# ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD) in specialty:
6D070700 – Mining

**Suimbayeva Aigerim Maratovna**

Geotechnological research to justify the parameters of stability of the rock mass during combined mining (on the example of the Akzhal field)

**The relevance of the research.** At the present time a number of large ore deposits in Kazakhstan are being developed in a combined way - with the transition from open-pit to underground mining methods. With this method of field development, the near-contour part of the massif is repeatedly exposed to loads from open and underground work, which leads to a complication of the ground state under the influence of various factors that constantly develop in space and time.

Currently the Akzhal mine is working out reserves of lead-zinc ores in a combined way with a sub-level caving system. In the future, according to the project of industrial development of the Akzhal field, a full transition to underground mining of reserves is planned, so the tasks related to ensuring the stability of preparatory and capital workings during mining of pit reserves are of great scientific and practical interest.

Ensuring the stability of a rock mass with different mining and geological characteristics of ores and host rocks in a rapidly changing mining situation requires the use of a scientifically based methodology for predicting the state of a stress-strain rock mass. Successful solution of geomechanical substantiation of rock mass stability parameters should ensure the efficiency and safety of mining operations.

To solve this problem, a comprehensive geomechanical assessment of the stress-strain state of the pit rock mass is required, taking into account the physical and mechanical features and structural properties of the enclosing rocks and the influence of the development and production workings.

The task of geomechanical substantiation of the stability parameters of a rock mass taking into account structural features today has several methodological solutions, but the main difficulty in the method of assessing the influence of fracturing on the properties of a rock mass is associated with the difficulties of comprehensive accounting of mining and geological factors, the lack of a scientifically substantiated relationship between laboratory the results of testing the strength of rocks and the strength characteristics of the massif.

As per world practice of underground structures' design and construction of the ore deposits, which are developed in a combined way, the assessment of the geomechanical state of the rock is made using numerical modeling methods and taking into account rating classifications. Nowadays in our country, the same methods of assessing the rock competence is used in the design and construction of mine workings as well.

Thus, the geomechanical feasibility of the rock mass stability parameters makes possible to predict the behavior of the surrounding technogenic outcrops of the rock mass during combined mining, which is an essential scientific and practical task.

**The purpose of the dissertation** is to substantiate the parameters of stability of technogenic outcrops based on the assessment of structural features of rocks using numerical modeling methods and to develop a method for complex assessment of the geomechanical state of the ground in combined development.

To achieve this goal, the following **tasks** were identified:

- analysis of the existing methods for studying the stress-strain state of a rock mass and methods for counting the degree of fracturing influence on the stability of technogenic outcrops. Determination of the modern methods' applicability limits for assessing the stability of a rock mass based on rating indicators;
- carrying out the comprehensive mine research of the geomechanical state of the rock mass to determine the value of the geological strength index (GSI) of rocks;
- carrying out numerical experiments to study geomechanical processes in predicting the stability of technogenic outcrops;
- development of a methodology for an integrated assessment of the geomechanical state of a rock mass based on an assessment of the rock structural features using numerical modeling methods.

**The idea of the work** is to substantiate the stability parameters of the sub-quarry part of the massif based on studies to determine the strength characteristics of rocks in the massif using the geological strength index (GSI).

**The object of research** is a rock mass near the sub-quarry part of the mineral deposit.

**Research methods.** In carrying out the work, a comprehensive research technique was used, including the analysis of literary sources, the results of laboratory experiments carried out by specialized organizations, mine studies to determine the geological strength index, numerical modeling of geomechanical processes occurring in the sub-quarry rock mass.

**Scientific provisions** submitted for defense:

- a numerical analysis of the stress-strain state of rocks, taking into account the geological strength index (GSI), makes it possible to quantitatively assess the geomechanical state of the sub-quarry rock mass during combined mining;
- the changes in the main stresses in the near-contour part of the mine excavations located in the sub-quarry ground depend on the distance to the bottom of the pit in a nonlinear relationship;
- an increase in the width of the open pit bottom leads to a decrease in the zone of concentration of tensile stresses in the ceiling of the stope.

The **scientific novelty** of the thesis is:

- in the substantiation of the stability parameters of the sub-quarry part of the massif on the basis of the methodology for a comprehensive assessment of the geomechanical state of rocks during combined development;

- in obtaining analytical dependences of the maximum values of horizontal stresses in the pit rock mass on the width of the pit bottom;

- in establishing the dependence of changes in the under-quarry part of the massif of the main stresses from the bottom of the quarry to the contour of the mine working by adapting the GSI geological strength index to the mining and geological conditions of the Akzhal deposit.

**The practical significance** of the work:

- a method for studying the stress-strain state of a rock mass was developed on the basis of systems for assessing the quality of the geological environment using numerical modeling methods;

- substantiated the parameters of the stability of man-made outcrops for the safe conduct of mining operations during the development of under-pit reserves of lead-zinc ores of the Akzhal deposit.

**The validity and reliability of scientific provisions.** The validity and reliability of scientific provisions are confirmed by the use of well-tested and widely used in world practice geomechanical calculations Hoek-brown classification based on the geological strength index GSI, analysis and processing of a large amount of data obtained as a result of laboratory and mine research.

**Implementation of the results of work in industry.** This method of studying the stress-strain state of a rock mass and determining the stability parameters of technogenic outcrops based on systems for assessing the quality of the geological environment using methods of numerical modeling was implemented when developing pit reserves of the Akzhal deposit for a rational choice of parameters for securing mine excavations. The obtained research results were used to assess the geomechanical state of rocks in the near-contour part of the mine excavations of the +505 m and +545 m horizons of the Akzhal underground mine.

**The author's personal contribution** consists of:

- setting the task of research works;

- conducting laboratory tests of rock samples to determine the uniaxial compressive strength;

- conducting mine studies to determine the quality of rocks (RQD) and fractures survey;

- preparation of initial data for numerical analysis in accordance with the rating classifications of rocks;

- identifying patterns and establishing dependencies of changes in the parameters of stability of technogenic outcrops;

- development of methods for complex assessment of the geomechanical state of a rock mass based on systems for assessing the quality of the geological environment using numerical modeling methods.

**Testing the work.** The main provisions of the doctoral dissertations were presented and discussed at international scientific conferences and forums: "International University Science Forum. Practice, science and education", Toronto (Canada), 2020, "Innovative geotechnologies in the development of ore and non-metallic deposits", Yekaterinburg (Russia), 2018, "Integration of science,

education and production-the basis for the implementation of the national Plan", Karaganda (Saginovsky readings No. 10, 11, 12) 2018-2020.

**Publication of the work.** The main provisions of the work are published in 12 publications, including 1 article published in a journal included in the Clarivate Analytics database, 1 article published in a journal included in the Scopus database, 2 articles published in journals included In the list of recommended CCSES publications, 6 abstracts of reports at international conferences and 2 certificates of entering information in the state register of rights to objects protected by copyright.

**The structure of the work.** The dissertation consists of an introduction, five sections and conclusions, contains 128 pages of printed text and a list of sources used from 163 titles.