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Problems complicating the introduction of technogenic deposits into economic circulation

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Abstract

Relevance. In modern conditions of depletion of the mineral resource base, deterioration of natural conditions of newly discovered deposits, the development of technogenic mineral resources gains primary importance. However, as the analysis shows, the level of use of solid mineral formations continues to remain insignificant.

The purpose of the study is to identify the reasons that slow down the process of involving technogenic deposits into economic circulation, in order to prevent their occurrence or mitigate negative impacts.

Research methods. In the research process, methods of comparative analysis, analogies, and expert analysis were used.

Results. Analysis and generalization of domestic and foreign experience in the management of technogenic mineral formations (TMFs) allowed us to identify the main reasons hindering the expansion of the practice of developing technogenic deposits. Nine reasons were identified: imperfection of the regulatory framework for the management of TMFs, low degree of geological knowledge, high geological risk, lack of waste processing technologies, lack of necessary financial resources, imperfection of the economic mechanism used by the state in regulating waste management activities, the possibility of extending shelf life of TMFs, imperfect availability of information about TMFs, lack of qualified personnel. As a result of an expert survey of 20 specialists, the identified reasons were ranked and the highest priorities were identified. These included: the imperfection of the regulatory framework, the lack of environmentally friendly technologies required and the lack of an effective economic mechanism for state regulation of this activity.

Conclusions. Identification of the primary reasons slowing down the process of development of technogenic deposits determines the further direction of work to prevent them or mitigate negative impacts.

Keywords: technogenic deposits, problems, development, priority, ranking of problems.

Introduction

The accumulation of technogenic mineral formations began in Russia from the moment the first state-owned factories appeared. According to data [1], the appearance of the first mining plants dates back to the 1630s, including the first most ancient formation of a dump with a volume of about 1 thousand m³ and a height of 2m [2]. During those years, the Pyskorsky copper smelter began operating on the western slope of the Urals, which was accompanied by the accumulation of slag. Since the beginning of the 18th century, the Urals have become a major center of mining and metallurgy, and the intensive exploitation of mineral resources leads to the accumulation of waste. Waste rock is used to fill mined-out space, waste copper ores are processed, for which a hydrometallurgical plant was

built on the basis of the Gumeshevsky mine in 1907. These are the first examples of the development of technogenic deposits.

The formation of TMFs dates back to the beginning of the 20th century. They constantly attract attention as promising sources of raw materials, and therefore, since the 30s, attempts have been made to study and evaluate them, which is confirmed by the surviving materials of these works. In 1931–1937 dumps of the Turyinsky copper mines were assessed for Cu and Co slags of the Bogoslovsky copper smelter, and in 1941 for slags of the Vyysky copper smelter. In 1934 and 1937–1938 an assessment of copper-containing waste from most copper enterprises in the Urals was carried out during geological exploration. The study of waste from the copper sub-industry in

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the Urals continued in the 50s, as well as in the 70–80s [3]. In the 70–80s geological exploration work was carried out to assess copper-containing waste from large copper smelters in the Urals.

The problem of the development of technogenic deposits (TGs) has become noticeable in 1986, when resolution No. 56 by the State Committee for Science and Technology of the USSR dated March 14, 1986 was issued, "Creation of scientific foundations and methods for increasing the efficiency of rational integrated development mineral deposits and subsoil protection for 1986–1990 and for the period up to 2000" [4]. The research tasks included the following: development of an inventory, geological assessment of the composition of existing heavy metals, development of ore processing technologies and promising heavy metals, development of effective methods for the development of heavy metals, economic assessment of the development of heavy metals, development of standard requirements for rules and regulations for designing the development of heavy metals. Resolution No. 56 was the impetus for intensifying activities on the study, assessment and development of TMs. Attention to this problem varied, but over time the problem became a national priority.

The problem of developing heavy metals is still quite acute today, which is associated with the depletion of the mineral resource base and the need to expand it and mitigate the threat of loss of stability. The second aspect is increasing the level of environmental safety by neutralizing sources of negative impact on the environment represented by TMFs. According to the specialists of the All-Russian Research Institute of Economy and Exploration of Mineral Resources, over 300 years of operation of the mining industry in Russia, about 100 billion tons of TMFs have been accumulated, which occupy large areas in the Central, Northern, Ural, Western and East Siberian regions. It is believed that 40 billion tons of them are suitable for the production of building materials. The largest share (up to 40% by weight) belongs to the TMFs of the coal series. According to [5], about 2 billion tons of technogenic coal-containing raw materials are concentrated in large coal-mining regions of Russia alone. Concentrations of TMFs and ore useful components are significant. Thus, the TMFs of non-ferrous metallurgy contain in thousand tons: copper – 7790, lead – 980, zinc – 9000, tin – 540, nickel – 2480, tungsten – 129, molybdenum – 114, lithium – 97, etc. The dumps of gold mines contain about 5 thousand tons of gold [6]. Despite the presence of such rich technogenic mineral potential, its development remains unsatisfactory. The accumulated volumes of TMFs are growing, as is their shelf life, which significantly reduces the quality characteristics of the latter, turning them into "metal trash."

Results

Despite all the power of the technogenic mineral potential, its use remains insignificant. Identification of the reasons inhibiting this process will make it possible to develop a set of measures to prevent their occurrence or mitigate possible negative impacts.

Analysis of the state of waste management in domestic and foreign practice made it possible to identify the main problems. The first of them includes the imperfection of the regulatory framework regarding waste management, including mineral technogenic formations. It is contradictory and does not distinguish TMFs into a separate category of legal

regulation. Technogenic deposits are equal to natural deposits in terms of exploration, licensing, and approval of reserves. Hence, to transfer TMFs into a technogenic deposit, the subsoil user must:

- submit an application for a competition, prepare a technical specification, participate in the competition, obtain a license that gives the right to carry out a certain set of works, determines the boundaries of the subsoil plot and the timing of the work. When holding an auction, make a one-time payment;

- prepare a project for geological exploration work (agreed with the authorities of the Federal State Institution Rosgeolpertzta);

- carry out geological exploration work, based on the results of which a feasibility study of conditions is compiled, a state examination is carried out and standards for calculating reserves are approved (according to the Decree of the Government of the Russian Federation dated January 22, 2007, No. 37);

- calculate mineral reserves according to approved standards, perform a state examination of reserve calculations in order to put them on the state balance sheet [7];

- develop a project for working out the reserves of a technogenic deposit, conduct a state environmental examination and an industrial safety examination, pass the project after its approval by the Central Territorial Commission for Development;

- develop the field in accordance with the approved project with annual approval of loss standards;

- upon completion of field development, carry out reclamation work in accordance with the reclamation project.

A critical condition for the transfer of TMFs into technogenic deposits is the state examination of mineral reserves, confirming the feasibility of developing a technogenic deposit, which is reflected in the State Reserves Committee/Territorial Committee for Natural Reserves protocol. Only after a positive decision by the State Reserves Committee/Territorial Committee for Natural Reserves can a man-made deposit be provided for use. Carrying out the above list of works turns out to be impossible if all the necessary formalities are followed.

Firstly, the state examination of reserves is based on approved regulatory documents, in which such objects as man-made mineral formations and man-made deposits are absent. The entire regulatory framework concerns natural deposits of the period of the 70–80s, when the problem of developing technogenic mineral resource potential remained irrelevant.

Secondly, there are practically no methodological recommendations on the organization of geological exploration work. The by-law approved by the State Reserves Committee Rosnedra in 1994 "Methodological recommendations for the study and environmental and economic assessment of technogenic deposits" is illegitimate. In fact, it cannot be used for practical purposes, and also cannot serve as a basis for the examination of geological exploration projects, and, consequently, for justifying conditions and calculating reserves.

Thirdly, according to experts, the recommended methods for exploration of technogenic deposits cannot provide a reliable assessment of reserves and their distribution within the boundaries of the deposit. Particularly difficult is the assessment of reserves of technogenic placers, which, according to A. G. Chernyavsky are even more complex than group IV

deposits, and therefore “gold resources... will never become reserves” [8], the necessary information for transfer to reserves is missing and cannot be obtained. The effectiveness of the recommended method for determining the efficiency of mining technogenic placers (sampling of large volumes with washing them on an industrial device), as the author himself believes, is close to zero; there are no patterns in the presence of gold at the site. This indicates the impossibility of reliably assessing reserves in order to put them on the state balance sheet. Fourthly, there is little experience in the development of technogenic placers, which allows us to formulate only preliminary recommendations. Thus, fulfilling the established procedure for transferring TMFs to technogenic deposits turns out to be impossible.

The listed conditions for solving the problem of calculating reserves and their approval by State Reserves Committee/Territorial Committee for Natural Reserves significantly complicate the process of possible development of man-made deposits, primarily due to a significant increase in the cost of development of man-made deposits (when performing geological exploration work). The development process also increases the cost of making a one-time payment subject to bidding in the form of an auction. In practice, the calculation of a one-time payment is carried out under conditions of unreliable information about the forecast resources of a technogenic deposit and, accordingly, about its capacity in relation to the extraction of minerals. The criticality of making a one-time payment confirms the sensitivity of net present value to changes in its value, which is proven by the example of the Allarechen copper-nickel deposit in work [8]. The subjectivity of determining one-time payments is noted in his work [9] and E. I. Panfilov.

The second aspect is the extension of the period of commissioning of a technogenic deposit, the negative nature of which is reflected in the work of I. V. Epstein [10]. Due to the transfer of cash flows to a later date, there is a decrease in income for both the subsoil user and the state in the form of a decrease in the amount of contributions to the state budget. An extension of the period of commissioning of a technogenic deposit also occurs in the case when the subsoil use object belongs to subsoil plots of federal significance (indigenous gold reserves from 50 tons, copper reserves from 500 thousand tons, deposits are located on land plots from the defense and security lands). In these cases, the subsoil user is forced to communicate with federal structures, and not with regional ones. The terms and approval procedures are being increased due to their increasing complexity.

A big obstacle to the development of technogenic deposits is the lack of necessary technologies or their inaccessibility for a number of subsoil users due to their high cost. The lack of technologies for processing technogenic mineral raw materials or the need to improve existing ones requires R&D, although, as the authors note [11], of the known about 60 technological solutions for the use of technogenic mineral resources for production, only one third is used, and two thirds remain only potential opportunities. Large mining companies usually do not finance technological developments, since the development of technogenic deposits is not in their interests, while small and medium-sized companies do not have enough funds for this. New innovative technologies are very expensive and their use often makes the development of technogenic deposits un-

profitable. It is also necessary to take into account the fact that when developing such deposits, the use of the best available technologies (BAT) is required in accordance with the Federal Law of the Russian Federation No. 219-FZ of July 21, 2014 “On amendments to the Federal Law “On Environmental Protection” and certain legislative acts of the Russian Federation “ The law defines BAT as “a set of production processes, equipment, technical methods, techniques and means used for the production of products at facilities that have a negative impact on the environment, based on modern achievements of science and technology, with the best combination of indicators for achieving environmental protection goals and economic efficiency, subject to the technical feasibility of their use” [9].

Reasonable criteria for determining BAT include [12]:

- the lowest level of negative impact on the environment per unit of time or volume of products produced;
- economic efficiency of implementation and operation;
- application of resource- and energy-saving methods;
- implementation period;
- industrial implementation at two or more facilities that have a negative impact on the environment.

Technologies used in the development of technogenic deposits must have technological standards that do not exceed the technological standards of the best available technologies. Providing information about BAT is carried out through the development and publication of special documents - information and technical reference books, which Federal Law No. 162-FZ of June 29, 2015 “On standardization in the Russian Federation” classifies as documents in the field of standardization. The legislation provides for a number of incentive measures for enterprises implementing BAT (exemption from payments for negative impacts on the environment, subsidized loans, tax reduction, etc.).

It is important to note that in Russia there are examples of effective development of technogenic deposits using domestic technologies. In recent years, bacterial-chemical leaching of sulfide ores, which is based on the ability of certain types of microorganisms to dissolve ore minerals, has become quite widely developed. This technology makes it possible to extract a complex of valuable components not only from ores, but also from enrichment and metallurgical wastes. A positive aspect is the environmental safety of the latter, which excludes emissions of sulfur sulfides, arsenic and sulfur compounds into the atmosphere, as well as the production of sulfuric acid naturally [13–15]. Bacterial leaching is successfully used for leaching rare valuable microelements from waste rocks of coal mining, and is also a source of leaching with sulfuric acid (leaching efficiency for aluminum is 8.91 g/100 g of rock, for gallium and germanium, respectively, 2 and 1.5 mg/1 kg of rock [16, 17]. Close to bacterial leaching is chemical leaching, in which sulfide ores are treated with acid solutions under normal conditions at elevated temperature and pressure [18]. Comparison of these methods in relation to the leaching of copper and zinc from flotation enrichment waste of sulfide ores of mining and processing plants of Southern Urals showed the advantage of bacteriological leaching, which allows for deeper processing of waste at a temperature of 30°C and normal pressure.

To process apatite-baddeleyite waste in the conditions of OAO Kovdorsky MPP, magnetic flotation-gravity technology is used, which makes it possible to obtain iron ore apatite and

baddelite concentrates. To process waste from the enrichment of ferruginous quartzites of the Zaimandrovskaya group of deposits, gravitational-magnetic technology has been developed and used, providing hematite concentrate and a quartz product. To process waste from the enrichment of apatite-nepheline ores, ОАО Apatit has developed a technology based on optimizing the parameters of its preparation for enrichment and the use of new reagent modes and flotation cycle schemes for the separation of mineral complexes. With the introduction of this technology, it became possible to obtain apatite concentrate, nepheline, sphene and titanomagnetite concentrates [19].

To use pyrrhotite tailings, the Norilsk plant uses an innovative technology that involves irradiating technogenic raw materials with powerful nanosecond electromagnetic pulses (PNEMP), which makes it possible to create breakdown channels to metal inclusions, through which leaching solutions gain access to particles of gold and other precious metals. Methods have been developed for selective flocculation of fine particles followed by flotation separation of the resulting flocs or their sedimentation. The most important condition for the selective flocculation of non-ferrous metal sulfides is the use of natural hydrophobicity or that imparted to minerals using collecting reagents. There are positive examples of the use of technologies for processing technogenic mineral resources, but they are few in number. Moreover, often the results of laboratory and pilot-industrial research do not reach mass production due to extremely high costs, which ultimately results in the unprofitability of the development of technogenic deposits.

The development of technogenic deposits is also hampered by the real possibility of extending the storage life of TMFs, which leads to their transition to “stale” waste and loss of use value. During long-term storage, mineral destruction, oxidation, segregation (in tailing dumps by height), and sorption of particles of chemical compounds and flotation reagents on the surface of tailing dumps occur. Useful components are washed out from the dumps and eroded with atmospheric flows. Under the influence of weathering and hydrochemical oxidation, the dump material gradually becomes crushed and becomes difficult to remove [20, 21]. The physical and mechanical properties of rocks also change. Thus, studies have shown a deterioration in the strength characteristics of overburden rocks: with a storage period in dumps of up to 15–20 years, the crushability of crushed stone varies from 800 to 600–800, with a storage period of up to 20–25 years – from 400–600 to 200–400.

The lengthening of storage periods is facilitated by the lack of technologies for the use of technogenic deposits or the lack of funds for their acquisition, as well as numerous administrative barriers in the process of approving documents, approving reserves and placing them on the State Balance Sheet. The process of obtaining a license and the right to use a technogenic deposit can last for more than one year. S. G. Seleznev, who deals with the problem of waste management, especially emphasizes the inflationary nature of reserves of technogenic deposits and expresses concern about the prevailing opinion about the suitability of the latter for processing [21].

Given the current amount of accumulated TMFs, the geological knowledge of most of them is clearly insufficient for making investment decisions regarding the development of technogenic deposits. For large mining companies, TMFs are

not of interest due to their small volumes, so they do not engage in geological study of the latter. Small and medium-sized companies most often do not have sufficient financial resources to obtain the right to use TMFs. The state that should engage in geological research, including “stale waste” is in no hurry to join this process. According to researchers, the most appropriate way to solve the problem of insufficient knowledge of the subsoil is to finance the entire volume of geological exploration work at the expense of the state. In this case, compensation for the costs of geological exploration can be carried out through a tax deduction. Its implementation is possible by reducing the production tax or income tax. Some experts even propose to abolish the mineral extraction tax for the development of technogenic deposits. A similar approach to reducing the size of the extraction tax already takes place in the coal industry, where the deduction from the mineral extraction tax corresponds to the costs of ensuring industrial safety in mines incurred by subsoil users.

The information aspect of this activity continues to hinder the intensification of the process of development of technogenic deposits. Lack of information about existing man-made objects, lack of a unified information base containing complete information about TMFs, including “stale” waste. Some information is contained in the State Cadaster of Mineral Deposits and Occurrences, as well as in the State Cadaster of Wastes. The Deposit Cadaster does not include information about some of the mining waste from existing enterprises, and even more so about “stale” waste for which there is no examination of reserves. In turn, the waste inventory does not imply accounting for useful components contained in TMFs; it mostly contains information about TMFs from an environmental point of view. As a result, the available information is characterized by incomplete data on TMFs, which is not updated in a timely manner and does not meet modern requirements.

A certain disadvantage of the information in the Cadaster about technogenic deposits is that it is not only insufficient, but also not addressed to anyone in particular and therefore most often does not contain such characteristics as:

- full costs of accumulation (placement) of TMFs at enterprises;
- preservation of the potential value of TMFs as a secondary raw material that is not yet in demand;
- methods and results of independent verification of the accuracy of information displayed in cadasters, etc.

The content of regional waste cadasters is not the same; the number and characteristics of classification criteria differ from each other.

The process of using waste is also hampered by the high geological risk associated with the non-confirmation of reserves of technogenic deposits due to the absence of any patterns in the distribution of useful components, high subjectivity when extrapolating data and turning to analogues. As mentioned earlier, there are still no approved regulations for the study of technogenic deposits. A by-law normative act approved by the State Reserves Committee of the Russian Federation, which solves to a certain extent this problem, is illegitimate. The range of opinions even concerns the number of identified groups according to the complexity of the geological structure. The experience in developing technogenic deposits is small, which does not allow us to formulate more or less re-

Table 1. Results of the expert survey**Таблица 1. Результаты опроса экспертов**

Expert	Imperfection of the regulatory framework	Lack of technologies for processing TMFs	Extending the shelf life of TMFs	Low degree of geological knowledge of TMFs	Lack of awareness about TMFs	Lack of own funds	Lack of qualified personnel	High geological risk	Lack of benefits and preferences for using TMFs
1	10	9	6	7	6	6	4	7	8
2	10	6	8	6	4	7	5	4	9
3	10	8	6	6	6	7	4	5	9
4	10	9	6	8	4	7	7	6	8
5	9	8	7	6	6	6	4	5	10
6	10	8	6	7	4	6	5	5	9
7	9	7	8	5	6	7	6	7	10
8	9	8	6	6	5	7	7	6	10
9	10	6	7	6	6	6	4	5	9
10	10	8	6	6	5	7	4	7	9
11	9	8	7	6	5	6	5	5	10
12	10	9	6	7	4	8	7	6	8
13	10	8	6	6	5	7	4	7	9
14	9	8	6	9	4	7	4	7	10
15	10	7	6	5	5	6	5	5	9
16	10	8	6	6	5	7	5	5	9
17	9	8	6	5	4	7	6	4	10
18	10	7	8	6	3	6	4	5	9
19	9	8	7	5	4	6	6	6	10
20	10	7	6	5	5	8	5	7	9
Average	9,65	7,75	6,5	6,15	4,8	6,7	5,05	5,7	9,2

liable recommendations for the organization of geological exploration work, as a result of which relatively reliable reserves can be approved, reflected in the State Balance Sheet.

The limiting factor is the lack of funds among subsoil users for carrying out geological exploration, preparing the necessary documents, conducting examinations and approvals, making a one-time payment, etc., the lack of adequate support from the state in the form of tax benefits, interest-free loans, direct participation of the state in activities related to the management of TMFs, etc. even if a significant economic effect is obtained from the development of technogenic deposits. According to [8], support for innovative projects, which includes projects for the development of technogenic deposits, should be provided by state development institutions, since technologies associated with the extraction and processing of technogenic mineral raw materials are innovative in nature. Financial development institutions include: the Fund for Assistance to the Development of Small Enterprises in the Scientific and Technical Sphere (Bortnik Fund, Assistance Fund), the Development Fund of the Center for the Development and Commercialization of New Technologies (Skolkovo Fund), and the Industrial Development Fund. Supporting the innovation process with the help of development institutions, including improving technologies for the extraction and processing of technogenic mineral raw materials is a worldwide practice.

Table 2. Ranking of problems**Таблица 2. Ранжирование проблем**

Problem	Problem rank
Imperfection of the regulatory framework	1
No benefits or preferences for using TMFs	2
Lack of technologies for processing TMFs	3
Lack of own funds	4
Extending the shelf life of TMFs	5
Low degree of geological knowledge of TMFs	6
High geological risk	7
Lack of qualified personnel	8
Lack of awareness about TMFs	9

A certain obstacle to the development of TMFs is the lack of qualified personnel required to carry out geological exploration, draw up feasibility studies and projects for the development of technogenic deposits, and calculate reserves. Today, the prestige of the geologist's profession has come to naught due to the loss of priority importance of the geological service at the state level, with a reduction in state participation in the development of the mineral resources sector. There is no reserve of professional geologists trained to work in government bodies, the quality of training of specialists has decreased to a critical level, the intellectual

Table 3. The main benefits of the state and business in the implementation of the development of public-private partnerships in the field of waste recycling

Таблица 3. Основные выгоды государства и бизнеса в реализации развития государственно-частного партнерства в сфере переработки отходов

For the state	For business
Solving the problem of waste recycling, reducing the risk of environmental pollution	A private company receives state assets for long-term ownership and use, primarily land plots and their infrastructure support, including on preferential terms
Shifting to business the costs of investing in waste processing projects, maintaining abandoned waste disposal facilities and operating infrastructure facilities for storing and processing waste	Minimizing risks. State support in various forms. Reducing the costs of disposing of your own waste
New sources of investment in waste recycling are emerging	Opportunity to increase the sustainability of companies in the face of declining demand in the core area of private business
The likelihood of quickly achieving results increases (the private investor is focused on obtaining maximum profits in the shortest possible time)	Demonstration of social responsibility and consideration of the environmental interests of the main stakeholders represented by the state and local community
The most effective technologies and innovative approaches to integrated low-waste waste processing with the extraction of minerals are being introduced	Improving the company's image, reducing administrative impact from government authorities

potential in scientific institutions and in practice does not meet the requirements.

In order to identify priority problems that require resolution, an expert survey was carried out among 20 specialists related to the problem of waste management (employees of academic institutes of economics and mining of the Russian Academy of Sciences, employees of the State Mining University, departments of mining production and industrial ecology of mining companies, employees of the Ministry of natural resources and ecology of the Sverdlovsk region). The initial data from the expert survey are given in [table 1](#).

As a result of processing the materials of the expert survey, a ranking was made of the identified problems that hinder the process of development of technogenic deposits ([Table 2](#)).

As follows from [table 2](#), the priority problems that require a priority solution are:

- Imperfection of the regulatory framework;
- No benefits or preferences for using TMFs;
- Lack of environmentally friendly, resource-saving technologies for processing TMFs;

The identified priority problems are external to subsoil users, i. e. assume direct participation of the state in their solution. Currently, state participation in the field of waste management has not received proper development; the public-private partnership mechanism practically does not work, although the benefits from its implementation are obvious, [table 3](#) [22].

Despite the obvious benefits from the development of technogenic deposits, examples of the implementation of relevant investment projects are insignificant. We believe that, to some extent, this situation is related to the incomplete assessment of the national economic effect, i. e., the lack of interest of the state in supporting this activity.

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Проблемы, осложняющие введение в хозяйственный оборот техногенных месторождений

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Аннотация

Актуальность. В современных условиях истощения минерально-сырьевой базы, ухудшения природных условий вновь открываемых месторождений приоритетную значимость приобретает освоение техногенных минеральных ресурсов. Однако, как показывает анализ, уровень использования твердых минеральных образований продолжает оставаться незначительным.

Цель исследования – выявление причин, тормозящих процесс вовлечения техногенных месторождений в хозяйственный оборот, в целях предупреждения их возникновения или смягчения отрицательных воздействий.

Методы исследования. В процессе исследования использовались методы сравнительного анализа, аналогий, экспертного анализа.

Результаты. Анализ и обобщение отечественного и зарубежного опыта обращения с ТМО позволили выявить основные причины, препятствующие расширению практики освоения техногенных месторождений. Было выявлено девять подобных причин: несовершенство нормативно-правового обеспечения обращения с ТМО, низкая степень геологической изученности, высокий геологический риск, недостаток технологий переработки отходов, отсутствие необходимых финансовых средств, несовершенство экономического механизма, используемого государством при регулировании деятельности по обращению с отходами, возможность удлинения срока хранения ТМО, несовершенство наличия информации о ТМО, недостаток квалифицированных кадров. В результате проведения экспертного опроса 20 специалистов было выполнено ранжирование выявленных причин и установлены наиболее приоритетные. В их число вошли: несовершенство нормативно-правовой базы, недостаток требуемых экологически безопасных технологий и отсутствие эффективного экономического механизма государственного регулирования этой деятельности.

Выводы. Выявление первоочередных причин, тормозящих процесс освоения техногенных месторождений, определяет дальнейшую направленность работы по их предотвращению или смягчению отрицательных воздействий.

Ключевые слова: техногенные месторождения, проблемы, освоение, приоритетность, ранжирование проблем.

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