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Integrated Processing of Mineral Raw Materials: Factors of Readiness and Resistance of Economic Entities

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Abstract. Ensuring the integrated processing of mineral raw materials remains a relevant topic of modern research due to its socio-economic, environmental and technological significance, as well as one of the key conditions for sustainable development of Russia, defined by the Strategy for the development of mineral resource base up to 2035. At the same time, the practical realization of this concept continues to be occasional and non-systemic. Under the new conditions of sanctions restrictions, the acute need for import substitution, taking into account the regional specifics of strategic mineral resources in the Arctic zone of the Russian Federation, it is necessary to change the paradigm of development of the resource and raw materials complex of Russia from extensive to intensive one and to shift the research context towards readiness of regional economic systems to such changes. Considering the accumulated scientific background, the article attempts to consolidate and systematize the research on the topic of integrated processing of mineral resources in relation to the factors that determine readiness and cause resistance to the practical implementation of the concept on the part of economic entities as key actors in this process. The scientific novelty of the study consists in the systematization of existing positions on the issue of transition to the implementation of the concept of integrated processing of mineral resources to develop a set of indicators as a tool for assessing the readiness and resistance of the regional economic system to the paradigm shift. The research method used is a review of publications on the topic of integrated processing of mineral resources. As a result of the study, 20 factors were identified and systematized into 5 groups. The obtained classification of factors can become the basis for further research of the question posed in this article, which will allow assessing the readiness for changes at the regional level, to identify obstacles that hinder their implementation, and to determine the directions of search for solutions to eliminating or levelling of the identified resistance factors.

Keywords: *environmental management, sustainable development, mineral resource base, complex processing of mineral resources, regional economic system*

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Introduction

The problem of integrated use of mineral resources remains relevant in terms of searching for organizational and economic mechanisms for its practical implementation. The accumulation

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of mining waste, which causes environmental problems in the regions, and the increasingly complex mining and geological conditions, leading to a decrease in production volumes and an increase in costs, cause concern on the part of all economic agents of the market: state, society, and business. Modern challenges of the Russian economy, expressed in tightening sanctions, and the aggravation against this background of the problem of import substitution, including in the provision of certain types of mineral raw materials, predetermine the increasing relevance of the issue of integrated processing and the need to find solutions for its practical feasibility.

The concept of integrated processing of mineral resources was first discussed in the 1930s. Academician A.E. Fersman can rightfully be called its founder. The principle he proposed, by analogy with nature, to locate production so as to extract not individual components, but the entire geochemical spectrum of chemical elements concentrated in a given territory, became the basis for the concept of integrated use of raw materials [1, Kalinnikov V.T., Grigoriev A.V.].

Since 1960, the accumulation of industry knowledge on the rational use of mineral resources continued. This period is associated with such scientists as S.G. Strumilin, A.A. Mintz, K.G. Goffman, A.A. Arbatov, A.S. Astakhov, M.I. Agoshkov, Yu.V. Yakovets, V.S. Nemchinov. The most important theoretical developments of this time include the development of the principles of optimal planning of mining production, the concept of systemic management of the industry, the theory of efficiency of production activities, the concept of economic assessment of mineral resources [2, p. 63].

In the 1990s, in the context of the transition to a market economy and the formation of the private ownership of natural resources, researchers have focused on determining the role and place of the state in solving problems of environmental management, developing measures that stimulate the integrated development of mineral resources and the use of waste from mining and processing industries, as well as the participation of the state in solving waste disposal problems. In scientific research of this period, the mining-technological, mining-ecological, economic (ecological-economic, geological-economic) directions of environmental management were more clearly identified. The mining-technological direction, based on the principles of intensification (low waste, comprehensive use of minerals), was developed in the works of V.N. Makarov, K.N. Trubetskoy, V.N. Umanets, N.B. Nikitin, L.A. Barskiy and others [2, p. 67]. The economic direction, covering ecological-economic and geological-economic aspects of rational nature management, was developed in the context of developing methods of economic evaluation of mineral resources and deposits, searching for approaches to stimulate the integrated use of minerals, waste processing, taking into account the peculiarities of the transition period. Ecological and economic issues of rational environmental management in that period were most reflected in the works of O.F. Balatskiy, L.G. Melnik, A.F. Yakovleva, A.A. Golub, E.B. Strukova, E.A. Solovyova, N.Ya. Lobanova, Yu.A. Cherenegova, A.A. Averchenko, A.S. Gumilevskiy. Scientific studies of anthropogenic deposits as complex geological objects with significant resource potential have been developed (K.N. Trubetskoy, V.N. Umanets, A.V. Kogut, O.E. Gorlova, A.B. Makarov). In addition, the need for eco-

nomic evaluation of technogenic deposits as objects of investment activity has arisen (V.V. Chainikov, V.T. Borisovich, E.L. Goldman, etc.) [2, p. 68].

Since the early 2000s, changes in the system of state management of nature use have begun. These problems are reflected in the studies of L.Z. Bykhovskiy, E.A. Kamenev, Yu.A. Kiperman, M.A. Komarov, N.B. Karpenko, V.A Kotkin, S.G. Seleznev. Researchers note the need to systematize information about waste and technogenic deposits, their resource potential, systemic environmental and economic assessment and government accounting [2, p. 71].

The transition since 2014 to a new paradigm of state environmental regulation, based on the principles of the best available technologies and focusing on the environmental and technological side of the problem of handling mining and processing waste, has pushed its economic and property aspects to the background. At the same time, the resource potential of accumulated waste from past activities and its negative impact on the environment in the absence of institutional conditions that would stimulate the effective involvement of waste in processing was a problem area of natural resources management, which was reflected in the Strategy for the Development of the Mineral Resources Base of the Russian Federation up to 2035 (hereinafter referred to as the Strategy). The implementation of the Strategy was to ensure the consolidation of efforts of legislative and executive bodies of state power, government bodies of the constituent entities of the Russian Federation, scientific, educational and business communities (including small and medium-sized businesses) to create a favorable legal, investment and business climate, provide the necessary technological and personnel potentials. The first stage, approved by the action plan for the period 2018–2024, envisaged the improvement of the main legal and economic mechanisms contributing to the growth of the investment attractiveness of Russian subsoil resources, optimization of the areas of work at the expense of the federal budget in accordance with the provisions of the Strategy. The results of the first stage were to be the necessary program and project documents that would ensure the concentration of financial resources, technological and human resources to achieve the development indicators of the mineral resource base of the Russian Federation. At the second stage (2025–2035), it was planned to carry out the entire range of work to achieve the goals and objectives of the Strategy, taking into account its updating, which requires the development of a new action plan during 2023 [1].

As part of the implementation of the first stage of the Strategy, significant work was carried out to improve the legal framework. Thus, in 2021, Federal Law No. 123-FZ was adopted, introducing the most extensive changes to the law “On subsoil” in the last 30 years. To implement the law, 9 resolutions of the Russian Government, 2 orders of the Russian Ministry of Natural Resources and 22 joint orders of the Russian Ministry of Natural Resources and Rosnedra were approved.

[1] Rasporyazhenie Pravitel'stva RF ot 22.12.2018 N 2914-r «Ob utverzhdenii Strategii razvitiya mineral'no-syr'evoy bazy Rossiyskoy Federatsii do 2035 goda» [Order of the Government of the Russian Federation dated December 22, 2018 N 2914-r “On approval of the Strategy for the development of the mineral resource base of the Russian Federation up to 2035”]. URL: https://www.consultant.ru/law/hotdocs/56356.html?ysclid=lfr4bfx9r110726943 (accessed 01 February 2023).

The changes carried out since 2015 have given a great impetus to the development of geological exploration.

At the same time, the way approved within the framework of the strategy to achieve the goal of a sustainable supply of mineral raw materials by increasing the investment attractiveness of geological exploration at all stages, increasing the quality of forecasting and searching for new deposits, as well as increasing the efficiency of development of known, including undeveloped deposits, through the introduction of modern processing technologies, enrichment and complex extraction of mineral resources is not carried out fully and in a balanced manner. At the current moment of the Strategy implementation, the greatest emphasis is placed on extensive methods, i.e. increasing the quality of forecasting and searching for new deposits. This is evidenced by the key indicators of the Strategy, by which its effectiveness is assessed, namely the increase in reserves of the most important types of minerals and the volume of extra-budgetary investments in geological exploration, which are achieved quite successfully (Table 1).

Table 1

Indicators of implementation of the Strategy for the development of the mineral resource base of the Russian Federation up to 2035 [2]

Indicator	Unit	2015	2016	2017	2018	2019	2020	2021
Number of licenses issued on the "application" basis	un.	256	427	404	797	1244	1636	1685
Investment cost of projects for geological exploration of subsoil, carried out according to the "application" principle	bn rub.	9.1	17.8	25.5	23.3	38.8	65	83.4

At the same time, the part related to increasing the efficiency of development of known and undeveloped deposits through the introduction of modern technologies for processing, enrichment and integrated extraction of mineral resources remains the least covered. The consequences of this imbalance are the continued accumulation of mining waste, an increase in the volume of technogenic deposits, and the involvement of large areas of land in production processes (Table 2).

Table 2

Dynamics of generation, use and accumulation of production and consumption waste [3]

Indicator	2018	2019	2020
Mineral extraction			
Generation of production and consumption waste by type of activity: mining	6 850 485.40	7 257 022.10	6 367 335.60
Recycling and neutralization of production and consumption waste by type of activity: mining, thousand tons	3 585 213.50	3 561 595.40	2 970 827.40

[2] Source: compiled on the basis of the report of the Ministry of Natural Resources on the implementation of the Strategy for the Development of the Mineral Resources Base of the Russian Federation in 2021.
[3] Source: compiled on the basis of the statistical bulletin "Main indicators of environmental protection". URL: http://www.gks.ru/ (accessed 01 February 2023).

The ratio of waste generation and disposal by type of activity: mining, %	52.3%	49.1%	46.7%
Mineral processing			
Generation of production and consumption waste by type of activity: mineral processing, thousand tons	204 190.60	214 818.70	201 332.60
Recycling and neutralization of production and consumption waste by type of activity mineral processing, thousand tons	103 395.7	113 678.3	99 668.5
The ratio of waste generation and disposal by type of activity: mineral processing, %	50.6%	52.9%	49.5%

In addition, the need in the near future to revise the subsoil use policy from extensive to intensive development methods, including through the involvement of accumulated technogenic deposits in circulation, is also evidenced by data on the number of discovered deposits (Table 3) and the risk of import dependence on strategic types of mineral raw materials, the reserves of which are presented in small volumes as associated elements that can be extracted, or as low-quality deposits, which necessitates their import from abroad (Table 4). In the current conditions of tightening sanctions policy and unstable geopolitical situation, the need to resolve the issue of self-sufficiency undoubtedly increases and this will become one of the goals of forming a new action plan for the second stage of implementation of the Strategy for the period 2024–2030.

Table 3

Dynamics of the number of deposits registered with the state [4]

Indicator	2019	2020	2021
Number of deposits registered with the state, units.	59	49	37

Table 4

Strategic types of mineral raw materials with the greatest risk of import dependence [5]

Raw materials	Volume of domestic production in Russia	Volume of domestic consumption in Russia	Import volume	Importing country	Application
Uranium	2 897 t	10 300 t	7 905 t	Kazakhstan, Ukraine, Canada	Nuclear power
Titanium	439 thousand tons	365 thousand tons (titanium concentrate) 82.6 thousand tons (pigment titanium dioxide) 11 thousand tons (titanium products)	207.4 thousand tons (titanium concentrate) 59.8 thousand tons (pigment titanium dioxide)	Kazakhstan, Ukraine, Japan, China, USA, Mexico, Germany, UK	Metallurgy, Aviation
Zirconium	19.5 thousand tons	10 thousand tons (zirconium concentrate)	7.9 thousand tons (zirconium concentrate)	Ukraine, Netherlands, Indonesia, USA, Spain, Ger-	Alloys for the production of nuclear reac-

[4] Source: compiled on the basis of Rosnedra data.
[5] Source: developed on the basis of data from the state report “On the state and use of mineral resources of the Russian Federation in 2020”.

			197.6 thousand tons (high purity zirconium dioxide) 119 thousand tons (metallic zirconium)	many, Italy, China, South Africa, India, France	tors, light alloys
Rare earth elements	114.8 thousand tons	1.1 thousand tons	1.1 thousand tons	China, Estonia	Electronics, production of magnet batteries

The results obtained from the Strategy do not allow us to fully assess the effectiveness of its implementation. This conclusion is also reflected in the analytical report of the Accounts Chamber "Subsoil use" No. 5 for 2020. One of the recommended activities of the report is the involvement in the recycling of waste from mining and processing industries, the introduction of cost-effective technologies for the enrichment of low-quality mineral raw materials through the development of a targeted project in the field of geological study and rational use of subsoil.

Modern research of recent years also indicates the need to change the paradigm for the development of the resource and raw materials complex of Russia. The paradigm shift is associated with the transition from an extensive to an intensive development trajectory [3, Eder L.V., Kontorovich A.E., pp. 16–18]. At the same time, the emphasis of the research problem is increasingly shifting towards taking into account the regional component, which includes conducting a broad interregional comparison of the current state of subsoil development in the resource-producing regions of Russia for the purpose of theoretical justification and practical development of new promising project forms of interaction between business and the state, as well as the development of an active regional policy on this basis, focused on solving the problems of innovation development, import substitution and sustainable socio-economic development [4, Kontorovich A.E.].

Taking into account the fact that most promising deposits of strategic types of mineral raw materials, which have the greatest risk of import dependence, are represented in the regions of the Arctic zone of the Russian Federation (Table 5), the importance of taking into account its regional specifics, due to complex natural and climatic conditions, non-standard social economic aspects of activity and the ecological fragility of the Arctic territories, as well as the changes occurring in it [5, Zaikov K.S., Kondratov N.A., Kudryashova E.V., Lipina S.A., Chistobaev A.I., pp. 10–12] becomes even more relevant.

Table 5

Geographical distribution of existing and prospective deposits of import-dependent strategic mineral resources by regions of the Russian Federation [6]

Mineral raw materials	Regions with active deposits		Regions with prospective deposits	
	AZRF regions	*Other regions*	*AZRF regions*	*Other regions*
Uranium	The Republic of Sakha (Ya-	Transbaikal Krai, Republic of		Amur Oblast, Jewish AO,

[6] Source: developed by the author on the basis of the data from the state report "On the state and use of mineral resources of the Russian Federation in 2020".

	kutia)	Buryatia, Kurgan Oblast		Transbaikal Krai
Titanium	Murmansk Oblast, Komi Republic		Murmansk Oblast	Tomsk Oblast, Transbaikal Krai, Amur Oblast, Chelyabinsk Oblast
Zirconium	Murmansk Oblast		Komi Republic	Tomsk Oblast, Irkutsk Oblast
Rare earth elements	Murmansk Oblast		Republic of Sakha (Yakutia), Krasnoyarsk Krai, Komi Republic	

Most of the projects for the development of promising deposits in the Russian Arctic regions are included in the Strategy for the development of the Russian Arctic and ensuring national security for the period up to 2035, approved by Decree of the President of the Russian Federation of October 26, 2020 No. 645. This determines a high responsibility for ensuring the preservation of the fragile ecological balance in the territory of the Russian Arctic with an emphasis on intensive methods of mining and processing of minerals, including through the use of complex processing of mineral raw materials in existing and promising deposits.

The state of subsoil development in resource-producing regions is largely determined by the economic activity of entities engaged in the extraction and processing of mineral resources on its territory, and the corporate policy they implement regarding their production. In view of this, it becomes important to take into account their readiness to change the paradigm of their development towards the integrated processing of mineral resources, and to identify the factors causing resistance to such a transition. Forming a list of such factors and assessing the opinions of business entities regarding them is an urgent scientific task. Its solution will make it possible to clarify the implementation of the Strategies for the development of the mineral resource base of the Russian Federation and the Russian Arctic up to 2035 by taking into account the characteristics of the Arctic regional economic systems of resource regions and to develop substantive solutions to the most pressing problems that complicate the implementation of the Strategies.

Thus, the purpose of this study will be to form a list of factors of readiness and resistance of economic entities to implement complex processing of mineral raw materials and systematize them for further research on assessing the readiness for such a change in the regional economic system as a whole and developing measures that will help increase the level of its readiness and reducing resistance.

In order to achieve the set goal, it is proposed to solve the following tasks:

- review existing research on the implementation of integrated processing of mineral resources;
- identify factors that determine readiness to implement integrated processing of mineral resources, and risk factors that cause resistance and hinder such a transition;

- systematize the identified factors of readiness and resistance, presenting them as a set of indicators against which further research will be conducted to assess the readiness of the regional economic system for the transition to the concept of integrated processing of mineral raw materials.

The method of content analysis of scientific publications on the topic of integrated processing of mineral resources was chosen as the research methods. 100 publications of the last 10 years were analyzed regarding the factors, promoting and restraining the implementation of the concept of integrated processing of mineral resources (hereinafter referred to as CPMS). The factors identified in the works were systematized into subgroups and classified into opportunity factors and resistance factors.

Results and discussion

As a result of the content analysis, 20 factors were identified that researchers emphasize when considering the problem of complex processing of mineral resources. At the same time, the identified factors have both positive and negative emotional coloring: both creating opportunities and limiting the implementation of the concept of integrated processing of mineral resources.

The first and most common factor is the mineral reserves factor. It was mentioned in one way or another in all the publications reviewed and to a greater extent (67%) had a positive emotional connotation, due to Russia's significant supply of mineral resources, of both natural and technogenic nature. The conditions that created the possibility of implementing CPMS also included the deterioration of mining and geological conditions of work and the quality of deposits involved in development, as well as reduction in the volume of geological exploration work. From the point of view of a negative assessment of this factor, which hinders the implementation of CPMS, a deterioration over time in the qualitative and quantitative composition of previously formed old waste and a change in the physical and mechanical properties of rocks were indicated [2, pp. 27–28].

Along with reserves of mineral resources, publications highlight the factor of developed potential processing technologies. As a possibility, this factor is noted in 33% of publications where it is mentioned, and is characterized by the presence of a significant scientific foundation and accumulated experience in developed technologies for complex and advanced processing of mineral resources [6, Orekhova N.N., Shadrunova I.V., Zelinskaya E.V., Volkova N.A.; 7, Chanturia V.A., p. 568]. At the same time, in other cases, the technological factor has a rather negative connotation due to the lack of effective processing technologies ready for use on a large scale, and the need for further research on this issue. One of the key conditions in this direction is the need to create a unified information space for accounting for reserves of mineral resources: both natural and technogenic, in order to obtain reliable mineralogical information, which should be available to research institutes and production organizations of various departmental affiliations.

An important factor for the implementation of CPMS is the availability of the required production capacity. This includes both the availability of existing processing assets, the number of business entities that own them, and their category (small, medium, large businesses), as well as the equipment used in the processing process. The positive aspect of the publications reviewed was that Russia has significant potential for creating a complete production chain. However, interregional cooperation has not received proper distribution, and therefore, in most industries there is underutilization of production capacity. It is noted that organizing the production of CPMS is possible within one enterprise without the need to separate this activity into specialized production [8, Larichkin F.D., p. 12]. At the same time, there are limitations in terms of the adequacy of own material and technical base, expressed in the absence of R&D departments and the efficiency of existing equipment, in terms of productivity and environmental safety, as well as its wear and tear and the need for modernization [2, p. 233]. The latter requires large-scale investments from business entities in renovation, which is another factor in the implementation of the CPMS identified within the framework of the analysis [9, Litvinenko V.S., p. 62]. At the same time, investments are required not only to improve the material and technical base, but also to resolve the issue of staffing [10, Uskova T.V., Lukin E.V., Melnikov A.E., Leonidova E.G., pp. 73–74].

The success of the implementation of the CPMS, as well as the progress of the state of any branch of material production, is directly determined by the state of the personnel. The personnel factor in the reviewed publications positively characterizes the current system of personnel training in higher and secondary education for the mining industry in Russia, which has preserved the principles of traditional Russian education and a specialized form of training as the level of higher professional education. However, there is a need for its further improvement in order to bring it into line with the current needs of the business and to maintain a proactive attitude towards it. Some areas of training, such as geology and mineralogy, as well as the implementation of the concept of continuous education of mining engineers in cooperation with educational, scientific and business communities require strengthening [11; 12, Kazanin O.I., pp. 370–373; 13, Vercheba A.A., pp. 147–149].

The fifth factor in the reviewed publications was the factor of regulation by the state (legal field). To a greater extent (75%), this factor in the reviewed publications had a negative connotation, associated with the imperfection of the current regulatory framework in Russia and its insufficiency [14, p. 161]. This fact is fully reflected in the content of the first stage of the implementation of the Strategy for the development of the mineral resources complex of Russia up to 2035 as one of its key tasks. The restraining influence was also characterized by departmental disunity in terms of regulation of waste management activities (Rosprirodnadzor and Rosnedra); issues of establishing property rights; lack of a unified accounting system [15, Nevskaya M.A., Marinina O.A.; 16, Ponomarenko T.V., Nevskaya M.A., Marinina O.A., p. 2627]. The opportunity was determined by the emergence of new and updating of existing legislative regulations that strengthen the responsibility of subsoil users for the management of production waste [17, Mustafin S.K., Anisimova G.S., Trifonov A.N., Struchko K.K., p. 9], as well as the need to develop new approaches to

state management of processes working with deposits in general [18, Litvinenko V.S., Petrov E.I., Vasilevskaya D.V., Yakovenko A.V., Naumov I.A., Ratnikov M.A., p. 15].

The sixth factor — the factor of administrative barriers — became a derivative of the factor of regulation by the state. This factor was clearly considered negative. It was indicated that the activity of subsoil users on application (utilization) of wastes formed by them and their disposal becomes more complicated [2, p. 89]; access to accumulated technogenic waste is limited for organizations, including small mining businesses [2, p. 62]; there is a need to license waste management activities [19, Karpenko N.B., pp. 17–18]; the principle of "development of large deposits" applies when developing technogenic ones [2, p. 72]. The latter aspects were also singled out in separate factors — the factor of patents, licenses to carry out activities and the factor of permits to carry out a type of activity.

The marketing component of CPMS is directly related to the demand factor. In the reviewed publications, it is encountered when substantiating the relevance of CPMS in the analysis of the areas of application of extracted valuable components [20, Nikolaev A.I., Krivovichev S.V.; 21, Malyshevskiy V.A.]. As an opportunity to implement CPMS, the demand factor is conditioned by the development of areas of activity where valuable components of mineral raw materials, the content of which in the extracted ore, as a rule, is insignificant, become in demand. At the same time, their diversity becomes a deterrent, since most often the demand for them is differentiated and small in volume [22, Kryukov V.A., Yatsenko V.A., Kryukov Ya.V., pp. 82–83].

The profitability of CPMS is determined by the price factor for the valuable components being extracted. The key scientific issue in publications is the determination of the pricing methodology for CPMS, including the justification of prices for each valuable element that makes up multicomponent mineral raw materials, and various products of its complex processing at different stages of production, including recyclable mining waste [23, Dadykin V.S.; 24, Larichkin F.D., Vorobyov A.G., Glushchenko Yu.G.; 7, Chanturia V.A.]. The presence of a scientific basis for pricing methodology is a positive aspect of the highlighted factor. The restraining nature of the price factor is expressed in the correlation between the dynamics of world prices for the final products of the mineral resource complex and the traditional primary processing technologies used, which necessitates the regulation of this issue by the state, as a support measure for subsidizing costs and the corresponding export policy [22, Kryukov V .A., Yatsenko V.A., Kryukov Ya.V., p. 83].

When studying the issue of CPMS, the authors do not ignore the energy factor. The possibility of organizing CPMS is justified by the sufficient energy supply of the Russian national economy. At the same time, in a market economy, maintaining the competitiveness and profitability of companies requires a constant search for new technological solutions to increase the energy efficiency of production due to rising energy prices on the market. Russia currently has efficient energy-saving technologies for complex and deep processing of hard-to-process ores of complex material composition and technogenic mineral raw materials, which makes it possible to obtain high-quality finished products that are competitive on the world market [6; 7, p. 568].

In addition to energy, the main production costs in the processing of mineral raw materials are associated with the purchase of chemical reagents used to obtain concentrates and isolate commercial products, in view of this, the factor of the components required to organize production was the next selected factor. The positive coloring of this factor, which determines the possibility of implementing CPMS, is associated with scientific achievements in the field of creating new effective reagents [25, Petrov I.M., p. 29]. It is noted that the reagents used have a number of disadvantages due to their environmental unsafety and economic inefficiency, therefore the topic of searching and creating new reagents is still a pressing scientific problem. In addition, this factor can be classified as a factor of resistance due to the shortage of own, domestic products noted in publications and the insufficiency of the technical base for their production in Russia [26, Ryaboy V.I.].

The mechanism for leveling all factors of resistance was identified by the authors of publications as the need for support from the state. Regarding the stimulation of CPMS by the state, the issue of tax regulation of this activity is most often raised in publications. The increase in the economic efficiency of CPMS by researchers is determined by the need to eliminate the causes and conditions that contribute to the unlawful formation of the tax base and the determination of taxable objects for organizations implementing CPMS [27, Bogatkina Yu.G., Eremin N.A., Lyndin V.N.; 28, Bloshenko T.A., Dambaeva R.D.]. However, this condition acts more as a deterrent due to its impracticability in Russia. The flat scale of the current mineral extraction tax does not allow differentiation of its collection depending on the stages of development, mining and geological conditions, degree of depletion and location of the deposit, which creates unequal conditions for mining organizations. Mining with significant operating costs becomes impractical for subsoil users (a negative indicator of the economic efficiency of a field development project), and the state (the owner of the subsoil) increases the number of unprofitable deposits [2; 29, Bloshenko T.A., p. 46]

Other government support measures include preferences related to subsidizing costs, stimulating demand for a new product, and price regulation. The insufficiency of the implementation of these mechanisms in Russia, compared to other countries, for example, China, in terms of rare earth elements [30, Wübbeke Jt.; 31, Goodenough K.M., Wall F., Merriman D.; 32, Binnemans K., Jones P.T.] classifies these factors as deterrents to the implementation of the CPMS.

The development of CPMS also depends on the level of interaction between economic entities in the industry. In the publications reviewed, this condition was reflected in the factors of competition and the availability of necessary suppliers (contractors) and partners. The competition factor is considered as a constraint regarding import supplies, which fully satisfy domestic demand for valuable components that are by-products in the production of the main product in Russian factories and are often inferior in quality to imported ones [33, Novikov N.I., Salikhov N.I., pp. 143–147]. The insufficiency of business entities willing to act as suppliers, and the low degree of cooperation and interaction of companies as partners to create a single production chain, also have a negative assessment in publications where they are mentioned, which classifies these factors as factors of resistance [34, Tverdov A.A.; 35, Sinkov L.S.].

The final overview of the identified factors is presented in table 6.

Table 6

Review and systematization of articles regarding the plot and its emotional coloring (opportunity / resistance) [7]

	Factor	Number of mentions, units.	Percentage of total publications reviewed	Resistance rating (% of publications on the topic)	Opportunity rating (% of publications on the topic)
1	Mineral reserves	10	25.6%	30%	70%
2	Potential processing technology developed	10	25.6%	70%	30%
3	Availability of production capacity	8	20.5%	75%	25%
4	Staff	8	20.5%	75%	25%
5	Government regulation (state of the legal field)	7	17.9%	71%	29%
6	Administrative barriers	7	17.9%	71%	29%
7	Demand	7	17.9%	71%	29%
8	Market price	7	17.9%	71%	29%
9	Energy	6	15.4%	33%	67%
10	Components for production (additives, reagents, materials, components, etc.)	6	15.4%	67%	33%
12	Competition	4	10.3%	100%	0%
11	State preferences in terms of subsidizing costs	3	7.7%	100%	0%
13	Tax preferences	3	7.7%	100%	0%
14	Patents, licenses to carry out activities	3	7.7%	100%	0%
15	State preferences in terms of stimulating demand for a new product	3	7.7%	100%	0%
16	Investments	2	5.1%	100%	0%
17	Permission to carry out the type of activity	2	5.1%	100%	0%
19	State preferences in terms of market regulation (prices)	2	5.1%	100%	0%
18	Suppliers/contractors	1	2.6%	100%	0%
20	Partners (their presence and willingness to cooperate)	1	2.6%	100%	0%

In order to optimize further analysis and assessment of the identified factors, since the list of factors is not exhaustive, the factors were systematized according to their general characteristics into five main groups.

The first group, “Resource component”, includes such factors as the availability of mineral reserves, the availability of production facilities, the number of personnel and their qualifications, investment opportunities, the sufficiency of components for production (additives, reagents, materials, components, etc.) and energy security.

[7] Source: developed by the authors.

The second group of factors, “Technological component”, consists of the developed potential technology for processing mineral raw materials, as well as patents and licenses to carry out activities.

The third group, “Institutional environment”, is represented by factors that determine the legalization of activities, namely the availability of permits to carry out the type of activity, the level of administrative barriers and state regulation of this activity from the point of view of the state of the legal field.

Market factors are included in the fourth group “Market component” and determine the level of prices, demand and competition in the market, entrepreneurial activity in the market in the form of the presence of the necessary suppliers and contractors to be attracted to organize activities for the integrated processing of mineral resources.

The fifth group of factors is designated as “Supporting environment” and is represented by measures to support the type of activity from the state, as well as the development of partnership relationships, the willingness to cooperate of business entities for the implementation of the CPMS.

The classification of factors can become the basis for the formation of expert survey sheets, on the basis of which it is planned to conduct further research to assess the readiness and resistance of business entities to the transition to the implementation of the CPMS concept.

Conducting a study of the expert opinion of the direct actors of this type of activity — business entities and experts of the scientific community — will make it possible to determine the general trend in the development of the Strategy at the level of regions of the Russian Federation, identify problems and bottlenecks in its implementation, establish the main directions and develop targeted regulators in relation to a specific region, which will be, in turn, promising directions for further study of the issue posed in this article and can become the basis for the formation of a regional management policy that clarifies the Strategy for the development of the mineral resource base of the Russian Federation up to 2035, expressed in a new action plan for the period from 2024 to 2030.

Conclusion

Thus, an undoubted condition for the sustainable development of the Russian economy, taking into account its pronounced raw material orientation, is the need to maintain reserves at a level balanced with current consumption. The adopted Strategy for the development of the mineral resource base of the Russian Federation up to 2035 is aimed at achieving this goal; however, its implementation today requires adjustment due to the disproportionality of the measures taken and the need to strengthen them towards the integrated processing of mineral resources. Despite the long study of this problem, the integrated use of mineral raw materials and processing of mining waste is still not carried out at the proper level, which is due to many factors. Identification and systematization of these factors based on content analysis of publications devoted to the topic of integrated processing of mineral resources made it possible to identify 20 factors that were

systematized into 5 groups. Presenting them in the form of questionnaires for further research into the problem of transition to the implementation of the concept of CPMS and the application of a specific regional economic system will make it possible to identify region-specific obstacles and resistance factors that impede such changes, and to determine the directions for their leveling, which will be, in turn, promising directions for further study of the issue posed in this article, and can also become the basis for the development of regional programs for the implementation of the adopted Strategy for the development of the mineral resource base of the Russian Federation up to 2035.

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