

# Criteria for sustainable development in mining industry

*Margarita Ignatyeva, Oleg Kosolapov, Vera Yurak, and Andrey Ivanov*

Ural State Mining University, 620144 Ekaterinburg, Russia

**Abstract.** The article considers the problem of improving the transition to sustainable development in the conditions of the economy with environmental priorities. The study's aim is to substantiate the criteria for sustainable development in the development of resources that are consistent with the criteria stipulated by the concept of sustainable development and reflect the specific features of production activities within the framework of life cycle stages of a mining enterprise. The necessity of changing the existing vector of development is confirmed, which presumes the preservation of natural capital as far as possible while meeting the vital needs of the population. The paper offers the list of criteria for the development of subsoil resources, interrelated with the pre-production and production phases of the life cycle. At the pre-production stage, an assessment of the coordination criterion of the predicted technogenic load and assimilation capacity of the territory is required. At the stages of the production phase, it is necessary to slow down the depletion of mineral resources due to the completeness of mining reserves while increasing the reliability of geological information, improving the rationing of losses and dilution, as well as the socio-economic approach to the justification of operational conditions. The criterion regarding minimizing waste generation and maximizing their use in the context of a circular economy also requires compliance; the third criterion demands the timeliness and completeness of disturbed lands' restoration.

## 1 Introduction

The entire history of human development testifies to the constant interaction of man with nature, which has the character of impact - "violation or destruction of the natural forces of the territory, i.e. the biosphere" [1, p. 13-14]. If at first these impacts were quite weak, allowing ecosystems to regenerate themselves, then in the XX century, as a result of the rapid increase in the consumption of natural resources and the destruction of natural ecosystems, humanity went beyond the ecological capacity of the biosphere, which led to the development of a global environmental crisis. Awareness of environmental problems can be dated to the second half of the XX century. (The Stockholm Conference, 1972). For the first time, there was a consolidation of the link between economic and social development and environmental problems, which was reflected in the materials of subsequent conferences on population (1974), on the use of water resources (1977), on new and renewable energy sources (1977), and others. In 1983, the International Commission on

Environment and Development was established, which prepared the report "Our common future". The report formulated the main provisions of the concept of sustainable development, which involved changing the existing vector of development. In the report, sustainable development was defined as continuously supported development, "development that meets the needs of the present, but does not compromise the ability of future generations to meet their own needs" [2, p. 50], i.e. the sustainable development involved the preservation of natural capital [3]. Even more precise is the definition of sustainable development, formulated in the "Second strategy for preserving the world" [4], where it was defined as "continuously supported development, it is the improvement of the quality of life of people living within the carrying capacity of supporting ecosystems". We should not forget that this term originates from environmental practice. In the late 60s, it was used in Canada to determine the maximum catch of fish over a decade, which ensures the full recovery of the seized part of the fish resources by the time of the next seizure. In the mid-70s, this concept was transformed into the definition of the optimal use of resources, provided that the population is preserved (restored). In the 80s, the term in question was widely developed and began to be used in addition to ecology, economics, sociology, geography, etc. From the above it follows that a key issue of the sustainable development concept is to balance environmental and economic subsystems of the social-ecological-economic system of any scale (global, national, regional, local). So, the impact on the biosphere associated with socio-economic development should not undermine its foundations, because "people without the biosphere or with poorly functioning biosphere will not be able to exist on the Earth [5]. Biota controls the environment and, in the fight against it, man will never emerge victorious. Balance refers to the proportionality of economic development with the requirement to preserve the "health" of ecosystems. This is reflected in the criteria for sustainable development (table 1). According to the definitions given in the table, the requirements for preserving the amount of renewable natural resources are generally recognized. The requirements are slowing down the use of non-renewable resources, minimizing waste production and proportionality of their mass with the assimilative capacity of the environment. Their full use is also relevant to any type of natural resource use, including subsurface use. At the same time, the priority of the criteria determines the specifics of the life cycle's stages of the mining enterprise, which are part of the pre-production, production and post-production phases.

**Table 1.** Criteria for sustainable development.

Authors	Criterion 1	Criterion 2	Criterion 3	Criterion 4
1	2	3	4	5
Bobylev S.N. Environmental economics M. INFRA-M, 2014 – 400 p. [6]	The amount of renewable, natural resources or the ability to produce biomass should at least not decrease over time, i.e. provide a simple reproduction regime	Maximum possibility of slowing the depletion rate of reserves, with prospect to replacing them in the future with other unlimited types of resources	Possibility to minimize the amount of waste based on low- waste resource- saving technologies	Future environmental pollution should not exceed its current level. It should be possible to minimize pollution to a socially and economically acceptable level

Continuation of **Table 1**. Criteria for sustainable development.

Galperin M.V. Ecological bases of environmental management - Moscow: P.H. "Forum", INFRA- M. 2012 - 256 p. [7]	The recovery rate of renewable resources should not be lower than the rate of their consumption	Consumption of non- renewable resources should not exceed the speed of their replacement		The intensity of pollutants' emissions should not exceed the rate of their decomposition or assimilation by the natural environment
Glazyrina I.P. Natural capital in the transition economy M.: NIA. Priroda, Russian Ecological Federal Information Agency. 2001 – 204 p. [8]	The volume of withdrawn renewable natural resources should not exceed the volume of their reproduction	The use of non- renewable natural resources should be consistent with the use of renewable substitutes included in economic practice	Waste production should not exceed the assimilative capacity of the environment to absorb them (the ecological capacity of the territory)	
Karimova D.B. Sustainable development: new challenges for the development of environmental law in the countries of the Customs Union // Ecological Bulletin of Russia. 2013 No. 11 - Pp. 36-43 [9]	Renewable resources should not be used faster than they are restored	Non- renewable resources should be used no faster than they can be replaced with renewable resources	Emissions and wastes should not enter the environment faster than they can be assimilated	

**2 Materials and methods**

The methodological basis of the research are general scientific methods, such as historical, dialectical, logical, methods of analysis, synthesis, analogy, comparison, grouping. Herewith, systematic and evolutionary approaches have been applied. The information base consists of statistical data and reference materials of the Federal State Statistics Service, Ministry of Natural Resources and Ecology of the Russian Federation and subjects of the Russian Federation, legal acts of international law, as well as the research results by Russian and foreign scientists.

**3 Results and discussion**

The life cycle of a mining enterprise includes the stage of design and construction that form the pre-production phase, the stage of initial development of the projected production capacity. It is the stage of stable production and the stage of reserves' completion that are

included in the production phase. It is advisable to highlight the post-production phase, which takes place after the reserves' development, considering long-term consequences of anthropogenic activities.

Mining enterprises have an impact on all elements of the biosphere. Due to the individual characteristics of the natural conditions of the deposit, the content of possible consequences is not predictable, which indicates a high environmental risk inherent in the process of subsurface resources development. Therefore, at the design stage, the timeliness of an environmental impact assessment (EIA) is of particular relevance when developing feasibility studies and implementing the variance requirement. The EIA's aim is to select the option of developing a deposit that has the least environmental impact, i.e. to fulfill the condition to coordinate the technogenic load with assimilative capacity of the territory. The selection of the most significant impacts involving mandatory assessment of consequences and determination of the economic damage are also of great importance [10, 11, 12]. Recently, there has been a growing focus on setting up an ecodiagnosics of the territory [13], the results of which should be taken into account when predicting the consequences.

For the stages of the production phase, the important criteria are the following:

- slowing the depletion rate of mineral resources;
- minimization of waste generation;
- timely restoration (reclamation) of disturbed lands.

Slowing down the depletion rate of mineral resources requires, first of all, the full use of balance reserves, reducing losses associated with both production processes (mining, transportation) and the degree of reliability of geological information, the level of which is determined by the convergence of exploration and exploitation data. Currently, there is a classification of reserves, introduced in 1997, which provides for the allocation of four categories of reserves, such as A1 B1 C1 C2 , and three categories of resources - P1 P2 и P2. The more reserves of categories A, B, and C1, the higher the confidence of the reserves.

When assessing the availability of reserves, Russian case studies show that resources P1 and P2 are also taken into account. Therefore, overestimation of the actual reserves' volume can lead to the adoption of unsubstantiated technical decisions, accompanied by losses of mineral raw materials. Mandatory accounting of reserves reduction factors is required to increase the reliability of geological information about the value of the deposit.

In order to eliminate possible losses, the number of license conditions includes an indicator that determines the minimum amount of exploration work. With low exploration of reserves, at the stage of deposit development, mining exploration and obligatory advanced geological exploration (OAGE) should be done. The Federal law "On subsurface resources" also defines the need for the OAGE. Ignoring this requirement often leads 1) to abnormal losses due to the lack of reliable data that serve as the basis for planning mining operations, 2) to write-off of balance reserves, as well as 3) to the decrease in production safety [14], which is accompanied by an increase in accidents and collapses.

An important role in slowing down the depletion rate of non-renewable resources is played by improving of rationing of losses and dilution by preparing methodological support that meets modern conditions and tightening control over their observance. As well as by using new technologies that take into account the steady trend of increasing small mineral deposits from the number discovered in the exploration work process, and reducing the content of useful components.

At the stage of deposits' completion, the issue of reducing losses is directly linked to the exclusion of selective mining of reserves. The deterioration of natural characteristics and the corresponding increase in the cost of production pushes subsoil users to review and tighten conditions. It is important to move to social-economic justifications that take into account the interests of the population on whose territory the exploited deposit is located [15]. The role of state support for subsoil users is also important in these difficult

conditions. The developed countries' experience shows that it is advisable to create special funds (future generations fund, inheritance fund, etc.) for providing a support, which is created by deducting from the profits of enterprises for the entire period of their operation.

An important criteria for assessing the level of sustainable development of mining enterprises is the production intensity of waste: the creation of a mass of waste and their use. It is well known that mining is accompanied by the placement of a huge amount of waste on the surface. On the one hand, it can serve as an additional source of raw materials for the development of man-made deposits. On the other hand, it is a source of environmental pollution, deterioration of the environmental conditions of the territory [16]. Current transition to a circular economy demands to control the use of waste, in order to minimize waste formation by using low-waste and resource-saving technologies. Such issues as ownership of waste, economic incentives for waste processing, and mining clusters' creation, etc., also come into view. Feasibility studies of the man-made deposits' development indicate an undoubted priority of their use in comparison with the development of new sites, given the remoteness of the latter and the deteriorated climatic conditions [17].

An equally important requirement for sustainable development is the restoration of the ecological balance by rehabilitation (recultivation) of the lands disturbed by mining operations. In the most cases, there is an open-pit mining of mineral deposits. The requirement to have a restoration project is mandatory when obtaining a license for the right to use mineral resources. From the analysis of disturbed and restored lands, it follows that the lowest share of restoration distinguishes the regions that belong to the number of mineral resource centers: Ural, Siberian, and Far East [18]. Although, they are characterized by the largest volume of waste generation. Thus, in the Khanty-Manses Autonomous District only 3.6% of disturbed lands were reclaimed, in the Yamal-Nenets Autonomous District – 3.7%, and so on. Intensification of the restoration process requires improvement of the organizational and economic regulation mechanisms. Due to the imperfect regulation of land restoration, there are manipulation in the volume of restored lands, and poor-quality of restoration treatment. There are certain problems related to financing too. Problems of landscape optimization are not actively solving [19].

It is necessary to improve the feasibility study for choosing the reclamation way, as well as to expand the list of environmental measures that precede reclamation, and to accelerate the guidelines' development on the economic efficiency evaluation of mining engineering recultivation of the lithospheric solid mass. It is necessary to tighten control over the implementation of the biological stage of reclamation (recultivation) and transfer of restored lands, as well as to economic responsibility for non-compliance with the volume of recultivated lands.

## **4 Conclusions**

1. Sustainable development of natural resources management, including subsurface use, requires the implementation of criteria for the conservation of natural capital.
2. Criteria for sustainable development have different priorities at the life cycle stages of a mining enterprise, due to the production specifics on each of them.
3. Pre-production phase involves the criteria of coherence of technological load with carrying capacity of the territory, which requires a forecast of possible impacts in the form of EIA.
4. The production phase provides, firstly, the criteria for slowing the depletion of mineral resources due to the completeness of reserves development because of the increase in reliability of geological information and the improvement in the normalization process of

losses and dilution. Secondly, the minimization of waste generation and maximization of waste use, which corresponds to the concept of a circular economy.

5. The stage of deposit completion involves the criteria for sustainable development linked to the social-economic justification of operational conditions and the restoration of renewable resources as a result of reclamation (recultivation) treatment.

6. The formulated criteria, which interlinked with the stage of the life cycle, contribute to making the most informed decisions in terms of ensuring sustainable development of subsurface use.

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