

ANNOTATION

Dissertation for the degree of Doctor of Philosophy PhD in the educational program 8D07202 - " mining "

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Geomechanical justification of pillars re-development based on the data of complex monitoring of condition of the rock mass

The relevance of the work. According to the rules, the re-development of the targets should be accompanied by comprehensive geomechanical monitoring. The full complex of geomechanical monitoring consists of:

- visual (mine) observation of the processes of destruction of structural elements of the chamber-pillar development system;
- instrumental measurements along the profile lines of the process of subsidence (displacement) of the earth's surface during the development of chamber reserves and the re-development of the whole;
- continuous seismic (instrument) monitoring of the processes of destruction of the overlying strata;
- and others if necessary.

Comprehensive geomechanical monitoring of all three types at the mines of Kazakhmys Corporation LLP covers the mines at the Zhezkazgan deposit and the Zhomart mine. The Zhomart mine has been developed by a panel-pillar development system (a subspecies of a chamber-pillar development system) since 2006. The re-development of the tselikov was started in pilot-industrial order in 2009.

Since August 2017, at the Jomart mine, the seismic monitoring system has noted an increase in technogenic seismic activity of the massif in the areas of re-development. The strongest seismic events were registered by all seismic stations of the Seismological Service of the Republic of Kazakhstan as man-made earthquakes.

Observations of the subsidence of the reference points of the profile lines show that the displacement of rocks reached the earth's surface with maximum values of about 100 mm in the area of panels 42-44 (in which the MCC are worked out, and the BC are left) and along panels 39, 1, 2, 3 located along the profile line 1.

The increase in seismic activity of the massif and the movement of the earth's surface indicate a deterioration of the geomechanical situation at the Jomart mine. The reasons for the deterioration of the geomechanical situation:

- there are many local sections of the extraction of the whole with small spans of repayment, the sections between which are overloaded;
- hanging of rock strata on untreated BC and MC, creating a reference pressure on them and the surrounding massif;

- non-compliance with the design procedure for re-working; in particular, premature cutting of the BC ahead of the repayment front by more than 3 rows of MCCS.

In 2020-21, the earth's surface of the Zhomart mine was covered by satellite monitoring, in 2021, work was carried out to determine the collapse zones of the overlying strata over the sites of repeated development using seismic exploration technologies, since 2021, pilot work is being carried out on the use of massive pillars. All this makes it possible to consider in more detail the issue of safe conditions for re-development, taking into account the results of complex geomechanical monitoring and research work carried out.

The **purpose** of the dissertation is to determine the conditions for the safe conduct of the re-development of tselikov and controlled repayment of voids using data from integrated monitoring of the state of the rock mass.

The research objectives are as follows:

1. Analysis of the study of the issue of repeated developments in the chamber-pillar system of development and integrated geomechanical support of mining operations.
2. Analysis of data from visual monitoring of the condition of the roof of the worked-out space at the sites of pilot works with reduced spans of cleaning chambers to ensure safe conditions for working out chamber stocks and targets from the open worked-out space..
3. Determination of the dependence of the height of the collapse arch on the span of re-development, as well as the maximum span of side-work, in which the overlying thickness is fully planted to the surface using seismic exploration and numerical modeling.
4. Justification of the method of monitoring the entire area of re-development for timely assessment of the risk of dangerous geomechanical situations (man-made earthquakes, air strike)
5. Development of a methodology for calculating the displacement of the Earth's surface for the conditions of the Zhomart mine in order to predict the safety of surface engineering communications and transport routes..

The object of the study is the Zhaman-Aybat deposit worked by the Zhomart mine of Kazakhmys Corporation LLP.

The subject of the study is the stability of the rock mass, the passage of chambers, the overlying thickness and the Earth's surface; deformation of the contour array, the overlying thickness and the Earth's surface.

Factual material and research methods. Statistical analysis of the stability of the roof span of the chambers based on the results of mine observations and computer modeling using the RS2 program (RocScience, Canada) of the process of loss of stability of the thin-layered roof of the cleaning chambers. Comparative analysis of the results obtained by two methods of monitoring the movement of the Earth's surface (interferometry and leveling).

Mathematical modeling of the stability of the overlying strata using the Examine2D program and comparison of the data obtained with the results of seismic exploration. A computational and graphical method for determining the

angles of movement of rocks at the Jomart mine on the basis of instrumental data of subsidence of the Earth's surface.

Scientific novelty

1. The regularity of changing the margin of safety of the peripheral part of the chamber depending on the width of the chamber (7, 8 and 9 m) and taking into account the distance from the boundaries of the chamber (m). Reducing the span of the chamber by 1 m (from 9 to 8 m) reduces the deflection of the roof by 2 times (up to 5 cm); except in addition, the depth of the breakdown in the roof is significantly reduced – up to 1.75 m. Reducing the span of the chamber by another 1 m (from 8 to 7 m) reduces the deflection of the roof to 2 cm; The depth of destruction in the roof is also significantly reduced – up to 1.33 m.

2. It has been practically proved that with a chamber-pillar development system for the conditions of the Jomart mine, reducing the width of the roof span of the chambers from 9 m to 7 m increases its stability tenfold.

3. By comparing the results of satellite radar interferometry and instrumental control (leveling) along profile lines for the same period, the possibility of using a new technology for area monitoring of the movement of the Earth's surface with an accuracy of several millimeters has been proved.

4. Based on the results of determining the collapse zones of the overlying strata with the help of seismic exploration technologies, a reliable mathematical model was obtained on the basis of which the dependence of the formation of the collapse arch on the equivalent span of the repayment section of the re-working of the pillars was obtained ($h_{obr} = 16.473e^{(0,008L_e)}$);

5. The mathematical modeling method for the conditions of the Jomart mine, based on the results of seismic exploration, determined the condition for the complete working of the Earth's surface ($H < 1.6 L$ or $L > N/1.6$);

6. According to the results of instrumental observation of the subsidence of the Earth's surface along the profile line No. 3, located above the previously worked-out re-development of the whole panel 2, it was determined that the angles of displacement for the overlying thickness of the Zhomart mine are equal to $\nu = 107^\circ$; $\beta = 73^\circ$; $\gamma = 73^\circ$; $\delta = 73^\circ$; $\gamma' = 90^\circ$; $\beta' = 90^\circ$; $\delta' = 90^\circ$.

7. On the basis of inverse calculations of the maximum subsidence of the Earth's surface over previously worked-out panels 42, 43, 44, a function was determined linking the maximum subsidence of the Earth's surface with an inverse power dependence on the ratio of depth and equivalent span for the conditions of the Jomart mine and has the form $n_m = m / [1 + ((H/l_e))^{4,5}]$.

Scientific provisions to be defended

Based on the results of geomechanical monitoring of the condition of the developed space, it was found that reducing the width of the chamber during primary and repeated development leads to a decrease in compressive stresses in the roof and sides of the workings according to logarithmic dependence, thereby increasing their stability.

According to the results of geomechanical monitoring of the overlying strata with the help of seismic technology, it was found that the height of the collapse arch depends on the span of the work-up and increases exponentially until full work-up is achieved, at which a complete subsidence of the overlying strata occurs.

According to the results of geomechanical monitoring of the displacement of the overlying strata, it was found that during re-development, the parameters of the Earth's surface displacement have an inversely power dependence on the ratio of the depth of development and the span of the side work.

Practical significance

The results of the dissertation research of Zhienbaev Abzal Bakhitovich on the topic "Geomechanical justification of the re-development of the tselikov based on the data of integrated monitoring of the state of the rock mass" for the introduction of changes in the spans of chambers from 9 meters to 7 meters with a chamber-pillar system of development received practical implementation in the conditions of the Zhomart mine.

This proposal has increased relevance and is of practical interest in the issues of safe re-development of targets and controlled repayment of voids. In panels 21 deposits of W-A 5-III, 22 deposits of W-A 4-III, there were no signs of destruction of the pillars. The stability of the roof span of the chambers is satisfactory (photos 1, 2, 3), the quantitative ratio of fallout has decreased tenfold and is within 1-2%.

The end result he aim is to develop a methodology for calculating the displacement of the Earth's surface during the re-development of the targets at the Jomart mine.

Personal contribution of the author it consists in the formulation of the purpose and objectives of the study, analysis of the study of the issue of repeated developments with a chamber-pillar system of development and integrated geomechanical support of mining operations, analysis of data from visual monitoring of the condition of the roof of the worked-out space in the areas of pilot works with reduced spans of cleaning chambers to ensure safe conditions for the development of chamber reserves and targets from the open worked-out space, it consists in the formulation of the purpose and objectives of the study, analysis and processing of the results of instrumental and satellite monitoring, determination of the dependence of the height of the collapse arch on the span of re-development, as well as the maximum span of part-time work, in which a complete landing of the overlying thickness to the surface occurs using seismic exploration and numerical modeling, justification of the method of monitoring the entire area of re-development for timely assessment of the risk of dangerous geomechanical situations, It consists in formulating the goals and objectives of the study, developing a methodology for calculating the displacement of the Earth's surface for the conditions of the Zhomart mine in order to predict the safety of surface engineering communications and transport routes.

Approbation of the work and publications. The main provisions and research results were presented at scientific conferences: - Saginovsky Readings

No. 13 (Map 2021); - Proceedings of the International Scientific and Practical online Conference "Formation of intellectual capital in the conditions of digital transformation: experience, challenges, prospects".- Karaganda: NAO "Map named after Abylkas Saginov"; - Collection of scientific articles based on the materials of the XII International Scientific and Practical Conference "INNOVATIONS IN SCIENCE AND PRACTICE".- Ufa: SIC Bulletin of Science.

- at seminars of the Department " Development of mineral deposits " of NAO "Karaganda Technical University named after Abylkas Saginov"; - Tashkent State Technical University named after Islam Karimov" (Tashkent, Uzbekistan); Completed a scientific internship in the period from June 27 to July 8, 2022 at the Tashkent State Technical University named after Islam Karimov (Tashkent, Uzbekistan)

The main provisions of the dissertation work have been published in 8 scientific papers, 4 of which are in the publication recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Republic of Kazakhstan; 3 - in the proceedings of international conferences; 1 – articles included in the Scopus database; 2 certificates of state registration of copyright rights.

The dissertation structure and volume. The dissertation work consists of an introduction, 5 chapters and a conclusion, is presented on 109 pages of typewritten text, contains 73 figures, 17 tables, a list of references from 181 titles.

Acknowledgements. The author expresses gratitude to the scientific supervisor, Associate Professor of the RMPI Department, Ph.D. E.A. Abeuov for assistance at various stages of preparation of the dissertation work, Ph.D. D.K. Takhanov, as well as specialists of Kazakhmys Corporation LLP, Chief geomechanic D.V. Mosyakin, Ph.D. Professor, member of the ISRM Academy of Sciences A.B. Makarov, to the deputy head of the Geomechanical Department M.A. Zharaspaev and the staff of the RMPI Department for their support.