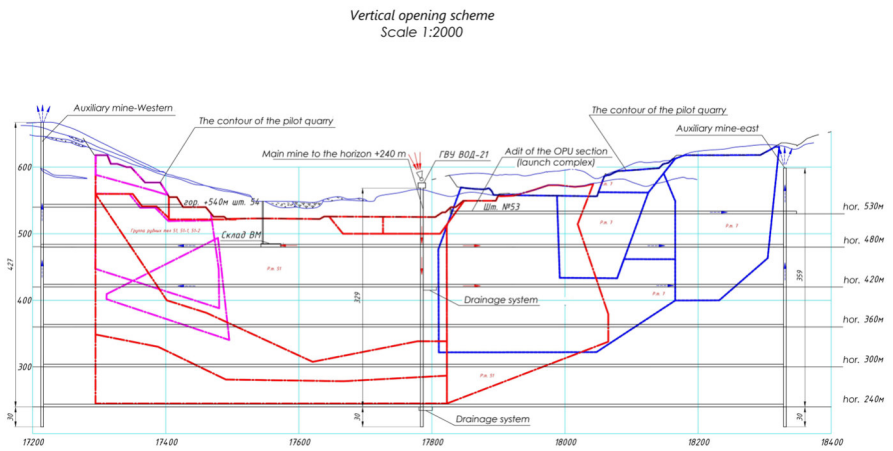

Fig. 2. Schemes of opening of near-contour stocks of Karakutans using a system of opening tunnels passed in the space of the quarry, and vertical trunks outside the space of the quarry.

When applying the second opening scheme, it is necessary to perform the following basic mining and capital works:

1. Carrying out the tunnel from the quarry space on the eastern side of the mountains. 530.00 m and the western side of the mountains.540.00 m with a total length of 1500 m;
2. Carrying out three vertical cage and auxiliary trunks - the auxiliary trunk -the eastern one with a depth of 359.0 m, the trunk -the western one with a depth of 427.0 m, and the main trunk with a depth of 329.0 m.
3. Carrying out pumping-out coulages from concentration horizons, with a total length of 3600 m;
4. Chamber workings in the amount of 30% of the total volume of opening mine workings.

When using this option, opening tunnels passed from the quarry space are used to issue part of the ore of the instrument reserves.

The delivery of part of the instrument and sub-quarry stocks is carried out through the cage trunks, passed outside the contour of the quarry.

4 Conclusion

To determine the optimal opening scheme from the options under consideration, calculations are carried out using a well-known technique using the Excel 2010 computer program to determine a more acceptable scheme.

Due to the fact that reserves and deposits remain more significant behind the contours of the quarry, the transition to underground mining is expected at the last stage of completion of the open pit.

In general, the implementation of the proposed strategy for the development of the Karakutan field provides for an increase in the efficiency of using the geo-resource potential to 85-90%. The logical continuation of the strategy for the development of the Karakutan deposit is the development of a general strategy for adapting mining technology to changing conditions.

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