

Method for systemic risk analysis of mining and economic assessment of high-mountain ore deposits in the Kyrgyz Republic

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Annotation. The prevailing uncertainties that arise during the development of high-mountain deposits are identified, and a method is given for their subsequent minimization and cost reduction, which makes it possible to more reliably and objectively carry out pre-feasibility studies. The results can serve as an assessment of the planned capital and operating costs, which significantly affects the profitability of the development of high-mountain deposits and risk events.

Keywords: mineral deposits, risks, operating costs, feasibility studies of deposits

Introduction

The rational development of high-mountain ore deposits is associated with a high degree of risk activity at all stages of development and operation. In order to avoid negative consequences in combined development, it is advisable to carry out complex design, which is achieved by forming at the stage of preparing a feasibility study a multivariate complex combination of open pit, underground, physical, and chemical methods of development.

The formation of such a strategy involves the consideration and analysis of several options for decisions from the most unfavorable (pessimistic), the most real (probable) and favorable (optimistic), which is carried out using a “decision tree”, to identify the main three branches and further split them into smaller ones. and obtaining a detailed grid of possible events. This makes it possible to determine the boundaries of the implementation of project activities for the development of high-mountain ore deposits.

The expediency of forming such a tree of events is confirmed by the fact that all mining enterprises are exposed to constantly changing risk factors of the internal and external environment: political, economic, technological, environmental, natural, industrial, which give rise to many uncertain risk events. Their identification and assessment of factors do not exclude the risks of negative phenomena, but can lead to a decrease in the state of uncertainties and create the necessary conditions for the development of measures and technological processes

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that allow at an early stage to plan the necessary costs for managing risk events and lead to their negative minimization. Therefore, at the stages of the feasibility study of high-mountain deposits, it is necessary to carry out a systematic risk analysis.

Relevance

As the practice of developing high-mountain deposits shows, it is impossible and impractical to completely eliminate the risks, since part of the income from development is lost and leads to the loss of investments already made, a decrease in the efficiency and intensity of development, and even a refusal to further develop part of the reserves of a high-mountain field for safety reasons. This can give rise to gaps in the extraction of raw materials and cause social tension in most mining enterprises. Therefore, the risks need to be identified, assessed and the choice of future activities and their management already at the stages of development of the feasibility study of high-mountain deposits, in order to identify the future profitability of the project.

Method of systemic risk analysis of mining and economic evaluation

In [1], it is proposed to single out the following strategic sectoral risks in the mining industry: external measurable (price and tax risks), internal measurable (geological, technological and mining risks), external non-parametric (legal risks), internal-external non-parametric (environmental and information risks).

In our opinion, risk should be understood as the possibility or probability of occurrence of adverse or favorable events for their control, management and timely response, therefore, the measure of risk is the frequency of their occurrence.

For the Kyrgyz Republic, it is necessary to single out internal measurable and internal-external non-parametric risks in the calculation and operation of high-mountain ore deposits.

For the Kyrgyz Republic, due to the presence of high-mountain ore deposits throughout its entire part, it is necessary to take into account specific types of risks. With non-systemic risks in geotechnical assessments of parameters, an important factor is the assessment of the quality of the array, which will allow to reduce operating costs at the stages of field operation. It is especially necessary to pay attention to such risk factors as seismicity and inaccessibility, due to the fact that most of the deposits are located in the high mountain zone.

In economic factors, it is necessary to identify and implement innovative technologies for assessing deposits of the CRIRSCO family (International codes of the CRISCO family unite such national resource reporting organizations as Australasia (JORC), Canada (CIM), Chile (National Committee), Europe (PERC), Russia (NAEN), South Africa (SAMCODES), USA (SME), Mongolia (MPIGM) and Kazakhstan (KAZRC[2]), taking into account the specifics of the development of high-mountain ore deposits at the stages of feasibility study, which will ensure access to international exchanges, IPO and issue of shares to attract investment.

For systemic uncertainty in the assessment of political parameters, it is necessary to introduce legal risk and for its quality management, the creation and implementation of the Mining Code, amendments to the Subsoil Law, this will allow investors to feel protected and come to the market of the Kyrgyz Republic.

To assess the parameter of macroeconomic conditions during the transition to the digitalization of the economy, it is necessary to add a digital risk factor. This new innovation factor is related to cybersecurity, the introduction of blockchain platforms in which companies are now investing their funds in order to remain competitive in terms of innovation.

Among the main digital innovations leading to the reduction of digital risk are data mining, information architecture, knowledge management, as well as social networks - they are

currently producing the greatest effect in almost all areas where knowledge work is involved. [3]

Data mining allows you to identify patterns from large volumes of statistical information, optimize the internal structure of the company and carry out commercial intelligence. For the mining sector, big data analytics can align supply plans with demand forecasts, as well as detect production problems early and successfully invest in a brand. In addition, manufacturers can predict the wear and tear of production assets and schedule maintenance and repairs to keep the production line running. An example of the application of Data Mining in industry is predicting the quality of a product depending on the parameters of the technological process. [4]

Information architecture helps to provide information about the company in a convenient way for the target audience and future potential customers.

Knowledge management allows you to increase the intangible assets of the company by building your own know-how - the intellectual foundation of the company.

Social networks are currently the basic basis for the communicative interaction of companies and building their branding.

Today, the GKZ classification of inventory accounting is used, which does not meet market conditions. There is a risk of a repeated feasibility study, which must be carried out according to international, innovative for the country, methods for assessing minerals of the CRIRSCO system. In the conditions of high-mountain fields with increased tectonics, there is a risk of underestimation of geological uncertainties using international methods, although there is such a section in the general part, but it needs to be changed taking into account the specific features of the Kyrgyz Republic. The introduction and refinement of these international innovative methods for assessing mineral deposits should lead to an increase in the efficiency of the mining sector.

It is especially important in the sphere of recent events to highlight the political risk. Over the past 15 years, the republic has faced three civil unrest, which affected foreign investors who invested in the country's mining sector. With the onset of negative events, damage to property and demands to close mining enterprises, the state was afraid to rebuff the local population. It is worth noting separately the missed opportunities of the state to work with the local population to reduce this type of political risk. To reduce this uncertainty, the state needs to amend the law "On Subsoil", which clearly defines the security measures of the international investor, give clear guarantees for the return of capital in the light of the onset of this risk.

The possibility of entering the international exchange as with the Kumtor company can allow the state to sell shares of companies to a private investor in a timely manner at high prices and attract financial resources from the sale to national infrastructure projects.

Table 1. Systemic and non-systemic risk factors in the process of implementing investment projects in the mining industry of the Kyrgyz Republic (Compiled by the author [6])

Parameter Estimation	risk factor	Classification
Geotechnical	Array quality assessment Seismicity Inaccessibility (infrastructure)	Non-systemic risk / technical / operational risks
Economic	Innovative technology for evaluating deposits of the CRIRSCO family, to ensure access to international exchanges and issue shares to attract investment	

Environmental	Groundwater pollution dust, noise ecosystem disturbance	
Political	Legal risk: influencing political events to protect investors	Systemic risk / financial risks
Macroeconomic conditions	Digital risk: data mining information architecture knowledge management blockchain platform cyber security	

To identify a quantitative risk assessment, it is necessary to find the difference between the products of the probability of a favorable event (pda) and the possible maximum income (Pi) and the probability of an adverse event (pno) and the inevitable loss (Ui) [5].

$$\{O = P_{\text{инт}}^{\text{общ(инд)}} \times \Pi i - (P_{\text{инт}}^{\text{общ(инд)}}) \times \gamma i \rightarrow \text{MAX}, P_{\text{инт}}^{\text{общ(инд)}} = K_{\text{знач}}^{\text{геол}} \times p_{\text{да}}^{\text{геол}} \times K_{\text{знач}}^{\text{пол}} \times p_{\text{да}}^{\text{пол}} \times K_{\text{знач}}^{\text{экон}} \times p_{\text{да}}^{\text{экон}} \cdot P_{\text{инт}}^{\text{инд}} = \\ = K_{\text{знач}}^{\text{геом}} \times p_{\text{да}}^{\text{геом}} \times K_{\text{знач}}^{\text{техн}} \times p_{\text{да}}^{\text{техн}} \times K_{\text{знач}}^{\text{произ}} \times p_{\text{да}}^{\text{произ}} \times K_{\text{знач}}^{\text{экол}} \times p_{\text{да}}^{\text{экол}} . 0 < K_{\text{знач}}^j < 1, 0 < p_{\text{да}}^j < 1 \quad (1)$$

where KJMEAN is the coefficient of significance of the influence of the j -th general (individual) risk factor (mining and geological, political, economic);

PI, UI - discounted income (damage) from a favorable (unfavorable) outcome of the implementation of the i-th variant of ore deposits. The values of RDA and K3BEGINNING for each specific variant are determined by analytical, simulation (Monte Carlo method) and expert way.

To build a model of the algorithm of the methodology for the systematic risk analysis of the development of ore deposits, it is necessary to carry out a procedure for identifying risks and risk events, as well as assessing and selecting risk management methods.

At the first stage, it is necessary to analyze the internal and external environment of the enterprise, as a result of which it is supposed to identify external factors, such as political and economic and internal - environmental, natural (geological and geomechanical factors), production, technological.

To compare and select options for the integrated development of high-mountain ore deposits, all available risk factors are divided into individual ones that are inherent in specific options for implementing the strategy and general ones - changes in exchange rates, prices for raw materials and supplies, unreliability of geological information, calculation of reserves using outdated methods and outdated equipment. General risk factors will have the same nature of influence for all options, since their implementation is expected in external conditions and therefore, when choosing an option, they can be ignored. They absolutely cannot be ignored, as they can have a significant impact on the high-mountain field and must be evaluated first of all for the further possibility of implementing the project.

A quantitative assessment of the probability of occurrence of a possible event (risk uncertainty) should be carried out for each identified risk factor. And the general choice of a strategy for the development of a high-mountain ore deposit should be based on a general integral risk assessment, where it is necessary to obtain certain quantitative parameters from the

totality of the main events. These parameters should characterize the considered risk, in general, without going deep and without operating on individual particular situations.

Based on their financial capabilities of the enterprise and relying on the permissible level of security for each specific case, it is necessary to establish acceptable limits for material damage, profit (consequences of the occurrence of risk).

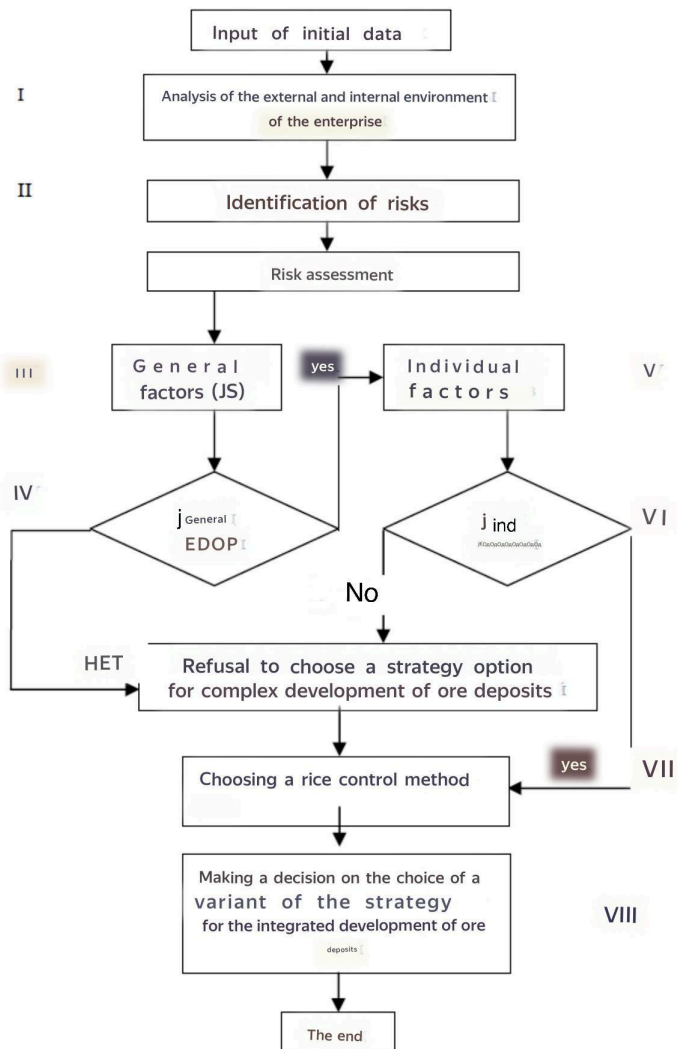


Fig.1 Algorithm methods of system analysis of the risk of development of ore deposits

Implementation decisions are made by designating various strategy options for maximizing the integral effect of the development of the entire field. Here it is expedient to choose the most effective options for technological schemes for the development of a field with the maximum value of the efficiency criterion, where the options are compared with the costs of managing the integral risk for each strategy for the integrated development of a high-mountain field.

The cumulative impact of changing risk factors can be different in each individual case from the most favorable to the least favorable, therefore, the choice of a decision on the

implementation of a strategy for the integrated development of a field should be accompanied by a reasonable specific set of risk management tools and methods.

The most common methods of avoiding or avoiding risk, used by most managers today. In this case, a conditional failure is created, which involves changing and revising the design specifications in order to improve the reliability of the entire organization. These methods may include elements such as avoiding the development of poor balance ores, unreliable partners and suppliers, and unreliable partners.

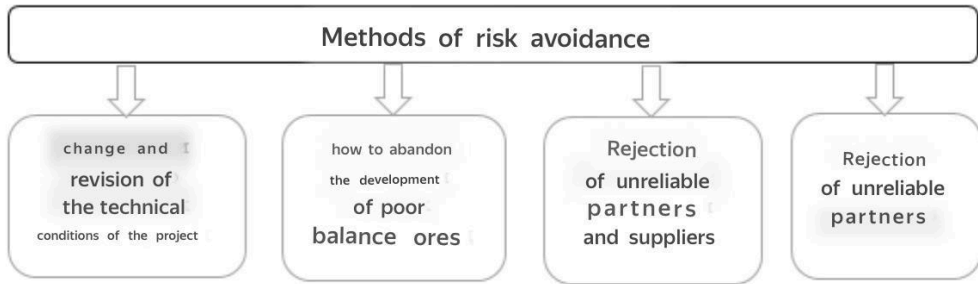


Fig. 2 Methods for avoiding the integral risk in the development of high-mountain ore deposits

To reduce risk uncertainty, many managers in the implementation of mining projects use compensation methods or proactive methods, which provide for the creation of the following mechanisms:

- Strategic planning of the organization's activities, which provides for the development of several different scenarios for the development of the deposit and the development of an optimal development strategy with an optimal level of integral risk;
- Creation of various reserves, for example, economic, based on national legislation, technological preparation and innovation, as well as technical, based on equipment reserves to increase production capacity;
- Implementation of insurance processes through the creation of self-insurance funds, through public and private insurance companies, as well as reinsurance;
- Search and attraction of public and private guarantee companies or investors;
- Operational monitoring of the geomechanical and geological state of the quality of the massif, the regulatory and legal external environment of the organization and the socio-economic situation.

To localize the risk uncertainty, it is necessary to create separate independent structural units in the organization, this may be an area of open and underground mining, a mine in the combined implementation of field development. In order to prevent losses in the event of a risk from falling on the parent company, it is necessary to allocate a separate venture company with a high level of risk for the implementation and implementation of high-risk innovations. This makes it possible to respond more quickly to unfavorable circumstances and to prevent the risk of losses faster, to increase the rhythm of the work of large organizations with a large number of employees and developed infrastructure facilities.

Risk uncertainty dissipation methods provide for the distribution of risks through integration with interested market participants, where the main tools can be different levels of diversification, distribution of responsibility between participants and expansion of their range.

At the same time, the main diversification measures in managing uncertainties in the development of high-mountain ore deposits are:

- Investing in highly profitable projects in the first place;
- Formation of portfolios of securities and their movement during exchange activities;
- Investment of private and foreign capital in the mining industry of ore supplier countries to create joint organizations for the extraction and processing of this ore with the supply of products to the investor's country for its further sale;
- The development of several deposits at once and the involvement of off-balance ores in cost-effective and expedient processing, as well as the introduction of various methods and technologies into the process within one high-mountain deposit.

Discussion

The method of systemic risk analysis and the allocation of integral risk make it possible to most fully and qualitatively evaluate and calculate systemic and non-systemic uncertainty factors that affect the operation of the mining sector as a whole and, in particular, to identify the effectiveness of the development and operation of high-mountain deposits at the initial stages of preparing a feasibility study implementation of mining projects.

Conclusions

As a result of the work carried out for the Kyrgyz Republic, systemic and non-systemic uncertainties have been identified that affect the efficiency of the mining sector. For geotechnical parameters, this is an assessment of the quality of the massif, without which the project may become completely unprofitable; in economic parameters, the factor of innovative technology for assessing deposits of the CRIRSCO family stands out to ensure access to international exchanges and the issue of shares to attract investment. In the environmental parameters, the factor of ecosystem disturbance is highlighted, in which you can eventually lose a habitable territory. The political parameters highlight the legal uncertainty that affects the investment attractiveness of the country's mining sector. In macroeconomic parameters, digital risk is highlighted, innovative for the Kyrgyz Republic and associated with the digitalization of the country's mining sector and affecting the competitiveness of the mining sector, which is one of the engines of the country's economic development. Currently, there are new types of uncertainties and risk factors associated with the emergence of new areas of human activity in the field of innovation and digital activity. Therefore, the state and companies in the mining sector must necessarily take into account new emerging types of risks and introduce innovative approaches to their activities to reduce the negative consequences of these uncertainties.

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