ANNOTATION
dissertation work
«Geomechanical securing for the development of flat ore bodies systems with open refining space»,
submitted for the degree of Doctor of Philosophy (PhD)
specialty 6D070700 – «Mining engineering»
BALPANOVOY MEREY ZHUMAGALIEVNY

The purpose of the dissertation work is to substantiate the parameters of mining systems with an open space based on a set of geomechanical studies to improve the efficiency and safety of mining operations.

Research objectives
- analysis of modern domestic and foreign experience in using a development system with an open treatment space for flat deposits;
- theoretical and full-scale study of deformation and physical processes in the overlying rock mass during the complete development of flat ore deposits, taking into account mining-geological and mining-technical factors;
- development of a rational technological scheme for mining ore bodies, ensuring the stability of pillars and chambers at the first and second stages of development, based on a set of geotechnical studies, multifactor accounting of technological parameters for mining reserves, assessment of the geomechanical state of the overlying rock mass;
- verification of the developed technological scheme in the conditions of the Zhamanai-Aybat field.

Research methods
The main theoretical basis of dissertation research is the theory of the body of natural equilibrium. To achieve this goal, a set of research methods was also used, including: scientific system analysis and generalization of data from experimental and theoretical studies of domestic and foreign scientists in the field of geomechanical processes occurring during the development of ore deposits leaving pillars for various purposes when using mining systems with natural maintenance of the roof of the mining space, followed by the collapse of the host rocks; methods of strength of materials, elasticity theory, continuum mechanics, computational mathematics; field methods using field seismic surveys; analytical studies of the stress-strain state and stability of pillars using innovative computer modeling technologies; analysis of data from rock fallout cards and protocols of commission surveys of the condition of pillars and rock structures in conditions of dynamic forms of manifestation of rock pressure.

Basic provisions (proven scientific hypotheses and other conclusions that are new knowledge) submitted for defense
1. Determination of the possible boundaries of the distribution of deformation zones in the overlying strata must be carried out taking into account the strength and

deformation properties of each type of rock composing the overlying strata, which is based on the construction of curved lines of sliding surfaces of three families.

2. The magnitude of the rock collapse angle δ depends on the angle β, determined from the strength certificate, and the angle of internal friction $\rho_{\text{кс}}$, and at a depth of 430 m at $\rho_{\text{кс}} = 33° \div 36°$, it varies within the range $\delta = 65.86° \div 62, 84°$.

3. If the condition of complete undermining of the earth's surface is met, the development of reserves must be carried out leaving barrier pillars, and if the conditions are not met, leaving massive pillars.

Description of the main results of the study

1. It has been established that for geomechanical support of the development of flat ore bodies by systems with an open working space, when designing two stages of development (extraction of chamber reserves and re-mining) it is necessary to consider immediately as one system, and not consider separately. Since, ensuring the complete reproduction of ore reserves at the second stage, i.e. in pillars, depends on the optimality of the adopted parameters at the first stage of ore mining.

2. For qualitative and quantitative prediction of the development of mechanical processes in a rock mass, it is advisable to use a numerical modeling method. At the same time, the BABO method of prof. Ѳ. Sabdenbekuly is convenient for solving problems on a plane (in two dimensions) and has shown its effectiveness to date.

3. Reducing the load on barrier pillars and inter-chamber pillars on adjacent panels is achieved under the condition of complete seating of the overlying thickness.

4. The room-and-pillar mining system has two main structural elements that determine the levels of mining safety, ore extraction from the subsoil, and mining productivity. This is the roof of the cleaning chambers and the supporting inter-chamber pillars.

5. In order to assess the influence of the chamber span on the stability of the roof mass, numerical modeling was carried out with chamber widths of 9.0 (adopted in the current project), 8.0 m and 7.0 m. The dependence of the safety factor of the roof rocks on the chamber width was determined. The stability criterion is satisfied by the width of the chambers being 7 m.

6. By superimposing curved sliding surfaces on the geological section, deformation zones were identified in the overlying thickness of panels 1, 39, 40, 41, 42, 43 of deposit 4-1 and compared with the result of seismic exploration. It has been established that the parameters of the arch calculated by the BABO method and the results of seismic exploration are in agreement.

7. The methodology for calculating the deformation zone in a rock mass has been improved in order to adapt it to the conditions of the deposit. Taking into account that the angle of inclination β_i depends on the stresses depending on the depth of the sliding surface, the dependence of β_i on the value $\rho_{\text{кс}}$ was determined. The dependence of the rock collapse angle δ on the parameters β_i and $\rho_{\text{кс}}$ has also been established. At $\rho_{\text{кс}} = 33° \div 36°$ the value of δ varies within the limits $\delta = 65.86° \div 62.84°$.

8. 8. Using the adjusted methodology, the fulfillment of the condition for complete subsidence (subsidence) of the earth's surface with the width of the required space, ensuring complete subsidence of the earth's surface during ore extraction at a depth of 430 m in the conditions of the Zhomart-2 deposit, was assessed. The condition of full additional work is fulfilled at $H < 1,09 \, L_э$ or $L_э > H/1,09$.

10. An improved version of the development system with an open working space has been developed, which allows you to control rock pressure at the first and second stages of field development, ensuring the safety and optimality of mining operations.

Scientific novelty

- it is scientifically substantiated that the pattern of changes in the safety factor of the chamber roof rocks depends on the width (span) of the chamber (7, 8 and 9 m);

- patterns of formation of displacements and deformations in the zone of influence of mining operations have been established, depending on the size of the mined-out space and the location of the barrier pillars relative to the mined-out space.

- as a result of comparing the results of field studies (seismic exploration) with the results of calculations using the BABO method, the sliding parameters in the conditions of the Zhomart field were determined using the reverse calculation method and the BABO method was adjusted.

- the condition for complete undermining of the earth's surface ($L_э > H/1,09$), necessary for designing the procedure for re-mining pillars, has been established as the main geomechanical parameter of the room-and-pillar development system;

- an improved version of the development system with an open treatment space has been developed, which allows you to control rock pressure at the first and second stages of field development, ensuring the safety and optimality of mining operations.

Compliance with areas of scientific development or government programs

The dissertation work was carried out in accordance with the priority direction of scientific development, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan, namely in the priority direction «Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures».

The dissertation was carried out within the framework of grant project No. AP14972873 «Creation of resource-saving technologies for the development of ore deposits in order to increase the completeness of the extraction of minerals» for grant funding of research by young scientists under the project «Zhas Galym-2» (scientific supervisor - Balpanova M. Zh.).

Practical significance of the work

The practical significance of this dissertation work, confirmed during testing, lies in minimizing the percentage of loss and dilution of the useful component when

mining flat ore bodies with systems with an open treatment space, which allows reducing the cost of the extracted minerals.

Description of the doctoral student's contribution to the preparation of each publication

The author's personal contribution lies in carrying out the bulk of theoretical and experimental research set out in the dissertation work, including the development of theoretical models, experimental research methods, conducting research, analyzing and processing the results in the form of publications and scientific reports.

10 scientific papers have been published on the topic of the dissertation work, including: 1 (one) article in a peer-reviewed scientific publication on the scientific direction of the dissertation topic, indexed in the Web of Science Core Collection and 1 article on CiteScore in the Scopus (Elsevier) database, 5 (five) articles in publications recommended by KOKSNVO MNandVO RK, 3 (three) theses in collections of the International Scientific and Practical Conference.

In a journal indexed in the Web of Science Core Collection database:

Journal of Mining Science, 2020, volume 56, №2, 184–195 (2020) https://doi.org/10.1134/S1062739120026637

Article in recommended journals from the Scopus list:

Mining of Mineral Deposits, 2023, Volume 17 (2023), Issue 1, pp.129-137. https://doi.org/10.33271/mining17.01.129 (The article was published within the framework of grant project No. AP14972873 «Creation of resource-saving technologies for the development of ore deposits in order to increase the completeness of the extraction of minerals» for grant funding of research by young scientists on the project «Zhas Galym-2» and on individual results of this dissertation work).

In journals included in the list of recommended publications of KOKSNVO:

Mining Journal of Kazakhstan №6 (2019);

Physical and technical problems in the development of field methods №2 (2020);

University Proceedings № 4 (2022);

Mining Journal of Kazakhstan №2 (2023);

Mining Journal of Kazakhstan №11 (2023).

Information about the documents of protection for the intellectual property object:

Patent of the Republic of Kazakhstan for utility model №8447 "Method of constructing an artificial pillar." from 09/22/2023. Balpanova M.Zh., Takhanov D.K., Balabaev O.T.

Implementation of work results

The results of scientific research have been brought to practical implementation and are used at the Zhomart mine of the «Zhezkazgantsvetmet» Production Association of «Kazakhmys Corporation» LLP.

The results of the dissertation research were used in the development of the project P 20-22/03-PZ «Pilot mining of reserves of panels 21, 22 using a room-and-pillar mining system leaving massive pillars» as a recommendation, within the framework of the research project «Conducting a study to carry out pilot industrial development of reserves of panel 21 deposits 5-III, 5-II, 5-I, panels 22 deposits 4-III, panels 23 deposits 4-I, 3-VI using a room-and-pillar system development with the abandonment of massive pillars» of the «Zhomart» mine, completed under contract No. P1100108845 dated March 24, 2022 between NPK «AlGeoRhythm» LLP and «Kazakhmys Corporation» LLP (confirmed by acts and certificates of implementation).