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CONDUCTING AN AUDIT USING SYSTEM MODELING TOOLS IN THE DEVELOPMENT OF DEPOSITS OF FLUX RAW MATERIALS

The object of research is an audit, which should be carried out to assess and feasibility of further development of new deposits of flux raw materials for the needs of the metallurgical industry and attracting potential investors. Some of the most problematic areas are limited by the economic potential of open pits for expanded reproduction and the difficulty of attracting investments due to the low investment attractiveness of the deposits.

The analysis of the current state of deposits of flux raw materials is carried out on the example of Ukraine. The main characteristics of the low investment attractiveness of limestone and dolomite quarries are determined. The need for an in-depth audit of the financial and economic activities of a quarry is determined, taking into account the specifics of the extraction of flux raw materials.

In the course of the study, system modeling tools are used to calculate the feasibility of developing new sites. The primary stages of the audit are shown to determine the feasibility of further development of new sections of flux raw materials, the production volumes of which will meet the needs of the metallurgical industry, subject to a competitive price of fluxes on the market. These stages provide for an assessment of the feasibility of further development of sections of flux raw materials and an analysis of the throughput of narrow links of the quarry to determine the amount of investment in making management decisions on these issues. For their implementation, an economic and mathematical model for optimizing the parameters is proposed to determine the economic feasibility of developing flux feedstock reserves in new areas, if the alternative is the loss of reserves in the underground resources. This ensures a reduction in the labor intensity of the check and its terms.

In comparison with similar well-known methods, the proposed approaches will reduce the amount of audit costs paid by the audit customer.

Keywords: *audit of financial and economic activities, investment attractiveness, mineral deposits, flux raw materials.*

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1. Introduction

In modern economic conditions in a number of countries the problem of further development of deposits of limestone and dolomite (flux raw material) for the needs of the metallurgical industry, glass, sugar and other enterprises remains urgent. A shortage of raw materials can arise for a number of reasons. This may be due to the expansion of metallurgical production in the country, the opening of new enterprises or the expansion of the existing production of glass and sugar enterprises, enterprises for the production of cement, etc.

But there are other reasons as well. For example, in Ukraine, a shortage of flux raw materials arose in connection with the annexation of Crimea and the occupation of a part of the Donetsk region, where priority deposits of limestone and dolomite are located (Novotroitske – Dokuchaivsk – Komsomolske region). Limestones and dolomites of similar quality are found in a number of other regions of the country, including in the central and western regions, but due to the absence of a metallurgical industry here, they were explored and taken into account by the state balance as raw materials for the needs of the sugar industry and for other purposes that are not designed for volume of consumption of metallurgical enterprises.

It is reliably known that there are detailed explored deposits of limestone and dolomite, accounted for by the state balance, and general information about them is relatively available. There are also deposits of similar limestone and dolomite with reserves of tens – hundreds of millions of tons, where no detailed exploration work has been carried out. These are deposits in the Vinnitsa region, a number of sites in the Ternopil and Khmelnytskyi regions [1, 2]. Information about these objects is available only in the form of archival materials. The shortage of flux raw materials can be covered by these deposits.

But there is a problem of assessment and feasibility of further development of deposits of flux raw materials, the need for which has grown. The issues of determining the investment attractiveness of certain open pits and deposits of flux raw materials for attracting non-state funds have acquired great importance.

Given the situation, there is an urgent task of conducting an in-depth audit and analysis of financial and economic activities in order to make a managerial decision on the feasibility of further development of deposits of fluxing raw materials. As well as the solution of theoretical and practical problems of improving the organizational and economic mechanism for the development of quarry reserves. Under such conditions, a team of specialists should be formed to conduct the audit. This group should be formed of independent specialist auditors for consulting on management and development of management solutions, technology auditors, directly employees of the finance department and mine surveyors of the quarry itself.

When conducting an audit of the economic activities of a quarry regarding the feasibility of developing new sites, certain difficulties and problems arise associated with the laboriousness and long periods of verification. Consequently, conducting an audit using system modeling tools when developing new sections of flux raw materials to reduce labor intensity and shorten the inspection time is relevant and requires further consideration.

2. The object of research and its technological audit

The object of research is an audit, which should be carried out to assess and feasibility of further development of new deposits of flux raw materials for the needs of the metallurgical industry and attracting potential investors.

It is known that the main reason for the slow reform of property relations in the development of dolomite and limestone deposits is their low investment attractiveness. The latter is dictated by a number of objective circumstances, the main of which are [2]:

– features of mining and geological conditions of occurrence of minerals and overburden rocks;
– physical and mechanical properties of flux raw materials;
– thickness of bedding layers;
– terrain relief;
– distance of transportation of rock mass;
– annual volume of mining and overburden rocks;
– sophisticated equipment and technology for field development;
– high cost of flux raw materials and the cost of delivery of products in comparison with limestone and dolomite of neighboring countries: Russia, Belarus, Moldova, etc.

That is, quarries for the extraction of flux raw materials require a detailed analysis of the strategy for further development: expanding production using the latest technology and further development of deposits, or stay at the same level of production. Almost every single open pit has very limited economic potential for expanded reproduction. This is also facilitated by the problem of lack of own circulating assets, lack of opportunities to attract investment.

So, one of the most problematic areas is determining the investment attractiveness of a quarry and the feasibility of further development of deposits using the least labor-intensive and short-term audit methods.

3. The aim and objectives of research

The aim of research is to determine the conditions for the economic feasibility of developing fluxing raw materials in new areas, if the alternative is the loss of reserves in the subsoil.

To achieve the set aim of research, the following objectives are identified:

1. To analyze the structure of the enterprise for the extraction of limestone and dolomite for the evaluation characteristics of the prospects for its development.

2. To determine the priority stages of an in-depth audit of the financial and economic activities of open pits using the means of system modeling.

4. Research of existing solutions of the problem

The issues of improving the audit of financial and economic activities for making management decisions are constantly in the center of attention of scientists. Among the main directions of this problem, identified in the resources of the world scientific periodicals, can be highlighted [3, 4], but they do not consider the features when auditing open pits for the extraction of minerals. This audit should take into account the specifics of open pits for the extraction of fluxing raw materials, as a system that includes three subsystems: natural, technological and economic [1, 5]. To address this issue, it is necessary to form a group, which will include not only auditors for consulting on management and development of management solutions, but also technology auditors, as well as employees of the financial department and mine surveyors of the quarry itself.

The need to combine the efforts of external and internal auditors to optimize the process of checking an enterprise and evaluating its activities is indicated in [6, 7], but here it is not directly investigated audit for the purpose of attracting potential investors. The issues of labor intensity and long terms of verification are also highlighted.

An alternative solution to the problem is presented in [8]. The author recommends the use of economic and mathematical modeling as an important tool for analysis and audit regarding the adoption of informed management decisions. In [9], the author proposes the use of innovative models in financial audit, but they do not take into account the peculiarities of the audit of the feasibility of further development of minerals and attracting potential investors.

The author of [10] notes the influence of an independent audit on investment decisions made by the owner. This issue is also studied by the authors [11, 12], who analyzed the relationship between the quality of financial reporting and investment efficiency. But it should be noted that they do not consider the analysis of technological reporting, which is necessary for an in-depth audit of the financial and economic activities of enterprises for the extraction of fluxing raw materials.

Thus, the results of the analysis allow to conclude that, due to their peculiarities of functioning, mining quarries require special attention when assessing the effectiveness of its activities. Therefore, the problem arises of combining the works of scientists to optimize the audit process. The audit mechanism should take into account the specifics of the enterprises for the extraction of fluxing raw materials, as a system that includes three subsystems: natural, technological and economic, which requires further analysis and research of the problem.

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5. Methods of research

During the execution of the work, general scientific and special research methods are applied:

– method of theoretical generalization, grouping and comparison – to study the signs of «investment attractiveness» taking into account the state of the subsystems of the enterprise for the extraction of flux raw materials; a transition was made to the concept of an «investment unpromising» quarry;

– system analysis – to assess the interaction of quarry subsystems using system modeling, taking into account the main factors affecting the feasibility of further development of new areas of flux raw materials;

– functional and cost analysis – includes the study by the auditor of the complete technological system for the extraction of flux raw materials and assessing the economic efficiency of technological processes;

– method of logical generalization – for the theoretical substantiation of the importance of the tasks and clarification of the key concepts of the study.

6. Research results

Due to the limited financial resources, the most important economic indicator of any option for the development of a quarry for the extraction of flux raw materials is its investment attractiveness. If to guide by this circumstance directly and in isolation, then the criterion for the best option will always be the minimum investment. However, such a criterion can't be accepted in principle, since it stimulates the priority of cheap quarry development options, which in the long term dooms it to economic stagnation. The increase in investments allows to solve the problem of increasing the volume of production of fluxing raw materials, improving its quality, increasing the level of concentration of production, and reducing the cost. The problem lies in the ratio of the investment volume and the achieved effect. Therefore, it is advisable to take into account investments in the form of a limitation by adopting a maximum limit that can't be exceeded [13].

A sound financial condition of a quarry is an important condition for its continuous and effective functioning. To achieve it, it is necessary to ensure the constant solvency of the quarry, high liquidity of its balance sheet, financial independence and high economic efficiency. To do this, it is necessary to study numerous indicators characterizing all aspects of a quarry (production, its potential, organization, implementation, financial transactions, cash flow) to identify the root causes of changes in the financial situation.

Thus, open pits require a detailed analysis of their development strategy: expanding production with the use of the latest technology and further development of deposits, or stay at the same level of production. Almost every single open pit has very limited economic potential for expanded reproduction. This is also facilitated by the problem of lack of own working capital, the difficulty of attracting investment.

To solve these problems, it is necessary to conduct an in-depth audit of economic activities, which will be carried out by external auditors in close cooperation with the internal services of the enterprise, especially with the department of mine surveyors. A separate line of activity of audit firms, according to the Law of Ukraine «On the audit of financial statements and auditing activities», is the provision of «non-audit services», in particular, consulting on management, development and support of management decisions. The persons who will conduct the audit must not only be highly qualified economists, but also understand the industry specifics of the operations of open-cast mines for the extraction of fluxing raw materials.

When conducting an audit, it is necessary to take into account the specifics of open pits for the extraction of fluxing raw materials, as a system that includes three subsystems: natural, technological and economic.

The first subsystem of the quarry is formed by the mining and geological conditions of the occurrence of minerals and overburden, which exist from the beginning and belong to uncontrolled factors. The second subsystem is the level of technology of working off stocks. It is formed under the influence of the level of mechanical and technological equipment and natural conditions to which it is necessary to adapt. The third is the result of the action of the first two parts of the system and the achieved level of social development. Natural and technological subsystems directly and indirectly affect the economic results of the quarry. In a systems approach, the indicator that characterizes a quarry must take into account all three of its components, so it becomes clear the failure of attempts to be limited to any one indicator. But it is obvious that a quarry with small reserves is a hopeless enterprise, even if all other parameters are high.

Therefore, the first stage of the audit should be the feasibility of further development of areas of flux raw materials, the volume of production of which will meet the needs of metallurgical enterprises, given the competitive price of fluxes on the market. The primary solution to this issue will reduce the complexity of the audit and its timing, and as a result, reduce the amount of audit costs paid by the customer of the audit (potential investor).

As it is known, some of the technological parts of the quarry have the maximum power, and the second – the minimum value. The ratio of minimum capacity to maximum is the coefficient of technological reliability [13]. At any given time, this ratio has a single deterministic value, which depends on the technical condition of the quarry and characterizes this condition: the minimum value determines the actual capabilities of the quarry, the maximum – its potential. The smaller the value of the coefficient of technological reliability, the greater the gap between the main links and the more difficult it is to realize the potential of the quarry.

The list of narrow quarry links is the main factor that determines the amount of investment needed to increase the load of the enterprise. All other things being equal, it is more profitable to increase the load of those quarries where less investment is required.

Various decisions to change the throughput of individual sections of the quarry can be considered as a consequence of the concentration of mining operations. Modeling of the parameters of open pits in this case is formalized in the form of transforming the initial technical and economic parameters into minimizing investment and production costs.

Scientific and technological progress opens up fundamental possibilities for the development of deposits, previously it was difficult, as a rule, due to the need for additional costs for carrying out mechanical and technological work. At the same time, there are individual enterprises and organizations wishing to invest their capital in the develop-

ment of deposits or the restructuring and modernization of existing quarries in these regions. But they need certain guarantees that the funds that will be invested in this production will be profitable in the future.

Let's introduce the concept of «degree of investment attractiveness» of a quarry. It is a quantitative characteristic of the result that determines the effectiveness of the system. From here, a transition can be made to the concept of an «investment unpromising» quarry, if to establish the line of the degree of efficiency at which the quarry belongs to the category of «unpromising». Since a quarry is considered as a set of three subsystems, the sign of «investment attractiveness» should take into account the state of these subsystems [14].

Thus, based on the analysis of the structure of the quarry, the following approach is proposed: from each of the subsystems, two most representative characteristics are selected, which can be quantified. Their list is given in Table 1 [2, 13].

Table 1

Assessment characteristics regarding the prospects of quarry development

Subsystem	Characteristic
Natural	Layer thickness Field condition index by natural factors
Technological	Technological reliability indicator Range of rock mass transportation
Economic	Cost of 1 ton of fluxing raw materials Annual production of flux raw materials

Note: developed on the basis of data [2]

The adoption of the cost as the marginal cost value can be considered rational, since this is the economic basis of the investor from the point of view of the expediency of financing the further development of mineral deposits. Considering this circumstance, let's consider it expedient to accept as a criterion of economic feasibility of field development and further advancement of the front of mining and overburden mining operations. Then the payback period for the capital costs for the development of these areas by reducing the cost of fluxing raw materials for the open pit as a whole:

$$T = \frac{K}{C_0 - C_1} \le T_0, \quad (1)$$

where K – additional capital in the development of advancement of the front of mining and stripping mining operations; C_0, C_1 – respectively, the cost of extracting flux raw materials in the open pit as a whole before and after the advancement of the front of mining and overburden mining; T_0 – desired payback period.

Reducing the cost of flux raw materials for the open pit as a whole in the case of the development of new sites is achieved due to the relative savings in the total open pit costs per unit of production due to the increase in production.

Let's introduce the following notation: R_0 – costs for the extraction of flux raw materials in the open pit as a whole to the development of new sites; D_0 – extraction of flux raw materials for the development of new areas; ΔR_0, ΔD_0 – respectively, an increase in costs and production in connection with the development of new areas.

Then:

$$\Delta C = C_0 - C_1 = C_0 - \frac{R_0 + \Delta R_0}{D_0 + \Delta D_0},$$

$$\Delta R_0 = \sum_{i=1}^{n} R_{\Delta i}, \quad (2)$$

where n – the number of accounted processes where the cost increases due to the development of new sites (removal of the soil and vegetation layer, blasting operations, the distance of transportation of rock mass to the crushing and sorting shop, placement of overburden in internal dumps, etc.).

It directly follows from (2) that the development of new sites is impractical if it leads to an increase in the cost of extracting flux raw materials in the open pit as a whole. An exception may be the development of areas of especially valuable and scarce varieties of limestone and dolomite.

As an initial postulate and for the sake of simplicity of calculations, it is possible to assume that the cost of extracting flux raw materials at the i-th section is nonlinearly related to the volume of production and is of extreme nature, but let's consider it constant in a certain interval. In this case, the condition for attracting new reserves into development is the excess of the wholesale price for fluxing raw materials over the conditionally variable part of the costs associated with the production and sale of products of the i-th section.

Then the volumes of production of a new development required to cover costs and make a profit are determined from the condition:

$$D_n = \frac{C_o \sum_{i=1}^{n-1} D_i - \sum_{i=1}^{n-1} S_{yi} D_i - R_{tqe} - \left(S_d + S_{tr}\right) \sum_{i=1}^{n-1} D_i}{S_{y_n}}, \quad (3)$$

where C_o – competitive price for flux raw materials, conventional units; S_{yi} – cost of extracting flux feedstock at the i-th area, c. u./t.; D_i – volume of production of fluxing raw materials in the i-th area, t; R_{tqe} – total quarry expenses, c. u.; $S_{tr.}$ – transportation costs, c. u./t.

With a negative D_n value, the quarry is unable to operate without losses when selling flux raw materials at competitive prices.

In terms of further development of new areas, that is, the advancement of the front of mining and overburden mining operations, an economic assessment of the options for the development of mining operations is necessary. At the same time, possible options for the development of mining operations are considered as a promising continuation of the existing development.

To attract investors to a quarry, it is necessary to conduct an in-depth audit of economic activities. If the enterprise has the ability to further develop new areas of flux raw materials, then investors, despite the reality of making a profit, will invest in the country's limestone and dolomite quarries. Conducting an audit of enterprises for the development of minerals of flux raw materials allows to assess how independent it is from the financial side, whether the level of this independence increases or decreases, whether the state of the assets and liabilities of the enterprise meets the goals of its economic activities.

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7. SWOT analysis of research results

Strengths. Thanks to the proposed economic and mathematical model for optimizing the parameters for determining the economic feasibility of developing stocks of fluxing raw materials in new areas, the labor intensity of the audit and its timing are reduced. The proposed approaches will reduce the amount of audit costs paid by the audit client.

Weaknesses. The use of system modeling when conducting an audit of financial and economic activities of a quarry has a number of disadvantages associated with a sufficiently large number of restrictions and prerequisites, which can lead to a decrease in the effective solution of real problems.

Opportunities. It should be noted that in the future it is necessary to use the methods of analyzing economic systems, which will increase the efficiency of their functioning and will contribute to obtaining additional economic benefits.

Threats. Threats to the use of system modeling methods include the need to form a significant sample of quarry subsystem characteristics, the quality of which will determine the adequacy of the model.

8. Conclusions

1. The analysis of the structure of the enterprise for the extraction of limestone and dolomite is carried out for the assessment characteristics of the prospects for its development. According to the task, it is substantiated that it is considered expedient to develop new sites with a decrease in the cost of extracting flux raw materials in a quarry as a whole, an exception may be the development of sites of especially valuable and scarce grades of limestone and dolomite.

2. It is determined that the primary stage of an in-depth audit of the financial and economic activities of open pits is to decide the feasibility of further development of flux raw materials. This means that the volume of production of flux raw materials will meet the needs of the metallurgical industry, provided that the prices of fluxes are competitive on the market. It is proven that the use of system modeling tools to calculate the feasibility of developing new sites will reduce the labor intensity of the audit and its timing, and as a result, the amount of audit costs paid by the audit customer will decrease.

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