Ecological safety monitoring of the territory of mining allotment at the stage of mines preservation

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Abstract
In the article, the scientific-methodological bases of formation of monitoring system of ecological safety in the territory of mining production are presented. The researches results in the field of environmental conditions complex forecasts development with use of modeling methods of potentially-enable situations are shown

Transition to market economy required change of Russian economy control system, and it set a complex of fundamentally new tasks, with which it did not deal earlier, to the production departments. With introduction of new underground mines, many operating enterprises, which stocks are being finished or their processing becomes unprofitable, are subject to closure. Problems of mine abandonment arise because of the increasing requirements for industrial and ecological safety; they limit the negative technogenic impact on the environment of the mining region population. Search of solutions of the disturbed lands restoration is required including tailings dams and waste dumps, which pose urgent threat to environment ecology because of possible pollution of the air environment, and also surface and ground waters. It is reasonably to notice here that about 100 billion tons of solid waste are stored in dumps, storages of slimes and tails of mining and metallurgical complexes of Russia, and about 15 million tons are added to them annually. The average values of waste formation at a stage of mining and processing are given in the Table 1 [1].

Table 1. Average values of waste formation

Useful product (1 ton)	Waste	
	in the course of mining	in the course of benefication
Steel	5-6 tons	0.5-0.7 tons
Non-ferrous metals	100-150 tons	30-60 tons
Rare precious and radioactive metals	5-10 thousand tons	10-100 thousand tons

Such technogenic objects of pollution cause the necessity of continuous control and perspective prediction of state of the enterprises and environment within mining allotment.

The information analysis of various regions of Russia, presented in special literature and research reports, allowed allocating of typical natural and technogenic factors, which generally determine character and scale of ecological consequences of mines closure [2, 3]. They include the following:

- features of geological structure of rocks massif (RM);
- hydrogeological, hydrogeochemical and gas-geological conditions;
- applied technology of ores production;
- parameters of surface and underground production constructions;
- technology of mines abandonment.

Particularly, when open area flooding, the role of the listed factors is presented in the impact on the following processes:

- intensity of underground and surface water movement;
- salt content, chemical and gas composition, bacteriological condition of surface water;
- formation dynamics of flows and ways of motion of mixed gas;
- nature of engineering-geological processes in and on surface of rocks massif.

The methodology of ecological processes control on mining allotment of the liquidated mines was developed with use of the fundamental theory of physical and mechanical, geological and hydrogeological processes in flooded area of RM [4]. On the basis of theoretical aspects and geological-surveying documentation of the region under investigation, the practical impact of the massif objects on the growth of negative ecological consequences is evaluated and the leading factors of process are revealed. The obtained information represents science-based expe- rimental and theoretical foundation for development of method, technologies and instruments of measuring.

Within mining allotment, RM contains dozens of productive layers (ore bodies) and rocky layers of various physical and mechanical characteristics; this determines their behavior when fields developing and flooding of the open area. As a result of additive effect

of natural and technogenic factors, physical and mechanical properties of rocks in the massif (hardness, openness, rock jointing, etc.) are significantly changed; this leads to emergence of new behavior aspects from the standpoint of impact on environment. For example, during long-term development of fields, the formation of mine opening internetwork is possible. As a result of mines abandonment, the uniform technogenic level of volume of several million cubic meters can be formed. During mines operation, mine and recycling waters of ore-processing plant, and also drainage waters of tailings ponds from a retention basin are dumped in the underground and surface network. Annual dumping of insufficiently purified mine waters reaches the value of 5 million m^3 [5]. The water filling the open area is characterized by occurrence of heavy metals, oil products and other harmful substances, which concentration exceeds considerably the standard indicators for general-use waters. The soil surface is flooded and surface hydraulic network is polluted under the influence of technogenic change of the underground hydrosphere mode.

Uncontrollable processes of RM flooding during mines abandonment can actuate global negative events: pollution of water supply sources of the region population by toxic waters, bogging of agricultural lands, deformation of a soil surface.

Thus, it is necessary to carry out the full-scale monitoring observations over dynamics of the abandoned mines flooding for ensuring of ecological safety of the population and environment in the territory of mining allotments. As a rule, it is necessary to measure the pH level, concentration of oxygen, general phosphorus, general nitrogen, ammonia nitrogen, chlorine, iron, chrome, nickel and zinc within the framework of control.

The normal activity of the mine staff members within mining allotment and the region population can be provided effectively on the basis of spatial-temporal (discrete-continuous) monitoring of environment conditions; it represents state-of-the-art tools of information receiving, processing and interpretation. The monitoring system must be based on application of mine geophysics methodology, which gave a good account of itself when ecological forecasting [6]. When building of organizational and technical systems of constructions of this kind, it is necessary to consider fundamental principles of the integrated system analysis: principle of structural properties, rule of hierarchy and plurality of system description.

The eco-economic calculations method (EECM) can be used for the analysis of ecological safety assurance program, which is developed on the basis of the received information. The following calculations can be conducted with practically satisfactory accuracy with the use of EECM:

- to carry out complex environmental assessment of engineering designs of mines development;
- to prepare long term scenarios of the territory development;
- to solve a problem of optimum control of mining plants abandonment considering ecological system condition and environmental protection.

The EECM unit must include the following elements: set of models and programs, data base; techniques of models identification and computational experiments. The natural and economic model is the basic model of system of the upper hierarchical level. It is designed to the integrated system analysis of the line of territory development considering influence of consequences of unpromising mines abandonment. Models of the second level are of the structure similar to the first one but describe separate environment indicators in more detail. In system of eco-economic calculations, the forecasting problems are solved; this problems are the following: regulation of technogenic impact, optimization, research of attainability set of dynamic systems.

Functionality of EECM is determined by the structure of object models and methods used for the tasks solution. The computational experiment, which includes a set of actions of building and numerical analysis of object model for decision-making, forms the basis of decision-making techniques with use of eco-economic calculations system. Important feature of EECM implementation lies in the fact that from common positions it is considered as the complex objects modeling system applied at the corresponding adjustment for the analysis of eco-economic systems. Within this approach, two system units are emphasized: functional part and equipment of automation and methodical support. The functional part includes the block of models and specific numerical methods used for the practical tasks solution. The model bank is the EECM important component. It includes the following systems: models of the rocks massif objects, air environment and hydrosphere; models of various geomechanics, hydrogeological and other technogenic processes; models of measurement processes and control actions; reference interpretation models of "normal" conditions of natural objects.

In order to achieve the high reliability of forecasts, it is necessary to follow the basic rules, which determine the process of building of above-mentioned models:

- compromise between the necessary accuracy of modeling results and model complexity;
- selection of sufficient error;
- optimum variety of model elements;
- model demonstrativeness for the researcher;
- block representation of model;
- model specialization (reasonability of use of rather small conditional sub-models dealing with the analysis of object, system or process).

On the basis of the simultaneous analysis of reference models and factual material, the spatial-temporal characteristics of process of environment pollution are controlled, and also long-term forecasting of situation development is made. Thus, the approach specification from the standpoint of decision-making on determination of the purpose combining the designed monitoring system is implemented. It is necessary to give an update that the problem of the suggested IESS of a high technological level lies not only in fixation of the current characteristics of the region ecosystem condition and forecasting of development dynamics of ecological processes, but also in development of the corrective actions in case of divergence of parameters of real conditions from the planned indicators [6].

The set of the methods, techniques and procedures, which allow obtaining of the forecasts focused on a certain objective function of forecasting object development in case of acceptable information volume, is predetermined in such systems. Design of the system solving a complex problem of synthesis of a set of alternatives, comparison and selection of development of forecasting object must be based on the following principles implementation: complementary dependency and hierarchy of forecasts of various levels of hierarchy of forecasting object, environment, coherence of normative and exploratory forecasts as new information becomes available [7].

Implementation of the optimization scheme of the forecast object conditions is an important feature of monitoring system functioning. The first stage is the analysis of alternatives, their evaluation on creation costs, formation of preference criteria and selection of set of preferable alternatives. The second stage consists in optimization of parameters and includes procedures of alternatives evaluation on expenses in case of variation of parameters within ranges, formation of optimality criteria and selection of optimum alternative by forecasting variant of object conditions. As a result, the reliable spatial-temporal forecast is made on the basis of reference models by means of combined interpretation of experimental data. The flow chart of the suggested monitoring system is shown in Fig. 1.

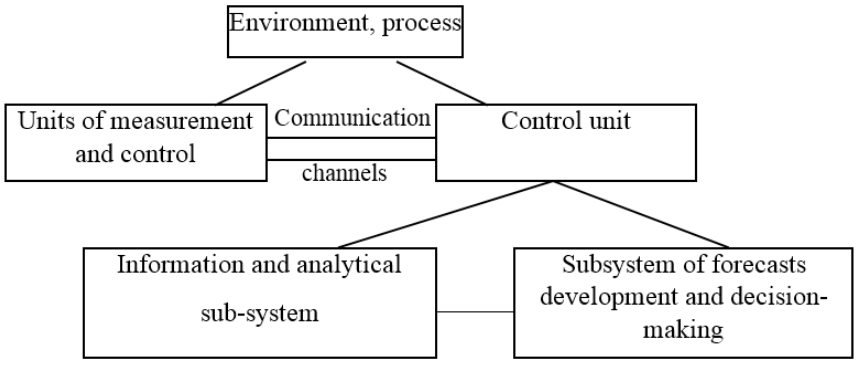

Figure 1. Approximate structure of ecological monitoring system

Conclusions

The experimental researches performed in the abandoned Russian Donbass mines, which are operated under mining and geological conditions almost similar to conditions of mines RM, have confirmed the efficiency of suggested monitoring system. When planning of actions for the prevention of negative consequences of coal mines abandonment for environment on the basis of reliable forecasts, the economic efficiency from introduction of monitoring system was 0.5 – 1.5 million rubles per mining allotment of the abandoned mine.

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Recycling of technogenic resources by microbial bio-conversion

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