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Geomechanical Processes and Their Assessment in the Rock Massifs in Central Kazakhstan

Springer

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Preface

The Republic of Kazakhstan is one of the largest republics of Central Asia, with an area of more than 2.7 million square kilometers, a population of more than 18 million people, land borders with Russia, China, Uzbekistan, and Kyrgyzstan. The bowels of Kazakhstan store a significant number of types of minerals. On the basis of explored reserves, a powerful mining industry has been created, for the extraction and processing of ores of ferrous, nonferrous, and noble metals of various types. The mining and metallurgical complex includes more than 200 mining and processing enterprises, the sale of marketable products of which is currently carried out in European countries, the USA, China, South Korea, Singapore, Malaysia, and other countries.

Mining is the most important branch of material production, the level of which determines the economic power and independence of states. Mining provides countries with the necessary natural resources, on the basis of which the manufacturing industry creates means of labor and consumer products.

Mining projects provide the population with work, build various infrastructure objects, and raise the living standards of the population.

In the field of open-pit mining of mineral deposits, the scientific potential of this area is of particular importance in the design and long-term planning of mining in deep pits, which currently produce more than 90% of iron ores, at least 35% of nonferrous metals, about 8% of coal in Kazakhstan , about 70% of asbestos and phosphate ores.

A major perspective area of research in the field of open-pit mining is the management of the developing of mining operations. This direction includes knowledge of methods for managing the development of mining operations, design methods, and substantiation of the regularity of mining development in time and space, research of geomechanical and geotechnical processes.

The aim of the research is to increase the stability of the quarry boards, the slope of the ledges by strengthening and hardening them for the effective and safe development of mineral deposits. New methods for determining the disturbance of the mountain massif are studied in detail and proposed in this work.

The significance of the results is the implementation of a complex of investigations of a field tectonics crack developed by the open method, which takes into account thermal, ultrasonic methods for strengthening the sideboards of the quarry, formation, and processing point diagrams from field measurement data and a map of the fracture of the most unfavorably oriented slopes. To improve the efficiency of its processing, the development of methods for express assessment of disturbance of the mountain massif for its operational control, strengthening of quarry slopes composed of fractured rocks has been proposed.

The monograph is of interest to mining engineers, researchers, undergraduates, and students of geomechanical, geodesic, mining, and environmental specialties.

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Special thanks to Dr. Bekmurzaev Batyrkhan for providing material on geoinformation technology in the design and planning of open-pit mining.

The authors sincerely thank all the participants and contributors in the project, colleagues, friends, and well-wishers for their support.

This research was funded by the Ministry of Education and Science of the Republic of Kazakhstan for 2015–2017, (grant 0424/GF 4) "Express-assessment of geomechanical condition of the rock massive and development methods of its strengthening and reinforcing for safe ecological developing of the fields of mineral resources in hard mountain—geological and mining engineering conditions."

Content and Structure of the Book

This monograph is the result of research on grant financing "0424/GF 4 Express-assessment of geomechanical condition of the rock massive and development methods of its strengthening and reinforcing for safe ecological developing of the fields of mineral resources in hard mountain—geological and mining engineering conditions". Issues for the environmentally safe mining of mineral deposits were reviewed to develop methods for: rapid assessment of disturbance of the mountain massif; fortifications; hardening quarry slopes; dust suppression on quarry roads.

Chapter 1, "Mineral Deposit and Studying of World Experience on the Study of the Geomechanical State of the Mountain Massif in Complex Mining and Geological Conditions." The issues of the development of mineral deposits, developed by the open method, characterized by a large variety of geological, mining, geomechanical, and technological conditions. Leading enterprises of the mining complex of Kazakhstan. Chapter 2 "Geological Setting Structural-Tectonic Features and Physico-Mechanical Properties of Mountain Rocks on the Stability of Slopes with the Account of the Time Factor and Large-Scale Explosions." This chapter discusses factors affecting on the stability of slopes with including rocky and semi-rock formations that must be taken into account when studying geomechanical processes. Chapter 3 "Petrology and Geochronology of Country and Studying of the Disturbance of Rock Massif with the use of the Teplometry Method." The main rocks and minerals at the Konyrat deposit are of three types: granodiorites, porphyrites, secondary quartzites. Chapter 4 "Spatial Distribution of ore Bodies and Teplometric Method of Express Evaluation of the Rock Massif Disturbance". A heat-measuring method was chosen to carry out an express assessment of disturbance in mountain ranges, which is distinguished by accuracy, measurement speed with ease of work, determination of the boundary of homogeneous zones according to the degree of disturbance of the pit slope, and on the basis of these data it is possible to correct drilling and blasting operations on the section adjacent to the pit slope supplied design position that will increase the stability of the pit walls for the efficient and safe mining of mineral resources in the bottom harboring horizons. Chapter 5 "Ultrasonic Method of Express Evaluation

of the Rock Massif Disturbance." The ultrasonic method of research is used, which has a high sensitivity to structural changes in the massif at the early stages of deformation development. Based on the determination of the propagation velocity of longitudinal and transverse elastic waves, samples of using appropriate ultrasonic equipment and measurement techniques were carried out. Chapter 6 "Development of Solutions for: Hardening, Strengthening the Sides of the Quarry; Suppression Dust Formation on the Quarry Roads." The composition of cementing solutions for hardening, strengthening of quarry slopes and dust suppression on the roads of the quarry has been developed. It is based on the task of creating a compound for fixing the dusting surfaces of the open-pit roads using waste from the mining and processing industry, the coating of which has high strength and weather resistance. Chapter 7 "Modern Methods of Researching of the Geotechnical State of the Massif for Engineering and Planning of Open Mining Works". As a result of analyzing various options for the structure and functions of the system and its elements, a model of computer-aided design and planning was built, which most closely corresponds to the conditions for implementing an automated decision-making technology for openwork tasks.

Introduction

The mineral deposits that developed with open mining works are characterized by a wide variety of geological, mining, geomechanical, and technological conditions. The leading enterprises of the mining complex of Kazakhstan are working out the fields by the open method. About 35% of copper ore is mined at the "Nikolayevsky" and "Shemonaikhinsky" open-pit quarries of the East Kazakhstan copper combine, the "Tur" mine ("Kazchrome") and the "Konyrat" mine of the Balkhash Mining and Metallurgical combine.

An important stage in the development of open-pit mining of mineral deposits is characterized by the following features: increasing the depth of the quarries, the lifetime of the slopes of the ledges and boards of the quarry, the growth of overburden, intensification and concentration of mining, the complexity of engineering, geological and hydrogeological conditions of mining, low content of useful components in the ore. Over 70% of quarries have a depth of over 200 m, many quarries work out the horizons of 400–500 m from the earth's surface, and the design depths reach 700 m or more. In order to improve the efficiency and completeness of field development, improve the technical and economic indicators of the enterprise, to ensure the safety of mining operations in the open pit, reliable maintenance of the stability of quarry slopes is required. In this case, the main task is to determine the optimal parameters of the slopes, ensuring their long-term stability with the minimum amount of overburden works. In addition, the control and regulation of the behavior of the array of mineral deposits in the development require a deep study of the properties and structure of the array, its geological, geostructural, and geotechnical characteristics, as well as geomechanical features.

The aim of the research is to increase the stability of the quarry boards, the slope of the ledges by strengthening and hardening them for the effective, and safe development of mineral deposits. New methods for determining the disturbance of the mountain massif are studied in detail and proposed in this work.

The significance of the results is the implementation of a complex of investigations of a field tectonics crack developed by the open method, which takes into account thermal, ultrasonic methods for strengthening the sideboards of the quarry, formation and processing point diagrams from field measurement data, and a map

of the fracture of the most unfavorably oriented slopes. To improve the efficiency of its processing, the development of methods for express assessment of disturbance of the mountain massif for its operational control, strengthening of quarry slopes composed of fractured rocks has been proposed.

The monograph is of interest to mining engineers, researchers, undergraduates, and students of geomechanical, geodesic, mining, and environmental specialties.

Considering the importance of stakes, the slope design in open-pit mines must be based on a well-controlled methodology, especially since experience shows that each rock mass characterized by its geological structures is unique, and therefore there are no standard recipes that achieve the right solution with certitude. This methodology can be broken down into several phases: (1) characterization of the rock mass through the acquisition and analysis of geological and geomechanical data, (2) identification n of potential mechanisms of deformation and failure, and their modelling; (3) the slope design and the definition of methods of reinforcement and monitoring. These phases largely developed by Cojean and Fleurisson are briefly recalled here.

This phase involves the acquisition of geological, geomechanical, and hydrogeological knowledge by observation and measurement. It employs all the disciplines of earth sciences and mechanical sciences, and particularly the disciplines of the engineering geology, geotechnics, soil and rock mechanics, and hydrogeology and groundwater hydraulics. First, the geological approach is essential in order to analyze material behavior. The geologist identifies the petrographic nature of the material (rock or soil) and their state of weathering and fracturing. These data are essential for the characterization of mechanical properties of material. It also provides the spatial variability of these parameters throughout the mass. Similarly, the geologist identifies geological structures of the deposit.

The data obtained from this initial geological approach are significant because they will then guide and optimize the geological and geotechnical field investigations using subsurface geophysical methods, drilling operations or shallow excavations carried out with hydraulic excavator which can, cost-effectively, provide valuable information.

Particular attention must be given to the discontinuity network that cuts the rock mass at different scales. Natural variability of the geometric but also mechanical parameters of the discontinuities requires statistical study and therefore the implementation of rigorous sampling methods. They include the following stages field measurements of discontinuities through systematic survey on outcrops, excavation face or oriented core drilling; classification of discontinuities in directional sets using stereographic projection techniques or automatic classification; statistical analysis of the geometrical parameters of each set using histograms of the principal geometric characteristics of the discontinuities: dip direction, dip angle, persistence, or trace length and spacing.

Contents

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Her research interests are focused on the study of the stability of mountain ranges in the development of mineral deposits in difficult geological conditions by the open method at great depths.

She regularly participates in international conferences, symposia with reports on the studies conducted and the results obtained on the sustainability of the career slopes of solid mineral deposits developed by the open method in Central Kazakhstan. The scientific results obtained are patented in the Republic of Kazakhstan.

Khaini-Kamal Kasymkanova has a sufficient number of articles in international journals that are part of the Scopus database, the Russian Science Citation Index (RISC) and is the author and co-author of several monographs and textbooks, such as Innovative Geomonitoring Techniques for Predicting Hazardous Technogenic Phenomena during Subsoil Development,

"Designing re-underground technology in the development of natural and man-made reserves of the collapsed deposits of the Zhezkazgan field", as well as the author of one of the chapters in the monograph ecological and Industrial Safety Exploitation of Mineral Resources published in Russian in Kazakhstan.

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Her field of interest focuses on the study of physical laws and the possibility of their useful application, working with modern satellite data, the possibility of predicting various indicators from these data, and the possibility of their application in science.

She worked at the Scientific Research Institute of Mechanics and Mathematics as a lab technician, where she carried out researcher work, as well as engaged in science in the field of mathematics and computation. For several years, she had been working as a laboratory assistant at the Kunaev Institute of Mining.

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