Toolkit for Assessing and Forecasting the Level of Mineral Resources in the Context of Rational Subsoil Use

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Abstract. In modern economic conditions, regions need to find new drivers of investment growth in order to maintain sustainable development. In this regard, the problem of information security of the subsoil use management at the federal, regional and municipal levels is of particular relevance. It should be noted that in recent years a large number of problems has accumulated in the field of management of mineral resources potential, as one of the most important elements of national economic security. One of the most acute problems in this area is almost complete lack of tools for assessing and forecasting the level of mineral resources potential in the context of rational subsoil use, especially in terms of information on the subsoil use of common minerals. The authors consider an approach to develop appropriate tools in the form of an information system of geological and economic monitoring in order to improve the socio-economic efficiency of the subsoil management, including common minerals.

1. Introduction
At present, in order to improve the quality of state and municipal management, it is necessary to develop and implement a unitary social, economic, financial and environmental policy, a unitary system of summarizing the results of the activities of management bodies and checking them for compliance with the goals [2,7,9]. The solution of this task involves the following actions:
- preparing strategic draft decisions and plans (programs) on socio-economic development of the region [1];
- implementing management of social and economic development of the region [5];
- assessing the socio-economic situation in the region and the impact on its development in order to stabilize [8];
- organizing the monitoring of socio-economic development of the region [3].

2. Relevance
Local self-government bodies, as the main users of local information resources, are their sources at the same time. They form and accumulate information since the considerable part of local information resources contains the documents reflecting details of authorities and organizations in this or that sphere of municipal management [4,6].
The objects of attention of management bodies are:
- economic entities of different departmental subordination and form of ownership;
- regional resources: financial, labor, commodity, natural;
- environment;
- population of the region.

The need to ensure the management system highlights the functions of property, resources and social management [10,11,12,13].

3. **Formulation of the problem**

The scope of information system development on the local level should include information support of the following:
- legislative and executive branches of power[14];
- activities of economic entities [15];
- processes of social management;
- processes of effective nature management and environmental protection in terms of providing data for the local authorities to assess the state of natural resources and reproduction of conditions for the population activities.[16,17].

In this context at the regional level the task of preserving the mineral resource base and reproducing the mineral resource potential of the subsoil is of particular relevance. To solve this problem it is necessary to form information support of geological and economic monitoring by means of which there will be defined representative indicators observed in dynamics for the purpose of preventive determination of negative influences in the condition of mineral resource base of the region.

Recently, in addition to the accumulation of geological information on objects of federal importance, it is necessary to create an information array of common minerals (CM). The information system in the block of CM should include data on licenses, mineral reserves, certificates of state cadastre of deposits (SCD), cards of geological exploration. An important task is to form the project "Digital maps of CM and licensed areas location" [18].

Currently, at the regional level, management bodies of mineral resources in Russia show a certain interest in the use of this information system due to delegation of their powers of CM recording.

4. **Theoretical part**

The main goal of managing subsoil stock at the territorial level is the arrangement of balanced, efficient, and environmentally friendly utilization of mineral resources, ensuring the optimal level of their consumption, reproduction and protection of mineral resources to provide the economy of the region with the required resources and to improve the life quality of the population [19,20].

In our opinion, the main tasks of the management bodies of subsoil stock at the territorial level are the following:
- providing the state licensing system of subsoil using with subsoil plots of common minerals (CM);
- working out the strategy for the development of raw material bases (RMBs) in the region and geological exploration programs;
- organization of examination of CM stock materials, record and balance keeping of CM stocks;
- control over the rational subsoil usage;
- providing data for the preparation of annual reports "The condition and use of natural resources of the Russian Federation", programs of socio-economic development of regions, territorial planning schemes and other analytical materials and references.

Let us focus on solving these problems in more details.

1. Effective provision of the state licensing system with CM subsoil plots depends on the quality of the initially prepared analytical information for management decision-making, which is based on the data of monitoring the state and use of objects of the distributed subsoil stock, including:
   - extraction volume and the amount of remnant stock of minerals;
provision of enterprises and communities with CM;
schedule of exhaustion of mineral stocks at the operated deposits.

An important condition for ensuring the state licensing system is to identify promising licensing facilities, and to include them into relevant programs. Definition and preparation of promising objects for licensing should be carried out, taking into account geological exploration, ecological safety and economic efficiency of development.

In our opinion, the main criteria for choosing promising objects for licensing are the following:
- the amount of stocks and forecast resources of minerals \( Q_i \);
- predictive assessment of the raw material quality \( R \);
- acceptable geological conditions (the thickness of overburden \( M \) and productive layer \( T \), water cut \( W \));
- absence of specially protected natural areas (SPNA), sanitary-protection and protected zones on the territory of the object;
- availability of transport and industrial infrastructure near the object.

2. Working out the strategy for the development of RMBs in the region and geological exploration programs includes:
- study of the market conditions of mineral raw materials and mineral products (volumes of extraction and import-export of minerals, their processing, production and consumption of mineral products and others);
- determination of the perspective needs of the region's economy in various types of minerals, on the basis of programs of socio-economic development of the region (providing existing and new plants with minerals for the production of building materials, road infrastructure and construction of large infrastructure projects);
- preparation of measures (programs) on geological exploration of subsoil, including the main directions and perspective objects of geological exploration.

3. In order to carry out the expertise of materials to assess CM stock, when compiling geological reports and feasibility studies, information is often required for comparative characteristics of the quality of raw materials, mining and geological indicators, and data on dynamics of movement and state of CM stock, the size of operational losses on the objects of study and analogue deposits.

4. An important aspect in monitoring the rational use of subsoil is the compliance with the licensing terms of subsoil use, rates of exploitation and the size of operational (normative) losses.

In addition, the management bodies of the subsoil stocks provide initial data for the preparation of annual reports "The state and use of natural resources of the Russian Federation", programs of socio-economic development of regions, regional planning schemes and other analytical materials and references.

The information system offered by the authors and the block of CM allow to provide substantial assistance in obtaining the initial data to solve the problems mentioned above and to improve the efficiency of managing the subsoil stocks at the regional level. The main sources of information on composite indexes in the information system (block "CM") to solve the problems of regional bodies of managing the subsoil stocks are shown in Table.1. Block "CM" contains the following elements: 1 - collections of overall CM stocks, 2 - certificates of state cadastre of CM deposits, 3 - cards of geological knowledge, 4 - licenses, 5 - digital maps of the location of CM deposits.

Monetary evaluation of raw mineral potential is made for separate deposits, groups of deposits, ore districts, etc. Formula (1) is used for its calculation.

\[
MSP = (Q_{zap} + Q_{pr} \times K_p)P
\]  

\( Q_{zap} \) is mineral reserves in the subsoil, in units of measure, adopted in the State Register of Reserves (class A+B+C1+C2);
Table 1. The main sources of information on composite indexes in the information system to solve the problems of regional bodies of managing the subsoil stocks.

| Main tasks of managing the subsoil stocks at the regional level | Work type | Indexes | Block CM |
|---------------------------------------------------------------|-----------|---------|----------|
| 1. Provision of the licensing system of subsoil use           | 1.1. Monitoring of the state and use of objects of the distributed subsoil stock | - extraction volume of CM; | 1 2 3 4 5 |
|                                                               | 1.2. Identifying promising licensing facilities | - amount of remnant stock of minerals; | | + + + |
|                                                               |                                                     | - provision with CM stocks; | | |
|                                                               |                                                     | - schedule of exhaustion of mineral stocks; | | |
|                                                               |                                                     | - object distribution. | | |
| 2. Working out the strategy for the development of RMBs in the region and geological exploration programs | 2.1. Study of the market conditions of mineral raw materials | - amount of CM stocks; | | |
|                                                               | 2.2. Preparation of programs on geological exploration of subsoil | - amount of forecast resources of minerals; | | + + + |
|                                                               |                                                     | - raw material quality; | | + |
|                                                               |                                                     | - geological conditions; | | |
|                                                               |                                                     | - availability of transport and industrial infrastructure; | | |
|                                                               |                                                     | - geological exploration. | | |
| 3. Carrying out the expertise, balancing and recording of CM stocks | 3.1. Expertise of CM stocks, balancing and recording of CM stocks. | - amount and dynamics of movement of CM stock; | | + + + + |
|                                                               |                                                     | - raw material quality; | | + |
|                                                               |                                                     | - geological conditions; | | + |
|                                                               |                                                     | - size of CM operational losses; | | |
|                                                               |                                                     | - object distribution. | | |
| 4. Monitoring the rational use of subsoil                      | 4.1. Monitoring the state and use of distributed subsoil reserves | - conditions of subsoil use; | | + + + |
|                                                               |                                                     | - rate of CM exploitation; | | |
|                                                               |                                                     | - size of CM operational losses; | | |
|                                                               |                                                     | - object distribution. | | |
| 5. Preparation of the report The state of natural resources”, programs of socio-economic development, regional planning schemes and others | 5.1. Monitoring the state and use of RMBs | - amount of objects; | | |
|                                                               |                                                     | - extraction volume of CM; | | |
|                                                               |                                                     | - size of CM operational losses; | | |
|                                                               |                                                     | - amount of CM stocks; | | |
|                                                               |                                                     | - amount of forecast resources of minerals; | | |
|                                                               |                                                     | - raw material quality; | | |
|                                                               |                                                     | - geological conditions; | | |
|                                                               |                                                     | - absence of specially protected natural reservations, sanitary protection areas and protected areas. | | |
|                                                               |                                                     | - availability of transport and industrial infrastructure; | | |
|                                                               |                                                     | - geological exploration; | | |
|                                                               |                                                     | - object distribution. | | |
5. **Results of experimental studies**

Evaluation of raw mineral potential of the Central Federal District resulted in definition of projected values for the year 2034 (Table 2).

**Table 2.** Results of evaluation and forecasting of the raw mineral potential of the Central Federal District.

| Types of mineral deposits                  | Unit                  | Optimum scenario | Optimistic scenario |
|-------------------------------------------|-----------------------|------------------|---------------------|
| Iron ore                                  | million tons          | 177,0            | 230,0               |
| Titanium, zirconium (alluvial)            | million cub.m         | 1,5              | 2,0                 |
| Fluxing limestone                         | million tons          | 8,4              | 11,0                |
| Fire clay                                 | million tons          | 1,2              | 1,6                 |
| Glass raw materials                       | million tons          | 6,0              | 8,0                 |
| Halite                                    | million tons          | 0,5              | 0,7                 |
| Phosphate                                 | million tons P₂O₅     | 0,8              | 1,0                 |
| Dolomite                                  | million tons          | 3,3              | 4,3                 |
| Drilling clay                             | million tons          | 0,1              | 0,13                |
| Brown coal                                | million tons          | 0,8              | 1,0                 |
| Cement raw materials                      | million tons          | 35,0             | 46,0                |
| High-melting clay                         | million tons          | 2,5              | 3,3                 |
| Molding material                          | million tons          | 4,0              | 5,2                 |
| Gypsum                                    | million tons          | 2,9              | 3,3                 |
| Carbonate rock for chemical industry      | million tons          | 0,5              | 0,7                 |
| Chalk                                     | million tons          | 6,0              | 7,8                 |
| Rhenium                                   | tons                  | 3,5              | 4,5                 |
| Strontium                                 | th. tons              | 10,0             | 13,0                |
| Nickel                                    | tons                  | 18,0             | 23,0                |

The analysis of extraction volume of non-metallic mineral resources in the Central Federal District in 2016-2017 shows that the mining industry has practically overcome the consequences of the crisis. This positive trend is confirmed by the investment activity of subsoil users, who significantly increased the financing of geological exploration in 2016-2017. Stabilization and growth of the production of construction materials in recent years have led to favorable conditions for the production and consumption of non-metallic raw materials in the Central Federal District for the nearest future.

6. **Conclusions**

Summing up, it should be noted that the main directions at which development of the proposed information system is aimed are the following:

1. information support of the state cadastre of deposits and occurrences of common minerals (SDM certificates);
2. record keeping and managing geological exploration of the territory of the Russian Federation;
3. Accounting of forecast resources of solid minerals and preparation of digital maps of deposit location.

Thus, the advantage of using the proposed information system of geological and economic monitoring is creating an array of diverse information on the state of the mineral resource potential, with the possibility of its use to solve a wide range of management tasks. Further CM block improvement of the proposed information system is seen in the expansion of indexes of geological and economic nature (quality of raw materials, product range, wholesale price) and the formation of GIS projects of interactive maps with placing information for public use.

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