

Victor NORDIN
Kaliningrad State Technical University
nordin@gazinter.net

Pavel SHCHERBAN
Immanuel Kant Baltic Federal University
ursa-maior@yandex.ru

IMPROVEMENT OF MANAGEMENT DECISIONS QUALITY AT THE ENGINEERING AND CONSTRUCTING STAGES OF MODERN MINING COMPANIES

Summary. Nowadays, the peculiarities of design and construction of a modern mining company mostly are determined by the quality of decisions made by the management. Article provides view on various management methods, which provide effective research, correct interpretation of incoming information, evaluation of possible risks during project implementation and elaboration of optimal technical and technological solutions.

Keywords: risk management, quality management, modern approaches in mining constructing and engineering, mathematical solutions in modern mining management.

POPRAWA JAKOŚCI DECYZJI ZARZĄDCZYCH W KONSTRUKCYJNYCH I INŻYNIERYJNYCH ETAPACH BUDOWY NOWOCZESNEGO PRZEDSIĘBIORSTWA GÓRNICZEGO

Streszczenie. W artykule przedstawiono przegląd różnych metod zarządczych, które zwiększają skuteczność decyzji zarządczych, poprawiają przejrzystość interpretacji danych, pozwalają ocenić ryzyko w czasie implementacji projektu i ułatwiają wybór optymalnego rozwiązania technicznego.

Słowa kluczowe: zarządzanie ryzykiem, zarządzanie jakością, nowoczesne podejście do projektowania i konstrukcji w górnictwie, matematyczne metody w nowoczesnym górnictwie.

1. Introduction

The creation of modern mining company binds to the high requirements to provide quality of management solutions on different stages from the selecting and analyzing of scientific data, design of project researches to constructing and realizing of project itself. We have to note that importance of correct management solution is higher the earlier stage of mining company project realization process is. Though the mistake of incoming data interpretation, selecting of good technological and technical solutions in the early stages cost much more and it's consequences are more difficult to be resolved than in the late stages of the project. Let's point out different "ponderability" of various management solutions and their consequences, because there are solutions influencing the process of projecting and constructing drastically, as well as "indirect" solutions.

2. The mathematical approach of mining project management

Speaking about approaches increasingly probability the good management solution we will overview in frames of stages of projecting and constructing the modern mining company. The first stage is picking up and analyzing the geological information about the deposit supposed to exploration. Let's underline some blocks of information to be researched. Thus, the first block of information is presented by geological data characterizing the structure of deposit: geomorphology, location of productive layers it thickness, prevalence, availability of water bearing horizons and the character of layers [1]. This block of information allows to start the developing of project on deposit exploring. It makes the basis of evaluation of the possibility to implement technologies for opening the ore bed, the order and methods of deposit development.

The second block presents the analyzes of data about features of raw material, lithology, localization of useful components, percentage of components, percentage of components content, availability absence and character of add mixtures, and undesirable substances in dangerous concentrations (gazes, radioactive elements). The obtaining of the whole complex of data from the second block will allow to change the process of projecting the deposit development system and will make the ground for the creation for the efficient technological scheme for ore enrichment and extracting the useful components [2]. Alongside with that even on the stage of collecting and analyzing the information regarding the deposit of raw material it is necessary to coordinate strictly the geological research works with consequences they may cause in case of their unreasonable plaining and improper executing. So, for example geological wells drilling to specify the geological data is connected with the risk of violating

of deposit impermeability and makes background for penetration of water from upper horizons. In case of oil deposits such additional wells may violate the integrity of oil bearing layers and change the dynamics of hydrocarbon fluids. So, the same time with sufficiency of geological data the required criteria for making the scientific idea of deposit the required criteria of restorability and rationality of the data obtaining are important [5]. In various times, different scientists observed the problem of management solutions quality - in construction and engineering processes of mining companies'. In Russian Federation such researches could be presented by works of A. Bataev, as example "Provisions of operational efficiency improvement in mining companies". Also researches of I. Chaicovskaya "The formation mechanism of normative-informational support of quality management system at coal industry enterprises" and T. Klubenkov "Flexible management of main production in mining company" should be mentioned. In foreign countries, many scientists investigated this problem. As example this question is well observed in such works as "Industrial minerals and extractive industry geology" by P.W. Schott & C.M. Bristow and "Safety Management in Coal Mines – Risk Assessment" by Zygmunt T. Niczyporuk.

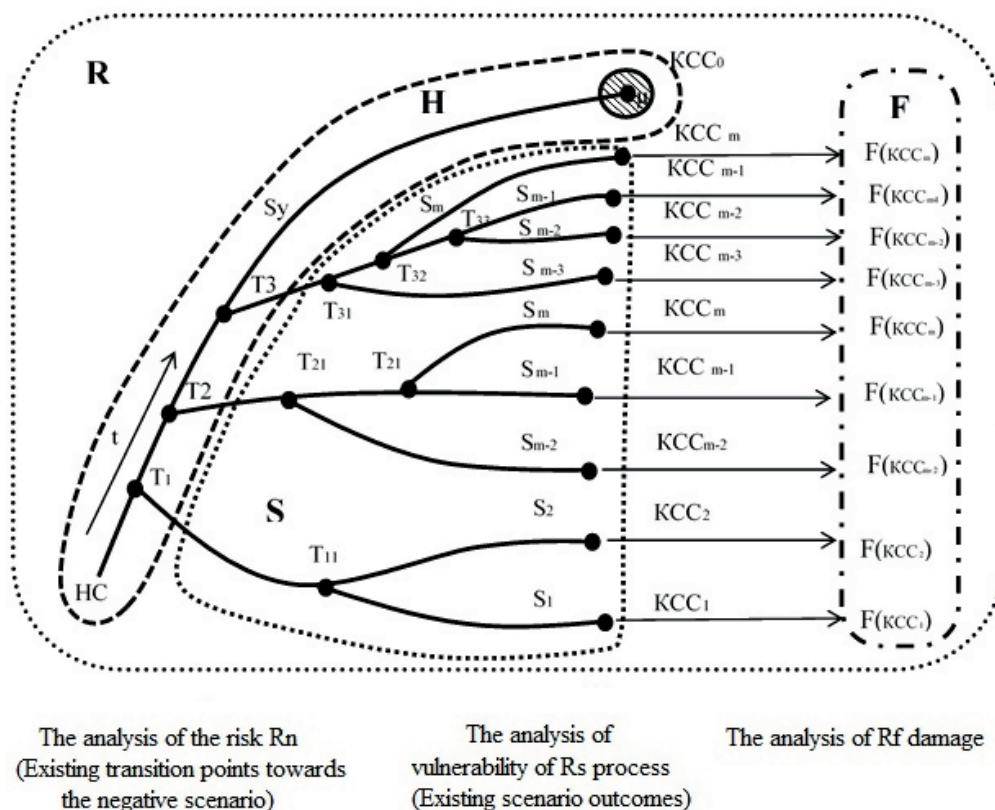


Fig. 1. The general scheme reflecting consistent risk analyses under different ways of mining company project realization

Rys. 1. Ogólny schemat przedstawiający spójną analizę ryzyka przy różnych sposobach realizacji projektów przez firmy górnicze

Source: Own work.

Improving the system of management solutions making regarding design and construction of mining company, first of all it is necessary to structure analytical approaches for evaluating dangerous factors, vulnerability points and possible damages which could appear in different stages of project realization.

Where: HC- the initial condition of the system, S_y – the scenario of successful mining company project realization, KCC_0 – desirable final condition of the enterprise, μ – limited area around point KCC_0 , where the final condition could be considered exactable, $T_1, T_2 \dots T_n$ – the bifurcation points in which the dangerous events could be start, S_i ($i = 1, 2 \dots n$) – i-failure scenario realizing after achievement of one of limit state, KCC_i ($i = 1, 2 \dots n$) – unacceptable final system condition corresponding to scenario S_i . $F(KCC_i)$ ($i = 1, 2 \dots n$) – the damage, corresponding to the system stage KCC_i .

According to the necessary volume of geological data about the deposit we get to the point HC – the start of technological and technical projecting. From the mathematical the process of projecting and constructing the mining company could be presented as trajectory of point movement in the space system H condition that defines the transmission from the initial condition of the system (the stage of development of technical, technological and project solutions) to the final stage of KCC system – the enterprise ready for exploration of the raw material. In case when it's possible to provide such transmission it's proved that the system has realized the “successful scenario” - S_y . During time period $t_1, t_2 \dots t_n$ the events $T_1, T_2 \dots T_n$ could happen – which could deviate the scenario trajectory from curve S_y . and start sequence of events causing to failure scenarios S_i , that would be finally realized as unsuccessful final system stage KCC_i .

In this connection, the degree of compliance of final system condition to the plan (the condition of ready mining company) determined by a set of parameters $\alpha_0^1, \alpha_0^2, \alpha_0^m$ – which should be taken by system variables $\alpha^1, \alpha^2, \alpha^m$. for mining company construction according the requirements. The example of such requirements is such parameters as: the integrity of the lining of mine shafts, lining durability, the integrity of the waterproof stratum, cement strength, the presence of independent power sources, the availability of rescue equipment, and environmental compliance of maximum permissible concentration, and maximum permissible emissions norms [5].

In case if in process, the undesirable condition of the system KCC_i was reached (the project of mining company wasn't realized or realized partly) we may speak about damage $F(KCC_i)$ corresponding to this negative scenario [4]. This model poses a series of questions. First of all, how such difficult processes could be managed for ensuring of stability and quality of projection and construction of mining company. Then, on which stage management decisions must be made for “successful scenario” realization [1].

In many ways, the answers to these questions could be found in technical and technological hazards minimization on the all stages of the project. According to the model on the figure 1 highlight the whole risk level, taking place during the mining project realization. Thereby, the whole risk level of mining project realization could be measured by such formula:

$$R = \vec{H} * S * \vec{F}^T, \quad (1)$$

where:

$\vec{H} = \{P[T_1]; P[T_2]; \dots; P[T_n]\}$ – vector of dangers, which components constitute the probability of triggering dangerous events T_n ;

$S = [P(KCC_i|T_j)]$ – A x B matrix which components constitute the probability of possible unsatisfactory final states of the system, in case of negative scenario development;

$\vec{F} = \{F(KCC_1); F(KCC_2); \dots; F(KCC_n)\}$ – vector of complex damage, the components of which are characterized by a finite damages of the system.

However the presented formula overviews mostly common theoretical approach to hazard estimation. However, each of this formula element has row of compounds through which the process could be managed. Such approach allows to minimize risks and achieve realization of “successful scenario”. As it was under lined previously.

During designing and constructing processes of mining company, there are plenty of points T_n where initiating dangerous events could take place [1]. As a result, the very first step in increasing of management solutions efficiency should be forward-looking planning and assessment of possible risks. It helps to overview the different scenarios of process development after the point T_i passing. Advanced planning allows you to discover the factors leading to the fact that the creation process of mining company can follow the negative scenario when passing through the point T_n . Speaking about formula (1) it is obvious, that it is necessary to reduce the value of the dangerous vector, by increasing of management quality in case of probability of dangerous initiating events realization. That is the reason why technical director and heads of departments should determine the complex of T_n points while projecting and constructing of mining company [1].

Each of determined points in reality transforms to management task. Wrong solution of such task becomes initiating hazard event. The most optimal approach in management task solution could be found in consistent decomposition of task into component parts. Ishikawa chart have made for each of T_n point could effectively show decomposition. In Ishikawa chart, we will see the management task as row of interdependent complexes of different parameters [3].

In the task, it is necessary to decompose each groups of parameters and ultimately get the measured parameters (which can be evaluated "quantitatively") or the parameters which couldn't be measured and should be evaluated "qualitatively". Figure 2 represent an example of the enlarged Ishikawa diagrams for the point Tj - responsible for management solution for the selection of metallic tubing.

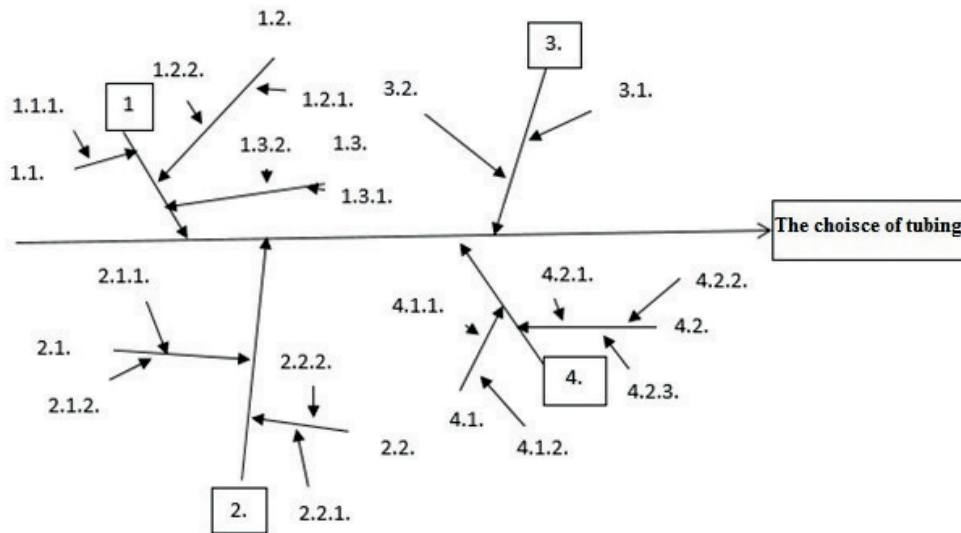


Fig. 2. The Ishikawa chart, decomposition of the tubing selection problem

Rys. 2. Diagram Ishikawy przedstawiający proces wyboru rur

Source: Own work.

1. The properties of the tubing material; 1.1. The type of tubing; 1.2. Physico-chemical properties of the tubing metal; 1.2.1. Physical properties (strength, hardness, brittleness etc.); 1.2.2. Chemical parameters (content of carbon, content of alloying elements, etc.); 1.3. Geometric characteristics of the tubing; 1.3.2. The geometry of the tubing; 1.3.1. The geometry of the holes and the additional fixing elements; 2. Factors of tubing production; 2.1. The quality of suppliers work; 2.1.1. The number of manufacturing defects; 2.1.2. The cost of the tubing production; 2.2. Experience of staff; 2.2.1. Personnel qualifications; 2.2.2 – Knowledge and skills; 3. Tubing quality control; 3.1. The detectability of manufacturing defects by internal control, 3.2. detectability of manufacturing and transporting defects by acceptance control; 4. Storage, transportation of the tubing; 4.1. The conditions of storage and transportation; 4.1.1. The suitability of climatic conditions; 4.1.2. Ergonomics of tubing storage, loading and unloading; 4.2. The quality of tubing elements adjunction; 4.2.1. The value of gaps; 4.2.2. Changing the shape of the tubing during heating and cooling.

The figure below demonstrates range of "qualitative" and "quantitative" parameters. "Quantitative"(measured parameters) include the geometry of the tubing, the physico-chemical parameters of metal etc. "Quality" parameters consist of qualification of personnel,

their knowledge and skills [3]. Setting parameters allow monitoring and control of the process at a particular point T_j .

3. Measured parameters management

Talking about the control and management methods, we should emphasize that one of the most effective methods of management of the measured parameters is the method of 6σ . This method allows monitoring measured parameters and rejection of materials or processes results in the case of parameters exceeding the limit values [2]. For example, let's consider the use of 6σ methodology for calculation of deviation of walls lining from the trunk center of the radius:

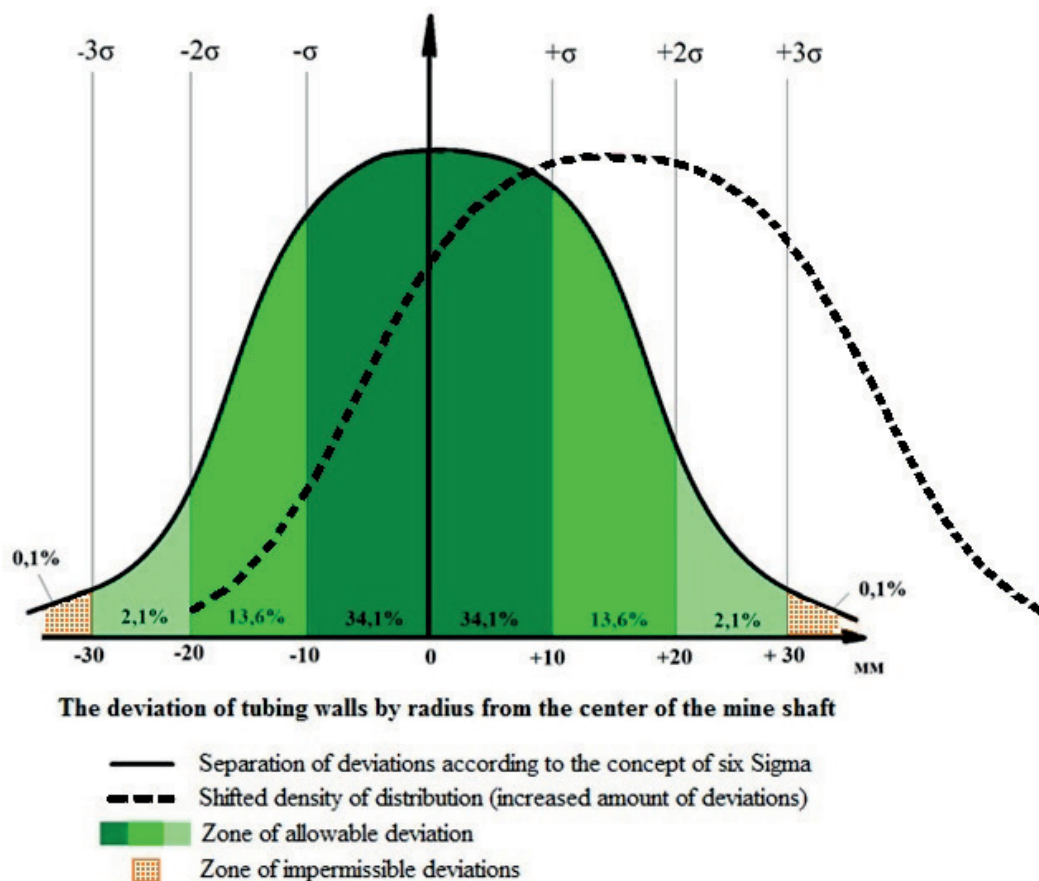


Fig. 3. Deviation lining the walls along the radius from the center of the barrel

Rys. 3. Nierównomierność ścian wzdłuż promienia od środka cylindra

Source: Own work.

Method 6σ indicates that the process or product qualitative if 99.8% of their deviations do not exceed the bounds of permissible values [2]. On the Figure 3 we can see boundary values of deviation of the tubing walls lining radially from the shaft center. For tubing lining deviation must not exceed 30 mm (SNIP 3.02.03-84 Building Code underground workings). If density distribution is shifted relative to the axis OY, we can state that quality of the process does not match the 6σ concept and can lead to the triggering a dangerous event at the point T_i and instead of the "successful" scenario we get "unfortunate" one.

In case of "quantitative" parameters, it is possible to eliminate dangerous triggering event by shifting density distribution to the 6σ area. In the example, the excess of inadmissible deviations of tubing walls lining from the trunk center can be eliminated by reworking or changing mounting tubing technology or by setting post-process inspection.

4. "Quality" parameters management

However, along with "quantitative" parameters in the implementation of any process there are "quality" parameters too. In case of "quality" parameters, mentioned previously methods could not be realized. Therefore, the best approach to the assessment and subsequent management may be expert assessments method or HAZOP method (Hazard and operability studies) - analysis of the hazard and operability [2].

While working with the "quality" parameters, expert evaluations method or the HAZOP method shows discrepancy between the analyzed process parameter and requirements and consequently, the possibility of dangerous triggering event. As a result, you must either develop a set of measures for the control and management of this parameter (their effectiveness must be proved) or revise technological or technical decisions made at the point T_n .

Thus, it is possible to form a closed loop, which will increase the efficiency of the management decision-making, allows increasing the probability of a successful scenario in each certain case, reduces the deviations in the process or, in case of failure, replaces inefficient technologies or technical solutions (Figure 4).

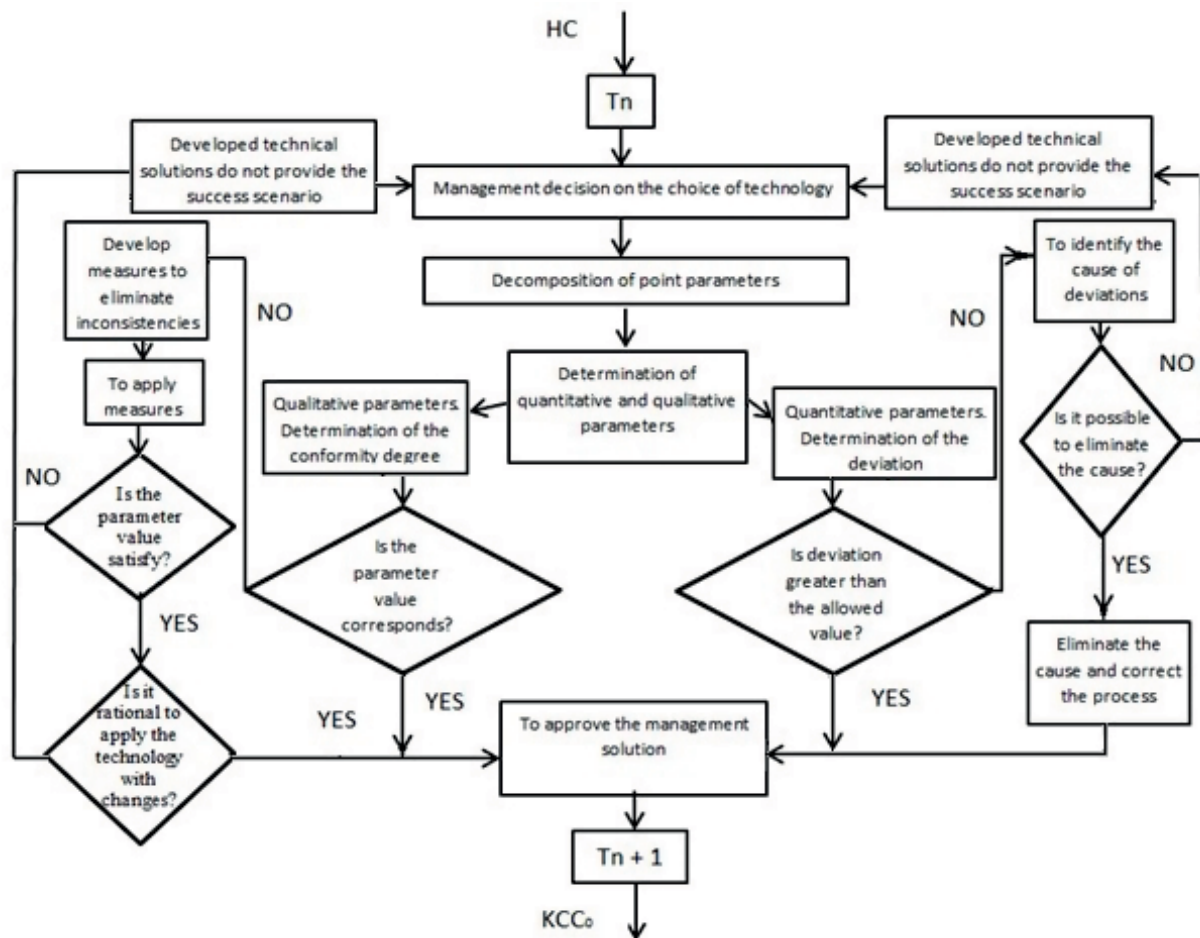


Fig. 4. The algorithm of quality managerial decisions improvement, during the design and construction of modern mining enterprises

Rys. 4. Algorytm optymalizacji jakości decyzji menadżerskich podczas projektowania i budowy nowoczesnego przedsiębiorstwa górniczego

Source: Own work.

5. Conclusions

In recent years, the implementation of various projects in mining coming into sharp, competitive phase. In this connection, demands of the quality of work, of technical safety, and environment protection are constantly growing. Such growth of demands (from the society, government agencies, or other market participants) forces companies to devote significant resources for their competitiveness improving, creation of new technologies, materials and original technical solutions development.

However, the implementation of any projects in the field of mining is impossible without effective management. In many ways, the effectiveness of management is determined by quality of implemented and reached goals and objectives, in comparing them with initially planned. In addition, the quality of management is determined by its flexibility - ability to

adapt for changing environment, by developing of new management solutions for the project. Presented approach can improve the quality of management solutions, taken during the implementation of mining projects. At the same time, this approach successfully combines depth and descriptiveness of raw data, focus on the result and flexibility in the development of management solutions. This combination should lead to the implementation of the "success" scenario - the successful commissioning of the new mining enterprise.

The natural resources necessity is growing at each new stage of technology and human society development. As a result, in present time we can observe a deficit in several resources production – potassium sulphate salts, polymetals, tungsten, nickel and other valuable components. All these facts lead to searching of new deposits resources, which could be found within deeper layers or at the territories where mining hadn't ever taken place (arctic areas, ocean shelf). Design and implementation of works on mineral extraction in such complex environment requires continuous improvement of management decision-making process. Such comprehensive problems arise special requirements for risk management, effectiveness of early warning and prevention of risk situations. Summarizing the results, approaches proposed in the article (identification of qualitative and quantitative parameters and further evaluation of their optimality for making informed decisions in a short time) are correct. These approaches require the construction of more detailed mathematical models which development is expected during further research.

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Omówienie

Obecnie zagadnienia związane z projektowaniem i budową nowoczesnego przedsiębiorstwa są zdeterminowane przede wszystkim jakością decyzji zarządczych. Badania naukowe, które obejmują także pozyskiwanie danych na temat złoża, wspomagane sekwencyjnymi analizami i selekcją sposobów właściwego zaplanowania kompleksu górniczego, pozwalają zminimalizować ryzyko techniczne w fazie implementacji projektu.