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Governmental stimulation of the mining waste processing in the Arctic zone

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Abstract. The article covers the problem of processing the mining (industrial) waste accumulating in the regions where solid minerals are mined. This problem is particularly relevant on the onshore territory of the Russian Arctic, specifically, on the Kola Peninsula, where the total weight of industrial waste has exceeded eight billion tons. Mining wastes are considered from two perspectives: as a resource increasing due to deterioration of the grades at primary deposits and as a source of environmental hazards threatening the natural ecosystems of the Russian Arctic. The study demonstrates that efficient mineral waste processing may only be ensured through an integrated approach to establishing incentive policies regarding the use of industrial raw materials to be subject to state regulation. This problem may not be solved solely through environmental legislation. The article specifies the major prerequisites for the success of industrial waste processing business projects, including the possibility of improving the technologies applied and the availability of a state support system for the development and implementation of the best available technologies for import substitution purposes. It is proposed to organize public-private partnership - based technology testing sites for the development and pilot testing of efficient processing circuits for low-margin industrial raw materials

1. Introduction

The traditional mining areas of the Russian Arctic hold significant reserves of ore minerals that have been mined for a couple of decades. Areas adjacent to the fields being developed or mined-out deposits, as well as to the respective raw materials processing sites, are covered by huge masses of mining wastes of technogenic origin that have accumulated and still continue to grow. Mining operations produce the major amount of waste in the form of overburden and host rock dumps, substandard ores, and tailings of processing plants.

The resource potential of the mining (industrial) waste accumulated in the northern territories is very high, but its current use can hardly be referred to as sustainable. In the process of technological conversion, valuable associated components, such as rare and rare-earth metals, are completely discarded as waste [1]. The reserves of major mineral resources of the developed deposits are depleting, with the percentage of useful components becoming comparable to that of the “old” waste. In addition, the deterioration of the grades and quantity of ore in newly discovered deposits, the lack of infrastructure and the deterioration of mining conditions make the development projects for such deposits less profitable and aggravate the processing of industrial waste.



Equally important is the environmental factor [2]. With inadequate storage, the value of the mining waste as a mineral resource decreases. Severe Arctic conditions turn the waste into an actual threat to the natural ecosystems of the North [3].

Experts ambiguously treat the issue of sustainable solution for accumulation of industrial “waste-resources”, dual in their nature, especially for the northern regions. It is understood that if the state – owner of subsoil resources, regards the industrial waste storages as problematic areas of subsoil resources, then a coherent and consistent policy must be formulated, aimed at resolving the problematic aspects associated with such areas, and appropriate economic instruments for implementing this policy must be provided.

2. Analytics

The problem of efficient processing of current and previously accumulated waste is relevant for all mining companies in the country. It is discussed from time to time at various levels, but no solution has been found yet. The relevance of this problem is increasing following the enactment in 2016 of the new regulation for waste disposal fees based on respective hazard classes and fees for negative environmental as stated in Article 16 of Federal Law No. 7-FZ On Environmental Protection. According to Law No. 7-FZ, the negative environmental fee is charged from subsoil user if the instrumental measurements indicate that the production and consumption waste placed by the user produce a negative impact on the environment. The negative impact is measured as the excess over the environmental standards established in the form of MPC or, if none, background values of physical, chemical or biological indicators of the state of environmental components in the area adjacent to the waste storage facilities.

Law No. 7-FZ provides for a system of differentiated economic incentives to reduce the amount of industrial waste. These include promotion of measures to reduce negative environmental impact and implementation of the best available technologies (BAT) through the introduction of reducing and multiplying factors to the payment base, with effect from January 1, 2020. The logic behind the new payment system for waste disposal and negative environmental impact is to make the subsoil users to organize safe storage of their waste, to ensure maximum utilization of the waste generated, or to minimize the generation of waste by applying the best available technologies (BAT).

However, in our opinion, it is impossible to reverse the negative trend in the accumulation of mining waste while relying on environmental legislation alone. An interdepartmental approach is needed that would enhance the investment attractiveness of projects for the processing of industrial raw materials in terms of all aspects motivating the subsoil users and external investors, with the technology applied being the key factor. The latter is prompted by the specific features and scale of the problem [4].

According to the Federal Service for Supervision of Natural Resources, since 2013, five billion tons of production and consumption waste is generated annually in Russia, of which mining waste accounts for approximately 90%. Mining waste includes over three billion tons of rock dumps, more than 0.5 billion tons of tailings, about 60 million tons of metal slags, over 50 million tons of slags and sludge from thermal power plants, etc. In Russia, less than a third of the total waste generated is recycled, whereas the global value reaches 85–90%.

Over the past 30 years, the grade of base metals in ores has decreased by 30–50%. Over the last 7–10 years, the average copper grade in the reserves developed decreased from 0.86–1.74 (g/t) to 0.31–1.67 (g/t); the nickel grade dropped from 0.56–0.85 g/t to 0.35–0.78 g/t; the lead grades reduced from 0.6–7.68 g/t to 0.6–6.55 g/t [4]; and this trend will continue. Therefore, extraction of the same amount of useful components now requires mining more and more ore from the subsoil, the bulk of which turns into industrial waste. For example, in the production of cast iron, 95–97% of the rock mass is dumped, with the value reaching 99.5% in copper production.

According to the official data of the Federal Service for the Oversight of Consumer Protection and Welfare, in 2017, 32.5 million tons of production and consumption waste were generated in the territory of the Arctic zone of the Russian Federation, of which 58% or 18.7 million tons were

recycled. At the same time, the total amount of waste dumped amounted to about 27.6 million tons, not including the unrecorded waste and the mining and processing technogenic formations with unclear ownership remaining from previous years [6].

Table 1 shows the general dynamics for the formation and use of mining and processing waste as types of economic activities in Russia.

Activity type	2010	2013	2014	2015	2016
Generation of production and consumption wastes					
Total,	3734.7	5152.8	5168.3	5060.2	5441.3
including:					
- Mining production	3334.6	4701.2	4807.3	4653.0	4723.8
- Processing industries	280.1	253.7	243.1	282.9	549.3
Use and neutralization of production and consumption waste					
Total,	1738.1	2043.6	2357.2	2685.1	3243.7
including:					
- Mining production	1562.2	1753.1	2165.7	2473.3	2885.6
- Processing industries	124.4	132.3	119.3	134.0	243.4
Unused mining waste					
Mining production	1996.6	3109.2	2811.1	2375.1	2197.6

Table 1. Formation and use of mining and processing waste 2010–2016, million tons (*Compiled according to the State Report “On the Condition of Environment and Environmental Protection in the Russian Federation in 2016”*)

The table shows that, over the five years of the analysis (from 2010 to 2016), 24.6 billion tons of waste were generated in Russia, of which 12.1 billion tons were used and neutralized and 12.5 billion tons were unused mining waste (i.e. more than a half). However, the published data does not clearly indicate how, for example, the secondary waste of technogenic raw materials processing was taken into account. It is not indicated which part of unused waste was disposed of in compliance with all safe storage regulations, and which part was not disposed in compliance with them. The latter aspects are important because:

- valuable components contained in mining wastes, when not properly stored, may be subject to erosion, oxidation, scattering, etc., whereby the reserves contained in such wastes lose their commercial value over time;

- negative environmental impact of mining waste occur through the deformation of the landscape, hydrochemical effects on watercourses, chemical effects of the liquid phase of tailing dams on the soil and groundwater, as well as through aerosols transfer to dispersion areolas. In addition, we should not overlook the environmental concerns of the northern countries bordering Russia [7]

Upon accumulation of large amounts of unsafely disposed industrial wastes, cost-focused mining companies will inevitably look for workarounds for the problem. Their range can be quite extensive: from distortion of monitoring results for waste disposal facilities (dumps, tailing dams, etc.) submitted to state environmental supervision authorities to lobbying of the necessary by-laws. This is facilitated by the fact that measurements for environmental reports are made by subsoil users independently, and decisions on excluding the negative environmental impact of waste storage facilities are made on the

basis of the data submitted by subsoil users in respective notifications, without any follow-up inspections.

It should be noted that the mechanism of incentive payments for the disposal of production and consumption waste does not apply to the undistributed fund of mineral resources and unrecorded technogenic formations.

According to the National Atlas of the Arctic, the Murmansk Region is one of the two regions that have been experiencing the greatest total anthropogenic load in recent years. Over ten mining and metallurgical enterprises are operating in the region, providing for major revenues for the budget. The largest of them are JSC Apatit and JSC SZFK, which develop the apatite-nepheline deposits of the Khibiny group; Kola MMC producing non-ferrous metals from the nickel-sulfide ores it mines; JSC Kovdorsky GOK mining and producing apatite, baddeleyite and iron ore concentrates; JSC Olkon, the northernmost producer of iron ore in Russia; and LLC Lovozero GOK extracting and processing loparite ores into rare-earth concentrate. Each mining company generates, partially uses and continuously accumulates industrial waste.

Out of the total amount of technogenic raw materials accumulated in the Kola Region, totaling over eight billion tons, 72.4% are waste rocks of overburden and preparatory work, 2.4% are off-balance and substandard mined ores, about 24% are processing tailings, and 1.2% are slags and ash. The annual utilization of all waste amounts to 3% to 4% [8].

Specialists of the Mining Institute of the KSC of the Russian Academy of Sciences conduct long-term observations over 40 technogenic formations in the region, which may be regarded as technogenic deposits in terms of their resource potential. According to their estimates, the three tailing dumps of JSC Apatit, JSC Kovdorsky GOK and JSC Olkon, which are technogenic deposits, hold 130 million tons of commercial concentrates in reserves. Integrated development of the ANOF-2 technogenic deposit (JSC Apatit) might render the potential revenue from the sale of all concentrates of over 2.62 trillion rubles [9].

The main prerequisites for the success of business projects on industrial waste processing, including establishment of high-tech facilities to extract associated components, are:

- acceptable cost of commodity products complying with the quality standards, levels of market prices and demand, availability and favorable dynamics of the sales market;
- the ability to continuously improve the processing technology for technogenic raw materials, availability of supporting partnerships with specialized research and development teams and service companies;
- availability of innovative competencies in the management of mining enterprise – initiator of such business projects and organizer of the network clusters for their implementation [10];
- availability of a state support system in the form of special mechanisms and preferential regimes for project financing to enable the development and implementation of BAT in the context of technology-oriented import substitution.

3. Analytics

The intradepartmental mechanism implemented through the new environmental regulations for accumulated and continuing to accumulate mining and processing wastes may only have a limited effect. The economic incentives being introduced do not turn attention of mining companies to the main reason behind the inefficiency of industrial waste processing, i. e. the lack of high-tech facilities. The “accessibility” of BAT may not be ensured by mere borrowing of “foreign” technologies, since the compositions of mineral raw materials and the processing circuits are case-specific and require individual scientific, technical and process solutions and comprehensive governmental support for their development.

Environmental incentives must be complemented through the consistent governmental support for the creation of effective processing systems for technogenic raw materials, to be implemented through private-public partnerships. It is advisable to organize special process testing sites at the main mineral resource centers for the implementation of pilot projects for the development and introduction of high-

level BAT. After their pilot application in technogenic waste processing, these technologies may be consistently used for the complex processing of multicomponent ores of primary deposits, creating prerequisites for the transition of the mining industry to a new technological level.

In the Arctic zone, a testing site for the development of cost-effective technologies for processing low-margin technogenic raw materials may be created in the Murmansk Region, with the involvement of scientists from the Kola Science Center of the Russian Academy of Sciences, who have the relevant expertise.

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