ANNOTATION

of the Thesis of Kopzhassaruly Koskanat
"RESEARCH OF GEOMECHANICAL CONDITION OF ROCK MASS AND STABILIZATION OF MINE WORKINGS"
for a PhD degree with a major in 6D070700 – "Mining"

Relevance of the thesis theme. Kazakhstan is intensely developing the mineral resource deposits. Therefore, the demand for the products of mining companies is of great importance not only for domestic needs of the country but also at the level of interstate relations.

Development of the mining industry is inevitably connected with the increase in the mining depth, especially at the open-cast mining of deposits there is a trend of increased depth of mines that in majority of cases results in unprofitable development of reserves using this method. Therefore, as an alternative solution at the development of deep horizons the most perspective is a combined system of development.

During the last years consecutive open-cast and underground mining of reserves has become more popular, which is proven by the development of a number of Kazakhstan deposits (Akbakay, Yshkatyn-III, Itauz, Nicolaev, Akzhal, Sokolov, Vasilkov and others). At that, dangerous geomechanical processes is intensifying. The fight with these manifestations and their rational management based on the knowledge of regularities are one of the most important tasks of the mining science and practice at the stages of construction and operation of underground mines at deep horizons.

The struggle against geomechanical processes pose threat to workers, and result in additional costs for the restoration of destroyed workings. One of the major stress concentrators is mine workings, especially those that are within the stopping zone: development and temporary workings. Stability of such workings is affected by so-called secondary stress field arising at the formation of an open area at the development of steeply inclined ore deposits.

In addition, these issues are governed by the Law of the Republic of Kazakhstan "about Subsurface and Subsurface Use which imposes the comprehensive monitoring of condition of rock mass and mine workings on mining companies "to ensure industrial safety and forecasting of dangerous situations." Thus, it confirms the importance of solving the applied scientific and technical task related to the rational and safe development of mineral resource deposits.

Another proof of the thesis theme relevance is the fact that the research was conducted in compliance with the Project Program No 757.MON.GF.15.RIPR.44, performed by the Department of Mine Surveying and Geodesy of KazNRTU after K.I.Satpayev with the participation of the author.

The work objective is to research the rock mass condition with the use of innovative methods and technologies to ensure stability of mine workings in the process of operation and safety of mining as a whole.

The purpose of the work is to improve the methods and means of monitoring to establish regularities of the geomechanical processes development typical for a certain deposit.

The object of the research is a rock mass around development and temporary workings at Akbakay mine.

The subject of the research is the research of regularities of geomechanical processes in the rock mass.

Research tasks. To achieve the set objective the following tasks have been solved:

- Review of domestic and foreign experience in the research of geomechnical processes at the combined method of development;
- Review of up-to-date technologies and methods used at the geomechanical monitoring;
- Establishment of regularities of geomechanical processes development at the field;
- Study and improvement of methods of determining structural particularities of rocks;
- Study and improvement of methods of stabilization of mine workings;
- Implementation of the results in production and teaching.

Research Methods. To solve the foregoing tasks, a comprehensive research method has been used including the review of references, practical provisions, methods and latest technologies of geomechanical monitoring, assessment of accuracy of measurement methods, and innovative ways of assuring industrial safety.

Defended Scientific Provisions:

1. Forecast of condition of the rock mass is based on identification of interconnection between the elements of a deposit geomechanical structure, which ensures the assessment of variability of strength parameters and depth of mining operations.
2. Shotcrete solution strengthens the fractured rocks and pillars.

Scientific novelty of the work results is as follows:

- Finding interconnection of strength characteristics and stress in the mass varying with changeability of rock properties at the mining depth, which ensures the forecast of the stress condition of the rock mass.
- Creating shotcrete solution that allows, on the one part, to strengthen fractured rocks and pillars, and on the other part, to utilize the waste of process plants. (RK Patent No 93790).

Substantiation and reliability of scientific provisions and conclusions is confirmed by the scope of geodesic measurements performed in the conditions of Akbakay deposit, their mathematic processing, positive assessment and testing of work results at various conferences and in print media, implementation of obtained results in teaching and production (certificates of implementation).

Scientific significance of the work is in the improvement of monitoring methods with the use of new generation devices and newly created means of

assessment of the rock mass condition.

Practical significance of the work is in the implementation of improved methods of geomonitoring in the production and teaching at KazNRTU after K.I.Satpayev.

The author's personal contribution is:

- Determining the research objective and task;
- Formulating and substantiating scientific provisions;
- Analyzing the methods and accuracy of geomechanical monitoring;
- Improving traditional methods of geomechanical monitoring;
- Implementing the results obtained in the course of the research in the production and teaching.

Publication of the work. The following publications were published on the thesis theme: over 16 scientific articles, including 3 articles in domestic editions recommended by the Committee for Control in the Sphere of Education and Science of the RK Ministry of Education and Science, 1 article "Innovative Methods of Disturbed Mass Surveying and Processing of Results" published in the magazine of Dnepropetrovsk Mining University included in the Scopus database, developed "Method of Cave Roof Subsidence Measurement" and "Composition for Strengthening Fractured Rock Masses", the novelty of which is confirmed by the RK invention patents.

Testing of the work. Major provisions and results of the thesis were reported and discussed at the following scientific and practical and international conferences: "Problems of Subsoil Development in the XXI Century as Viewed by the Youth" (Moscow, the Research Institute of Comprehensive Exploitation of Mineral Resources of the Russian Academy of Sciences, 2014, 2015); "Innovative Technologies in Surveying and Geodesy" (Almaty, KazNTU, 2015); Proceedings of the Republican Scientific and Practical Conference dedicated to the 80-th Anniversary of the Department of Surveying and Geodesy (Almaty, KazNTU, 2014). Integrated Sustaining of Techogenic Mine Structures (London: Theoretical end Practical Solutions of Mineral Resources Mining 2015); "Mashanov's Readings" (Almaty, KazNTU, 2014, 2015.); "The Role and Place of Young Scientists in the Realization of the New Economic Policy of Kazakhstan" Satpayev's Readings (Almaty, KazNTU, 2015). "Scientific and Personnel Support of Innovative Development of Mining and Metallurgical Companies" (Almaty: KazSRTU, 2017) at scientific seminar of the Mining Department (Almaty, KazSRTU, 2017).

Publication of the work. The following publications were published on the thesis theme: over 16 scientific articles, including 3 articles in magazines of the Ministry of Education and Science of the Republic of Kazakhstan recommended by the Committee for Control in the Sphere of Education and Science, 3 articles in magazines supported by the Scientific Academic Council of Education and Science of the Russian Federation, 5 articles in the international scientific and practical materials of the conference, 2 scientific articles in industrial and technical magazines, 1 patent for useful model, 1 article in the magazine included in the Scopus database, and one textbook.

The volume and structure of the work. The thesis consists of the introduction, 4 chapters and conclusion, the list of references and appendixes. The volume of the thesis is 135 pages of computer text including 65 figures and 21 tables.

The first chapter **"Modern Knowledge of Geomechanical Processes in Development of Ore Deposits"** contains analysis of geomechanical studies conducted by the Moscow, Leningrad and Kazakhstan schools of geomechanical engineers. Considerable contribution in the study of impact degree of various factors on the development of geomechanical processes at ore deposits was made by S.G. Avershin, I.M.Bahurin, V.I.Borshch-Komponiets, A.Zh.Mashanov, M.E.Pevzner, V.N.Popov, F.K.Nizametdinov, A.N.Shashenko and others.

During the last years at the opencast mining of deposits, there is a trend of increased depth of mines that in majority of cases results in unprofitable development of reserves using this method. Therefore, as an alternative solution at the development of deep horizons the most perspective is a combined system of development. Selecting the technology of application of this development method, one of the major factors affecting the efficiency and safety is geomechanical condition of the rock mass.

Scientific research and practical developments in the field of geomechanical processes in the conditions of combined method of deposit development are based on the research by K.N. Trubetckoy, Yu.A.Kashnikov, M.A. Iofis, G.I Chernyi, M.B.Nurpeisova, I.A.Maltseva and others.

However despite the achieved success, the problem of study of geomechanical processes and industrial safety is not solved yet. Thus, the scientific works of the above-mentioned scientists with regard to the study and management of geomechanical processes at the use of combined development method have been analyzed. One of them is the research results performed at Akbakay mine.

"Akbakay zone" under question consists of: 1 underground mine, 2 open pits with dumps, process plant with tailing pits and infrastructure. The Akbakay deposit is classified as steeply inclined gold vein type of the ore body, with latitudinal strike and thickness of 0.2-4.0 m. The strike extension of the ore bodies is within 100-680 m. At the deposit within the Main ore zone there are 5 steeply inclined veins: Glavnaya, Tukenovskaya, Oktyabrskaya, Frolovskaya, Zolotaya. The host rocks are granodiorites with the hardness coefficient f=14-16, berezite (f=11-14), quartzite (f=16-18).

A particularity of the Akbakay deposit is the development of its veins primarily using the open-cast mining at the depth of 60-80 m with consequent transition to the underground development, i.e. combined method. The possibility of rock shear at the deposit is explained by the fact that the applied system of development employs excavation of separate blocks and ore shrinkage, delivery of inter-block pillars and crown pillars. With such combined system of development the rock thickness on the side of a hanging wall along the strike and through the whole depth will collapse causing the shearing of the host rocks. In this case the task of determining the boundaries of the underground mining effect on the earth

surface is considered as determining the sliding surface of the wall as the open pit deepens.

In this case, to solve a range of the mining technical tasks (stabilization of open pit benches and walls, dumps and underground mine workings, pillars) special attention is paid to the comprehensive geomechanical monitoring one of the method of which is geodesic observations. The geodesic observations with the use of new generation devices (electronic tachymeter, laser scanner etc.) ensure the identification of the mass deformation, which is considerable for the assessment of a geomechanical situation in the area of deposit development. However, they do not ensure the overall picture of the deformation processes over time. This is possible only with the use of a comprehensive method of research of the natural and technical system (NTS) based on the geomechanical monitoring (Fig.1).

This very position caused the set objective, the substantiated idea and the formulated research tasks.

This problem is particularly covered by the Law of the Republic of Kazakhstan "On Subsoil and Subsoil Use", "Environmental Code", "Land Code", "On Innovation Activity", which obliges mining companies to implement and use modern geodesic devices to ensure stability of surface and underground facilities.

Moreover, in the framework of realization of the Message of the RK President N.A.Nazarbayev dated 31.01.2017 as a part of the State Program of the Industrial and Innovation Development of the Republic of Kazakhstan, the subsoil use employs various methods of research and forecast of deformation processes development arising in the rock mass. In this connection, the role of innovations is becoming more important since the methods are aimed at increase in the productivity and efficiency of priority sectors of economy, one of which is a mining and metallurgical complex. Therefore, the project problem and objectives fully comply with the priority tasks of the Concept of Sustainable Economic Growth Based on Investments.

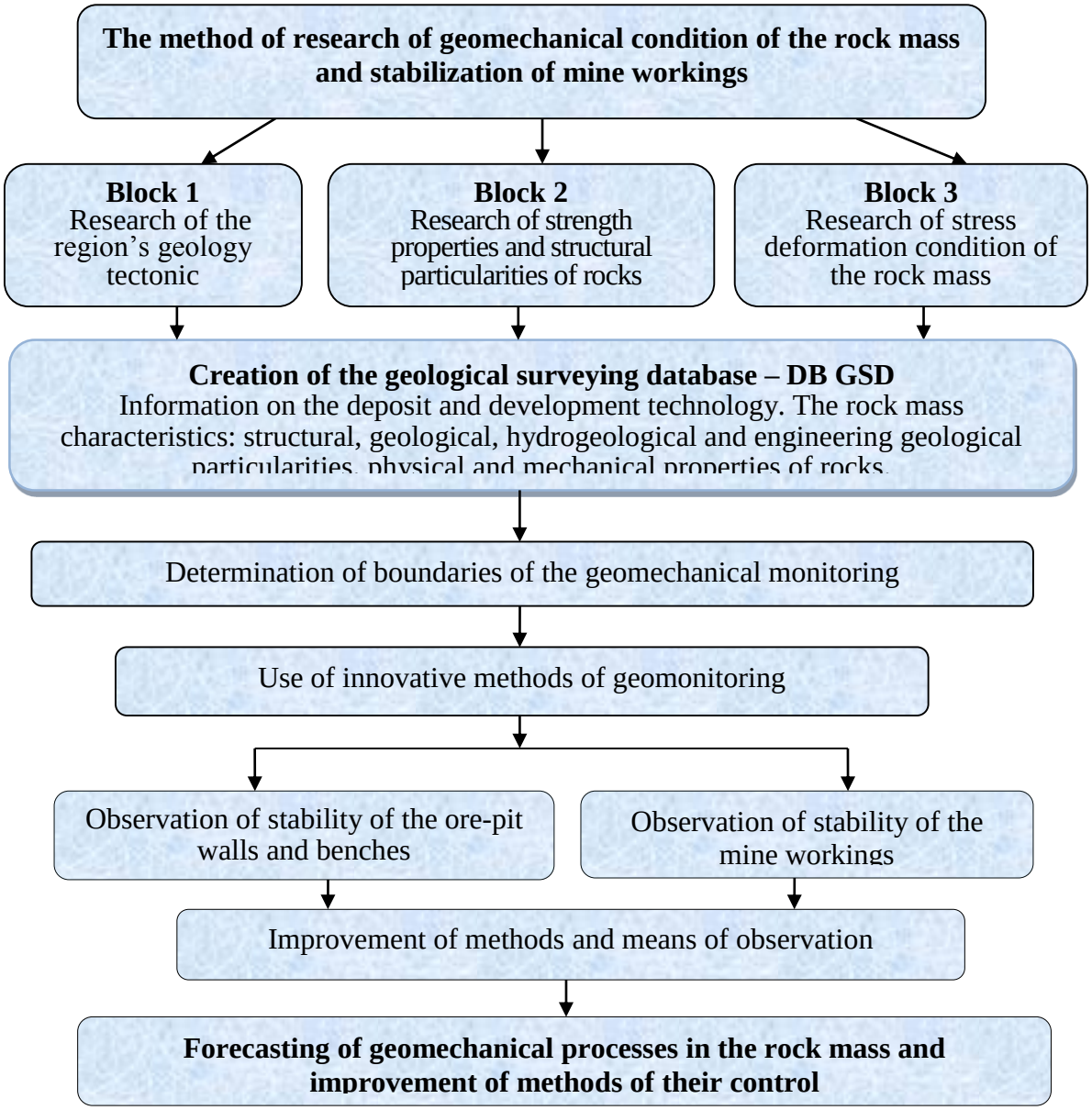


Fig.1- Method of forecasting of geomechanical processes and their control

The realization of this comprehensive method ensures safe labor conditions and uninterrupted mode of operation of a mining company as well as safety of surface buildings and structures.

The second chapter covers the question **"Research of Strength Properties and Structural Properties of Rocks"** in line with Block 2 of the proposed method (Fig.1). The important factors determining the stable condition of rocks and surface at the development of mineral resources include physical and mechanical properties of host rocks. The major strength properties affecting the geomechanical processes are density, resistance to compression and fracture, cohesion and angle of internal friction. The practice shows that such important parameter as rock cohesion can be several times less in the rock mass than in the monolith lump and therefore less

with regard to the weakened surfaces. In particular, this difference is clearly manifested in fissured rock masses.

Based on the performed research, the following data were obtained at the mine regarding some of important quantitative and qualitative properties of rocks of Akbakay deposit:

- Strength properties of rocks of Akbakay deposit were studied in in-situ conditions and as a result their major characteristics affecting the shearing process were obtained;
- Based on the study of physical and mechanical properties of rocks, correlation dependencies between the values of strength properties of rocks and the depth of their occurrence in the subsoil were obtained that ensure the forecast of the rock properties and stress condition of the rock mass;
- These characteristics will be used at the solution of a number of technical problems at open pits and underground mines: for assessing the stability of open pit walls and benches: design pillars and limit crown pillars, for generalization of results of instrumental observations and understanding of a physical aspect of the shearing process;
- A new method of surveying of rock fissuring in adjacent rock masses using the laser 3D scanner was proposed. The laser scanning is a technology ensuring the creation of a digital three-dimension model of an object by representing it as a set of dots with 3D coordinates. Obtainment of a digital model of adjacent rock masses of the open pit is possible due to the use of the software "Maptek I—SiteStudio", that calculates the values of elements of fracture occurrence: the strike, angle of depression and dimensions of rock blocks. The obtained results are published in the Bulletin of Dnepropetrovsk Mining University included in the Scopus base.
- Study of structural particularities of the rock mass and processing of surveying materials ensured the identification of 4 major fracture systems and regularities of their distribution in the deposit rocks and their impact on the geomechanical process.
- It was established that at the Akbakay mine the intensity of rock fracturing decreases as the development goes deeper, consequently as the mining operations deepen, the shearing will take place at flatter gradient.

The third chapter contains the results of **"Monitoring of Stable Condition of the Rock Mass"** and general information about the stress deformation condition of the rock mass and regularities of development of geomechanical processes at mutual impact of open and underground mine working before the geomechanical monitoring of the rock mass.

An important aspect at the determination of stresses based on the measurements of deformations at the end discharge is the method of transition from measured deformations to stresses.

The actual stresses are determined using the distressing method at 5 horizons of the Akbakay deposit: at the bottom of the pit -60 m and at the levels of 120 m, 180 m, 240 m, and 300 m. The depth of the holes is within 5.5 – 7.0 m and three measurements were done in each hole.

The stresses were measured at 12 sections of the mine. The results are given in Table 1.

Table 1- Results of measurements of natural stresses

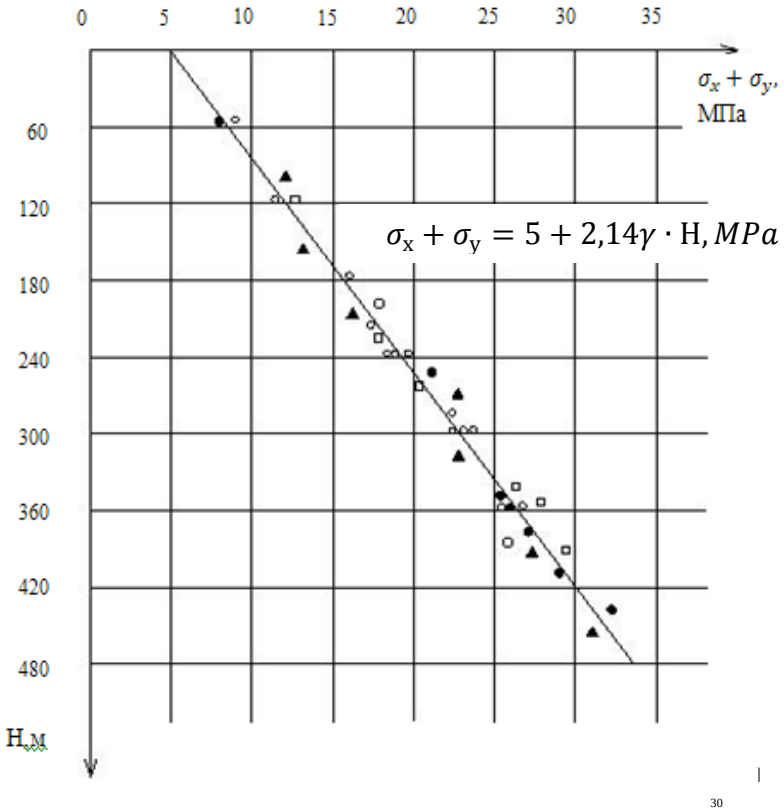
Place of measurement, horizons	Depth from the daily surface, H. m	Average values of stresses, MPa			Sum of horizontal stresses ($\sigma_x+\sigma_y$), MPa
		σ_x	σ_y	$\sigma_z=\gamma H$	
Open pit	60	5,2	3,3	2,2	8,5
	60	5,0	3,2	2,0	8,2
2	120	7,8	4,4	3,3	12,2
	120	6,3	5,7	3,5	12,0
3	180	9,1	6,6	5,4	15,7
	180	10.5	5,1	5,2	15,6
4	240	12,1	7,1	6,7	19,2
	240	14,0	5,1	7,2	19,1
	240	13,7	5,3	6,8	19,0
5	300	12,2	10,4	8,6	22,6
	300	14,0	9,0	8,2	23,0
	300	13,8	8,8	8.5	22,6

Note: σ_z is an average value of the vertical stress; σ_x is an average value of the normal meridional stress; σ_y is an average value of the normal latitudinal stress.

At each section, measurements were done in three directions. Only at one mine, 36 measurements of stresses in the rock mass were done using the distressing method.

The analysis of Table 1 with regard to the results of measurements of natural stresses of Akbakay deposit and other mines of Rudnyi Altay shows that there are the following particularities of distribution of horizontal stresses in the rock masses.

Firstly, the values of horizontal stresses are higher than the vertical ones. Secondly, at equal depths from the daily surface, horizontal stresses in hard rocks are higher than in weaker ones. Thirdly, the average values of vertical stresses are close to the value γH regardless of the rock strength. As a result of the research of the stress deformation condition of the rock mass of the Akbakay deposit it was established that the values of horizontal stresses are 1.2-1.5 times higher than the vertical ones. The graph-analytical dependency of horizontal stresses on the mining depth (H) was derived, and based on the linear correlation it is possible to forecast the stress-deformation condition of the rock mass (Fig.2).



○- Maladezhnyi; ▲- Tekeli; □- Maleev; ● - Akbakay

Fig.2- The variation of the sum of horizontal stresses ($\sigma_{x+}\sigma_y$) with the depth

The obtained results were compared with the results of analogous works of other authors and they allow concluding that the derived regression equations (correlation coefficient r =0.92; its reliability μ =16) are highly reliable.

Thus, the first scientific provision "Forecast of condition of the rock mass is based on identification of interconnection between the elements of a deposit geomechanical structure, which ensures the assessment of variability of strength parameters and depth of mining operations" is proven.

Based on the long-term comprehensive geomechanical monitoring performed at the Akbakay deposit, a chart of rock shearing has been drawn up. It consists of two areas: *distressing* and *increased mining pressure*, and 8 zones distinguished by characteristics typical only for these zones.

Long-term instrumental observations proved the labor-intensity of field works, especially the transfer of a set of devices from one point to another (the device, support, racks etc.) In this connection, first of all to ensure the installation of devices and quick measurements we have developed *a permanent bench mark* installed in the support point in the course of the geomechanical monitoring.

This chapter also covers the formation of the cave roof and zones of caved rocks above the open area. The performed research has also resulted in the establishment of regularities of formation of rock caving zones depending on parameters and geometry of stopes, i.e. the graph-analytical dependency of the caving zone height on the width of the open area has been derived. As the stopping

increases, the arch formation increments, and the practical stabilization takes place at the distance of 130-150 m of the stope width.

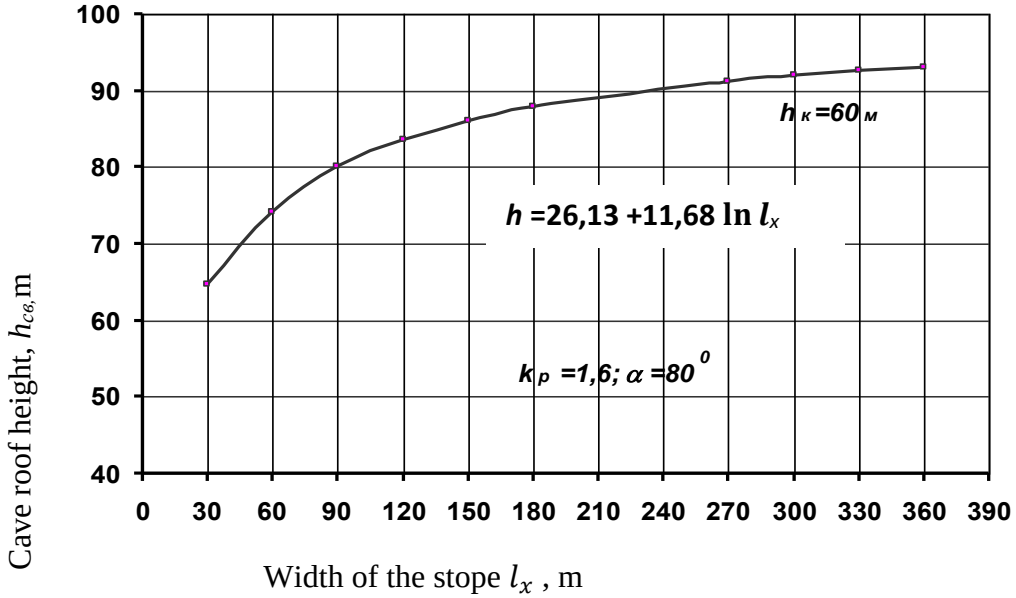


Fig.2- Formation of caving zones at the development of stoping

Thus, formation of cave roof in stopes *directly* depends on the height of a room at the initial stage and primary value of loosening and the *parabolic* value on the width of the open area, the form of the roof and cave angle when the rock caving stops.

The geomonitoring of the rock mass condition will be effectively done based on the implementation of innovative methods and means of control. For instance, to observe the shearing of the roof rock at the stop=ing, a method of constant registration of the roof rock shearing was developed with the purpose of timely warning of the approaching roof caving and taking the necessary actions. The technical novelty of the development is confirmed by the patent of the Republic of Kazakhstan.

The fourth chapter contains the results of **"Improving Measurements for Stabilization of Mine Working"**, considers traditional control methods of geomechanical processes at combined methods of development and offers the following improved methods of control specifically for the Akbakay deposit:

1. Comprehensive analysis of the mining production impact on the environment ensured the identification of regularities of this interaction and finding major ways of solution of this problem in the future. The principle importance have the new methods developed by us and the methods of reducing man-made environmental load.

2. The control methods of geomechanical processes were classified and the possibility of directed change of this process was considered.

3. At the Akbakay deposit, the possibility of directed change of the shearing process was established with the purpose of:

- Reducing the danger of sudden collapses by means of filling holes and pits with waste dumps that results in the filling of gobs and creating supports for open pit walls;

- Reducing deformations and increasing stabilization of the superincumbent rock by means of creating several artificial rock bridges (shearing wedges) through elongated open pits and systematic surveying of their condition.

- Since the final purpose of all geomechanical research is provision of industrial safety, to prevent further progressive destruction of pillars, *a strengthening solution* for fractured rock masses was developed. The solution contains cement, filler and water. Tailings of the process plants of mining metallurgical complexes are used as the fillers in the following amounts: cement, tailings of process plants, dispersion polymeric powder movilit, and water.

The composition is designed to strengthen the fractured rocks at the open pit and to strengthen destroyed rib pillars and crown pillars in underground workings. The technical result is the utilization of mining production wastes: tailings of process plants, achieving high fluidity of the solution, adhesion to rocks and strength of the produced solution.

The manufacturing of the solution. The manufacturing of import-replacing solution of domestic production complying with the requirements of the world level.

As a comparison the most popular solution in the CIS – shotcrete was accepted. It is applied in the construction and mining. If the cost of 1 kg of cement is 18.5 tenge (as of January 2017), the cost of 1 ton of the cement will amount to 18,500 tenge. The cost of 1 ton of sand added to the mixture is 6,000 tenge.

The source materials for the solution. The following materials are required for 1 ton of the solution: cement: 300 kg, tailings of process plants: 500 kg, movilit: 20 kg, tylose: 3 kg. Then the composition and cost of the source solution for the strengthening of fractured rocks will amount to:

1. Cement 0.3x 18,500= 5,550 tenge.
2. Tailings of process plants 0.5x0 = 0 tenge.
3. Polymeric additive Molivit 20x518 =10,360 tenge
4. Polymeric additive Tylose 3x1,221= 3,663 tenge.

Total..... ...19,573 tenge

Economic efficiency of production of domestic shotcrete solution (dry mixture) is calculated using the following formula:

$Э = (C_1-C_2)\ A,$

where C_1 is the cost of 1 ton of dry solution, tenge.

C_2 is the cost of 1 ton of dry solution based on wastes of the mining metallurgical complex, tenge;

A is the annual volume of product, tenge.

The expenditures including the cost of source materials are given in Table 2.

Table 2 – Calculation of the cost of 1 ton of concrete

Materials	Unit	Consumption of materials per 1 ton of solution		Unit	Cost of 1 ton, tenge	
		Traditional technology	Recommended technology		Traditional technology	Recommended technology
Dry mixture						
Cement	kg	300	300	18500	5550,0	5550,0
Sand	kg	677	-	6000	3993,0	-
Tailings of process plants			500	-		-
Movilit	kg	20	20	518	10360,0	10360,0
Tylose	kg	3	3	1221	3663,0	3663,0
Total:					23566,0	19573,0

Thus in harmony with the formula, the economic efficiency of manufacturing of 150 tons of dry mixture will amount to

Э = (23566,0-19573,0) x150 = 599950 tenge.

The technical novelty of the created solution is confirmed by the RK invention patents. The manufactured solution was tested in the central laboratory for certification of construction materials (CLCCM) and the certificate of testing was received.

CONCLUSIONS

The major scientific results and practical conclusions with regard to the thesis developments are the following:

1. Based on the analysis of adverse environmental impact of geomechanical processes arising at the application of combined method of deposit development and ways of their decrease as well as traditional and modern monitoring geotechniques, a flowchart of geomechanical monitoring on the basis of improved methods and means was developed.

2. Graph-analytical dependencies of variation of structural particularities and strength properties of the rock mass on the depth of occurrence were determined that ensures the forecast of stress-deformation condition of the rock mass.

3. Graph-analytical dependency of the height of the caving zone on the width of the open area was derived. As the stoping increases, the arch formation increments, and the practical stabilization takes place at the distance of 130-150 m of the stope width.

4. The method of measurement crown pillars subsidence in mine workings was developed and the solution was created for strengthening of fractured rocks based on the wastes of mining metallurgical complexes with the application of polymeric powders with low cost, sufficient fluidity for the filling of small fractures and high strength. The technical novelty of the created solution is confirmed by the RK patents and the annual economic efficiency amounts to 599,950 tenge.

5. Based on the long-term comprehensive geomechanical monitoring performed at the Akbakay deposit, a chart of rock shearing has been drawn up. It consists of two areas: *distressing* and *increased mining pressure*, and 8 zones distinguished by characteristics typical only for these zones. The control methods of geomechanical processes were classified.

6. The observation methods of the rock mass condition were improved for safe mining of the deposit and its efficiency. These methods increase the accuracy of measurement results. The control methods of the rock mass condition were improved and its results were implemented in the teaching of the Department of Mine Surveying and Geodesy of KazSRTU after K.I.Satpayev.

7. The research results represented in the thesis were practically used and approved by the legislative instruments at the open pit Kotyrbulak and tested in the central laboratory for certification of construction materials (CLCCM).

Assessment of completeness of solution of the tasks set.

The set objective is achieved and the formulated tasks including the realization of theoretical and experimental research are completely solved, the research results are implemented.

The thesis contains detailed analysis of domestic and foreign experience in the monitoring of geomechanical processes which is used for the development of mineral resources using the combined method. The control method of the rock mass

condition was improved for the purpose of safe mining of the deposit, increase in accuracy of measurement results and efficiency.

Development of recommendations with regard to source data for concrete use of results. The research results represented in the thesis are recommended for the use in the conditions of the Akbakay deposit and other deposits of the RK mining metallurgical complex.

It is recommended to implement scientific provisions and obtained regularities in the teaching at KazSRTU.

Assessment of technical and economic efficiency of implementation

The method of measurement crown pillars subsidence in mine workings was developed and the solution was created for strengthening of fractured rocks based on the wastes of mining metallurgical complexes with the application of polymeric powders with low cost, sufficient fluidity for the filling of small fractures and high strength. The annual economic efficiency amounts to 599,950 tenge. The manufactured solution decreased the deformations and increased stability of superincumbent rocks by means of creating several artificial rock bridges.

The following works were published on the thesis theme: 16 scientific works, including 3 articles in the magazines of the Ministry of Education and Science of the Republic of Kazakhstan, recommended by the Committee of control in the sphere of education and science, 3 articles in the magazines supported by the Scientific Academic Council of education and science of the Russian Federation, 5 articles in the international and practical materials of conferences, 2 scientific articles in industrial and technical magazines, 2 articles in the magazine included in the Scopus database and 1 tutorial.

Assessment of scientific level of the performed work compared to other achievement in this field

The review of literature, patents, results of theoretical and applied research and certificates of results implementation allows concluding that the performed work complies with the up-to-date scientific technical level and the technical novelty is confirmed by the RK patents and the use of research results in the report of the grant financing project of the RK MES “Reduction of Risk of Technogenic Catastrophes by Means of Developing Innovative Control Methods”.

Main provisions of the thesis were published in the following works:

1. Kopzhasaruly K**.** Kazakhstan Gold is a Blessing // Proceedings of the international forum of surveyors “Innovative Technologies in Surveying and Geodesy”.-Almaty, KazNTU, 2015.-P.91-94.

2. Kopzhasaruly K. Underground Geodesy of Mining Operations Using a Consolidated Method // Proceedings of the Republican Scientific and Practical Conference Dedicated to the 80-th Anniversary of the Department of Mine Surveying and Geodesy, KazNTU, Almaty, 2014.- P.30-35.

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