Justification of an approach to an economic assessment of projects development of technogenic mineral objects

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Abstract. With the gradual reduction of the quality of mineral resources and the deterioration of mining and geological conditions of mining operations there is a need to revitalize the mining companies within the Russian Federation to engage in the processing of the existing technogenic resources. This problem is particularly relevant for the Northern regions, where a significant amount of mining waste has accumulated as a result of long-term mining. This involves increasing the investment attractiveness of the waste management of mining projects through the development of methodologies for the economic evaluation of projects. The purpose of this research is to develop a methodological approach for economic evaluations during the development process of technogenic mineral processing facilities and mining waste projects. The considered research methods include: justification of key elements of the evaluation of project developments and technological fields of waste processing, compare the types of projects, the rationale for the selection of project solutions to the socio-environmental projects and organizational results. The study results propose a methodology for deciding on the implementation of development projects of technogenic deposits and recycling, based on the flexible use of the criterion of net present value (NPV) to evaluate the effectiveness of the project.

1. Introduction
The appropriate use of mineral resources, including technogenic ones, makes it possible to expand the mineral raw material base, overcome the deficit in natural mineral raw materials, obtain additional types of products, reduce costs of developing new deposits. In addition, the mining waste processing allows to reduce negative effects on the natural environment and waste placement costs, and to obtain additional social effects [1,2,3].

For instance, about 5 billion tons of production and consumption waste over 90% of which is extraction waste is generated annually in the mineral resources sector of the Russian Federation. Only half of the entire mass is recycled, the remaining mass is accumulated “until better times”. For the period of 2005-2015 over 24 billion tons of waste has been accumulated in spoil and tailing dumps, and according to the Ministry of Natural Resources of the Russian Federation, taking into account the previous extraction, this number amounts to about 100 billion. The data analysis of the official statistics has shown that the growth rates of waste generation and accumulation for the sector of extraction of mineral resources amounted to 185.7% and 231.1% respectively (the grown rates of extraction volumes are, for comparison, 113.7%). For northern regions, this problem is especially acute, since the northern territories are the most sensitive to the negative impact on the part of mining.
In addition, negative processes related to the effects of waste on the environment touch upon interests of the neighboring states and influence reputation of the country[4,5].

Against the background of deterioration of the mineral raw material base, mining and geological conditions grows the relevance of mining companies’ efforts to include into processing available technogenic raw materials and resources by introducing projects of the development of technogenic mineral objects (TMO) [5,6].

2. Definitions and methodological approach

In the context of this study a technogenic mineral object is an object formed in the process of production and economic activities of a mining enterprise. This object contains accumulations of mineral substances of natural and technogenic genesis, placed in special structures.

In order to boost the activity of mining companies in the field of mining waste processing, investment appeal of projects for development of TMO is required. This requires development of methodology for an economic assessment of projects the key elements of which are goals and results of the project, the object of the project, criteria and results of the assessment of the project.

2.1. Goals and results of the project.

The goals of the project for development of TMO must comply with the goals of development of the company. The following may serve as examples of strategic goals of a hypothetical mining company: entry into new markets, stable activities, improvement of an image component of the company’s value [7]. These goals must comply with the goals of projects for development of TMO (table 1).

| Company’s goals                  | Goals of a project for development of TMO                              |
|----------------------------------|---------------------------------------------------------------------|
| Entry into new markets           | Additional types of products made of technogenic raw materials       |
| Stable activities                | Maintenance of projected capacity, extension of the period of economic life of an enterprise |
| Compliance with the level of the best companies | Attainment of the required environmental quality parameters, improvement of working conditions, etc. |

Economic, social and ecological results of a project are related to the goals. The following serves as examples of strategic goals of a hypothetical mining company: entry into new markets, activity stabilization, improvement of an image component of the company’s value, with each of which the goals of projects for development of TMO comply. It is worth noting that for a mining company as a potential investor and consumer of products of a project, of great importance are organizational results including obtaining additional experience (expansion of professional competencies of employees), methodologies, new technologies, documentation, the assessment of which can be made only on the company’s level [8].

Therefore, it is advisable to differentiate such concepts as “result of a project” and “results of an economic assessment of a project”.

2.2 Justification of an object of the project. Technogenic mineral objects are specific objects of projects, since:

- they are formed as a result of the process of extraction and processing of a mineral resource, their formation is already envisaged in the projects of development of deposits;
- duration of development of natural deposits does not allow taking into account possible consequences of accumulation of waste (including ecological), and a possibility of their further processing and beneficial use at the design stage;
- waste processing is more complex in the format of an operating technology;
- the quantity and quality composition of a TMO changes over time, and mining waste can become inappropriate for further use [6].

The specifics of technogenic mineral objects and goals of projects for development of TMO allow them to be divided into two types of projects: projects for mining waste processing (MW) and development of technogenic deposits (TD).

For the purposes of this study, we assume that “mining waste” is the “products” of mining extraction and processing of rock, which the enterprise does not plan to use for industrial purposes or sell in the long term.

*Technogenic deposit (TD)* is a technogenic mineral object that is formed for the long-term development of potential mineral resources of low quality.

The singling out of two types of technogenic mineral objects is explained, in our opinion, by the nature of the production process, the rights which the mining company is granted with relation to TMO, the goals of the project, the quantity and quality composition of TMO.

An issue of division of projects into types of technogenic mineral objects is a debating point. In the domestic academic studies, assessment of projects for mining waste usage has gained the widest circulation within the framework of the concept of technogenic deposits [8]. According to this concept, MW is potential resource, and the site of their stockpiling is a technogenic deposit. The concept of technogenic deposits implies storage of extraction and processing waste. In addition, if any company wants to process that waste, it will be unable to get it without special permits and preliminary geological studies. These requirements are equal both for projects of mining waste processing, and for projects of development of primary deposits. The fulfillment of these requirements takes much time and it reduces the efficiency of mining waste processing [6].

It should be added that an assessment of resources, including technogenic ones is rather a costly procedure that includes fulfillment of a set of works related to geological and economic, cost, and special types of assessment [11,12,13]. Therefore the result of assessment of projects depends not only on the value of useful components, but also on additional expenses related to preparation of a project for mining waste processing. The comparison of the project types for development of TMO is presented in table 2.

| Table 2. Comparison of the project types for development of TMO |
|---------------------------------------------------------------|
| **Comparison criteria** | **Projects for development of technogenic deposits** | **Projects for development of mining waste** |
| Goal of development of TMO | Extraction of a mineral resource, recovery of useful components | Recovery of useful components, comprehensive mineral processing, reduction of negative impact |
| Life cycle | Life cycle additionally includes the stage of geological and economic assessment, development of feasibility studies of conditions; procedures of approving reserves, registration of rights (geological approach) | Life cycle is determined by the applied technology of development (technological approach) |
| Investment | Expenses of geological prospecting work and organizational procedures are included *additionally* in the investment. | Complex investment in innovative technology |
| Current expenses on the project | Provide for inclusion of a tax on the extraction of commercial minerals | Current expenses depend on organization of works on the project and the applied technology |
2.3. Project assessment criteria

Assessment of commercial efficiency of a project for development of TMO is performed on the basis of such indices as net present value, profitability index, internal rate of return, payback period. The main criterion according to which the appropriateness of implementation of a project is determined is positive value of the net present index.

In our option, the negative value of NPV cannot be a rigid criterion for projects for development of TMO, which may be ecologically and socially efficient. It is suggested to compare the value of the NPV index not with a “zero”, but with the company’s expenses, which will arise if the company declines the project. Those expenses include waste placement fee, expenses of maintaining engineering structures in which mining waste is placed, reclamation and other expenses, which were envisaged in a project for development of primary deposits. Such approach corresponds to one of the principles of economic assessment of projects: assessment of indices “with a project” and “without a project”.

For projects related to processing of accumulated waste on a going concern, the acceptable option is the one in which NPV = 0. In this case, it can be assumed that the project is directed at preventing future losses of a company resulting from accumulation of waste.

If NPV has a negative meaning (discounted expenses for the project exceed discounted revenue), it is necessary to compare the NPV meaning with the value of discounted losses in the “decline project” option.

If NPV is within the interval: \[ \sum_{t=0}^{T} C_t \beta_t < NPV \leq 0 \]
(where: \(T\) is the period of accumulation of waste (starting from the moment \(t_0\) until its disposal); \(C_t\) is expenses related to the maintenance of the object), the project can be viewed as a measure directed at reducing losses from accumulation of mining waste; \(\beta\) is a discount factor.

A decision-taking algorithm on implementation of a project for development of TMO is presented in fig.1

![Decision-taking algorithm](image)

Figure 1. Decision-taking algorithm on implementation of project for development of TMO

3. Results of the study

For waste processing projects to be implemented by a hypothetical Company, depending on the goal of the project, various results can be acceptable, which can be determined in the cost indices of the project itself, taken into account at the level of the Company itself, such as when assessing its cost,
and also as external effects. The economic effects for the company are manifested as additional profits and reduced losses. Organizational effects can be presented as new technologies, industrial engineering techniques, information, and new expertise. The reduced life cycle of waste allows additional ecological effects to be obtained that influence the condition of the territory. The revealed possible results of a project for mining waste processing are presented in table 3.

The economic effects for the company are manifested in the form of additional profits and lower losses. Organizational effects can be presented in the form of new technologies, methods of organizing production, information, new knowledge and experience. Reducing the life cycle of waste provides additional environmental effects that affect the state of the territory.

Table 3. Results of project for mining waste processing for a hypothetical mining company

| Project goal                      | Allowable NPV                  | RESULTS OF THE PROJECT                      | External effects         |
|----------------------------------|--------------------------------|---------------------------------------------|--------------------------|
| Earning additional income from   | Maximum positive              | Receipt of additional profit                 | Reduced life cycle of    |
| sale of products                 |                                |                                             | waste                    |
| Loss prevention                  | Non-negative                   | Prevention of losses caused by accumulation of waste |                         |
| Loss reduction                   | Should not be below the value of discounted losses | Reduction of losses from accumulation of waste |                         |

4. Conclusion

Projects for development of TMO are complex objects of economic assessment, which is mainly determined by the specifics of the objects of the project. The revealed specifics of technogenic mineral objects made it possible to single out two types of projects for development of TMO (development of technogenic deposits and mining waste processing) differing in goals, structure, and content of life cycle stages. The geological approach to the development of TMO (a concept of technogenic deposits) cannot be viewed today as the only one. Modern technologies allow processing of waste bypassing geological prospecting stages. The objective is to make them more available and sought-after.

In economic assessment of projects for mining waste processing, it is possible to apply the criterion of net present value to assess efficiency of a project more flexibly. The implementation of projects for development of technogenic objects should be accompanied by simplification of procedures of providing them for use, introducing tax privileges (such as reduction of tax on the extraction of commercial minerals where it is referred to reproduction of geological prospecting work); the condition of formation of a technogenic deposit should be reflected in the license for the development of a primary deposit.

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