

## **Abstract**

**of the dissertation for the degree of Doctor of Philosophy (PhD) in the specialty: 6D070700-"Mining"  
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**“Geomechanical substantiation of the technology of pillars in the combined development of contiguous steeply dipping ore bodies under conditions of Ushkatyn”**

**The relevance of research.** The dissertation work is devoted to the issue of geomechanical substantiation of the technology of working out the pillars in the combined development of converging steeply falling ore bodies.

Rational use of mineral resources in the exploitation of mineral deposits is of paramount importance for the development of the mining industry of any country. But the use of mineral reserves in many domestic and foreign ore deposits remains unsatisfactory. In particular, this is observed in the combined development of ore deposits, where significant losses and dilution of ore are associated with the complexity of working off the security and ceiling pillars. An unfavorable situation with the completeness and quality of the extraction of reserves from the whole has developed at many mines developed in a combined way. The low indicators of completeness and quality of ore extraction from the pillars at these mines are caused by the discrepancy of their parameters with the geomechanical conditions of field development.

Currently, a number of fields in the country are widely considering the issues of working off reserves of abandoned end-to-end pillars. In this regard, at the Ushkatyn-3 mine, there is a problem of re-mining of iron-manganese ores remaining in the whole of the spent horizons.

The Ushkatyn-3 deposit consists of steeply falling ore bodies and iron-manganese ores are mined underground at the deposit. The deposit is being developed in a combined way. That is, from the quarry through the tunnel, the transition to the underground method of development was carried out.

Mining involves certain difficulties in ensuring the stability of underground workings and sides of the quarry. Systematic studies of their condition have shown that the decisive factor in the stability of underground workings and pillars in the combined development of deposits is, first of all, the stress-strain state of the contour array. The analysis of the study of the stress-strain state of the rock mass in the vicinity of underground workings in the conditions of combined development of the deposit allowed us to establish that until now the issues related to the determination of the stress-strain state of the rock mass in the vicinity of underground workings during the development of converging steeply falling ore bodies, taking into account the influence of open-pit mining, have not been fully resolved.

**The purpose of the work** on the basis of a complex of geomechanical studies is to identify patterns of changes in the stress-strain state of the massif

during the complete and safe development of reserves in security and ceiling pillars during the combined development of converging steeply falling ore bodies.

**Research objectives:**

- analysis of domestic and foreign experience in the development of pillars in the combined development of converging steeply falling ore bodies;
- conducting seismic exploration and in-house processing of the received data to determine the actual power of security and ceiling pillars;
- study of the structure of the massif and the survey of rock fracturing on the contours of mine workings at the horizons of +288 m, +240 m, +192 m, +144 m to determine the index of geological strength (GSI) and the rating of the rock mass (RMR), as well as clarification of the physical and mechanical properties of rocks using the RocLab program;
- carrying out numerical modeling by the finite element method based on data obtained as a result of seismic exploration and determination of structural features of rocks;
- development of recommendations on safe mining operations and ensuring full extraction of ore reserves.

**The idea of the work** is to determine the structural parameters and strength properties of the array, the main acting stresses in the array and their orientation, the actual dimensions of the pillars and the formation of an internal dump when working out the pillars of the converging steeply falling ore bodies based on a complex of geomechanical studies.

**Object of research:** an array of rocks near converging steeply falling ore bodies in the conditions of the Ushkatyn mine.

**The following methods were used in carrying out research and scientific and technical work:**

- analysis and generalization of the literary fund, patent materials and technical developments on the topic of dissertation research;
- determination of the actual dimensions of the pillars during the combined development of converging steeply falling ore bodies, using a seismic survey apparatus;
- in-house processing of data obtained as a result of seismic exploration using a professional system and a set of software;
- to build a model of working out the pillars by numerical modeling of finite elements based on data obtained as a result of studying the stress-strain state of the array in the field, taking into account the strength properties of rocks.

**The main provisions submitted for protection:**

- the actual size of the pillars of the converging steeply falling ore bodies during combined mining is determined by seismic exploration in the field, taking into account their residual strength;
- the stability of the rock mass near steeply falling ore bodies during mining, depending on the depth, is estimated using numerical modeling.

**Scientific novelty of the study:**

- in determining the patterns of changes in the stress-strain state of the massif near the zone of pillars between ore bodies, depending on the rating of rock stability;

- development of a comprehensive research method for working out the pillars of the converging steeply falling ore bodies, including the study of geomechanical processes occurring in the mountain range;

- identification of stable parameters that ensure the working out of the pillars whole depending on the thickness of the whole between the approached ore bodies and the residual strength of rocks.

#### **Practical significance of the work:**

The practical significance of the work is considered to be the geomechanical substantiation of the technology of working out the pillars, taking into account the stress-strain state of the massif and the strength properties of rocks with the determination of the actual dimensions of the security and ceiling pillars in the combined development of steep-falling ore bodies.

**The validity and reliability of scientific statements, conclusions and recommendations** is confirmed by the results of computer modeling of the rock mass, comparative, static and analytical analysis.

**Implementation of the results of work in industry.** The actual capacities of the pillars are determined and the formation of an internal dump with a geomechanical justification of the technology of working out the pillars is proposed.

According to the dissertation work, certificates of introduction into the educational process of the NJSC "Karaganda Technical University named after Abylkas Saginov" in the bachelor's degree disciplines of the specialty "Mining" were obtained.

#### **Personal contribution of the author:**

- setting the task of research work;
- conducting field and laboratory tests directly in underground workings in order to determine the strength properties and structural features of rocks;
- conducting field and laboratory studies with a seismic survey apparatus in order to determine the actual dimensions of the pillars along the ore bodies;
- development of recommendations for safe mining operations.

**Approbation of the work.** The main provisions of the doctoral dissertation are presented and discussed at international scientific and practical conferences and forums: The International scientific and practical conference " Science integration, education and production - basis of the implementation of the Plan of the nation" (Saginov's readings № 11)(Karaganda, 2019), International scientific and practical online conference "The Formation of Intellectual Capital in the Era of Digital Transformation: Experience, Challenges, Future Prospects" (Karaganda, 2022), II International Scientific and Practical Conference "Modern Science: theoretical and practical view", March 14-15, 2023, Madrid. Spain.

**Publications.** The main provisions of the work are reflected in 7 printed works, including 2 articles published in a journal included in the Scopus database, 2 articles published in journals included in the list of publications submitted by the

Committee for Quality Assurance in Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan, 3 theses at an international conference.

**The structure of the dissertation work.** The dissertation consists of an introduction, five chapters and a conclusion, 105 pages of printed text and a list of 46 references.

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