Innovative Development of Subsoil Mining Complexes of Russia

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Abstract. In the consideration the facilities of the mining complex was approached using the interdisciplinary method based on accounting of the ecological, social, economic, technological factors. The «system of subsoil use» is considered as an aggregate developed subsoil areas and industrial production. They are united by the flow of energy, substance and information between themselves, with civil society and with natural environment. Considered two conditions for innovative development of mining complexes: formation of long-term motivation in subjects of economic activities and creation of long-term loan mechanisms. The main directions of innovative development of mining and industrial complexes are substantiated: the creation of new technologies for the extraction of minerals, advancing the world level in a number of studies, the development of public administration, the use of technogenic deposits and the restoration of damaged ecosystems, the digitization of subsoil processes, and the involvement of society in the organization of subsoil use.

1. Introduction
Russia is the country having the greatest volumes of natural resources and its share in the world reserves of resources totals (in %): oil – 13, gas – 32, coal – 11, lead, zinc, nickel, iron – from 10 to 36% [1]. But after the disintegration of the USSR Russia faced the problem of self-sufficiency in certain types of mineral resources: the complete absence of manganese, chromium, strontium, mercury, zirconium, a significant deficit in lead, zinc, fluorite, barite, kaolin and some others. The strategic goal of the development of the mining and industrial complex of Russia is sustainable mineral and raw material support for the development of the country's economy, taking into account the policy of resource-saving, social sphere, national security and long-term interests of the society development [2, 3].

Innovative development – these are innovations in the field of engineering, technology, organization of labor and management, based on the use of scientific achievements and best practices. In a large-scale practical sense innovative development is a constant stream of discoveries and inventions and their successful implementation from idea to production. According to S. G. Glazyev [4] two initial basic conditions are necessary for development of the innovative economy.

The first is the formation of long-term motivation among economy and business entities. The long-term motivation must comply with the conceptual principles of sustainable development and proceed...
from ideological principles of the economy of sustainable development. This requires the state industrial policy to create corporations with sustainable motives for long-term development [5].

The second condition for development of the innovative economy is creation of long-term credit mechanisms, formation of a taxation system stimulating innovative development. Special development banks (as in China) or mechanisms of working with savings of population (as in Japan now; earlier this mechanism was used in the USSR) may be considered as possible ways of investment into innovation development.

The current state of the subsoil mining complex in Russia is characterized by: a large decline of the share of the Russian Federation in the world mineral production over the past 30 years; depletion of rich and easily accessible deposits in the inhabited areas; increase of environmental and geodynamic load to the environment.

2. Methods
In substantiation of the main directions of innovation development of mining complexes methods of context analysis of publications of research papers on this theme (more than 320 publications in domestic and foreign collections and periodicals), critical understanding of scientific ideas, methods of analyses of associative links in the field of subsoil use have been used [6].

When considering the objects of the mining complex, an interdisciplinary approach was carried out on the basis of accounting environmental, social, economic and technological factors [7]. At the same time the “subsoil use system” is considered as a totality of developed areas of the subsoil (characterized by geological, geomechanical, aerogasdynamic processes), industrial production (geological exploration, extraction and enrichment of mineral raw materials, deep processing, utilization of industrial wastes) united by flows of energy, substances and information among themselves, with civil society and the natural environment (air, water, soil and vegetation cover).

3. Results
Results – ways of innovative development subsoil mining complex.

1. Conceptual provisions on the volume of mineral mining. Volumes of minerals mining are determined by the urgent domestic need to extract additional natural resources for development of home industrial production [8]. The possibility of subsoil mining for the sale of resources abroad and obtaining profit (copper-nickel ore deposit in the Voronezh region, Tominsk ore zone in the Chelyabinsk region) cannot be a priority basis for the subsoil use [9]. The motives commonly used by subsoil mining companies about people employment in the economy (job growth), possible compensation for damage (harm) from social positions should be solved in the first case by organizing of other environmentally safe industries (e.g. improving agriculture), in the second case – by execution of such projects, where the social aspect is in a priority (higher than profit obtaining), since Russia according to the Constitution is a social state.

The increase in the volume of minerals mining is caused by the strategic need for the extraction and processing of certain types of natural resources. Thus, in the USSR, in the period after the Great Patriotic War a strategic need arose in the search for and extraction of radioactive elements (thorium, uranium) and oil deposits. At present in Russia there is a strategic need for restoration, development and extraction and processing of rare-earth metals [10], both for the country’s own high-tech industrial production and for supply to the international market. The organization of oil production in hard-to-recover fields (Bazhenov formation in Western Siberia) [11] may become the strategic need for the country.

The general provisions of the long-term sustainability of subsurface use on volumes of production correspond to the theory of managing the use of exhaustible natural resources [12, 13].

2. The organization of technologies for mineral mining providing minimizing of disturbed ecosystems. Any of the existing types of subsoil use causes destruction, transformation, pollution of the environment; from fundamental scientific positions, it causes violations of the biotic regulation of the environment formed over a long period [14].
So far there are no super-modern environmentally friendly technologies in Russia. It is used to consider that methods of chemical and biological leaching of metals from deposits are less harmful. But still, with such technologies, large volumes of waste are generated (acidic waters, waters polluted with heavy metals), metals are “washed out” from the ore directly in the mines and its contamination, disturbing underground space.

Unfavorable situations because of the technogenic transformation of underground space in Solikamsk [15], Kurgan Region (uranium mining) [16], in the floodplain of the Khopyor River (canned exploratory wells) [17] indicate potential environmental problems in the underground space.

The principal position (strict rule) to ensure the minimization of ecosystem disturbances during subsoil use should be the organization of mineral extraction based on the results of interdisciplinary research [18] and multi-criteria optimization [19], that is, if preservation of life and health of the population living in the subsoil use territory is provided.

When restoring disturbed ecosystems in the subsoil use area, it is important to assess the ecological and economic significance of the whole diversity of their natural resources (biological ones, environment-forming functions, social role) in the space and time dynamics; it is important in assessing changes in properties, modes and functions of disturbed and recovered soils in subsoil use areas.

3. The creation of new technologies of "unmanned" and "low-harmful" mining. "Unmanned" and "low-harmful" technologies of minerals mining are developed for deposits that are dangerous to human health, and, if economically feasible, for production liquid and gaseous energy carriers from coal and mountain shale in underground conditions; on social conditions – for reducing of the "shift" variant of the work organization, etc.

The “digitization” of subsoil use systems based on automated control systems will contribute to the creation of “deserted” and “low-harmful” mining technologies.

4. Advancing the world level on a number of investigations of geomechanical, geodynamic, geochemical, geotechnological (borehole) methods of mining of minerals, research on the development of deposits of poor, complex-structured, geodynamically dangerous deposits with finely disseminated ores.

Innovative technologies of physical and chemical destruction of rocks, hydraulic and electromagnetic technologies of crushing of rocks, technologies of crushing and grinding based on the use of free impact and tensile loads are being introduced and put into practice in the world. The principles of sustainable development in the industry application are beginning to be used in the design of mining operations in Canada (Bradley C., Sharpe [20]), Australia (Mawby Maurice R. [21]), in other regions (Dubiriski J. [22], [23]), in specific projects of quarrying (Adibi N., Ataee-pour M., Rahmanpour M. [24]), mines (Euy Kscho J. [25], Davis G, Newman A.M. [26]); in multi-criteria analysis (Erzulumlu S.S., Erzulumlu Y.O. [27]), in justifying biotechnologies [28].

5. Development of public administration and improvement of public-private partnership in the field of subsoil use. Development of difficult (structurally complex, geodynamically dangerous, etc.) deposits is kept back by the lack of fundamental scientific works (R & D); subsoil mining companies do not have enough incentives to finance such works, so state participation in such situations is necessary. There are some proposals for public administration in geological prospecting for minerals [29].

The state program of the Khanty-Mansi Autonomous Okrug-Yugra “Reproduction and use of natural resources” (Resolution of the Government of the Khanty-Mansi Autonomous Okrug-Yugra No. 345-P dated 05.10.2018) determined the task of creating conditions for the effective reproduction of the mineral resource base, as well as the involvement and development of hard-to-recover oil reserves of Bazhenov formation. This program provides for fundamental scientific research on creation of a complex of domestic technologies and equipment for effective development of the Bazhenov formation. Measures for the state support: the Autonomous Okrug Law No. 68-oz dated October 29, 2017 “On Amendments to Certain Laws of the Khanty-Mansiysk Autonomous Okrug-Yugra in the Field of Taxation” is adopted which provides for granting of tax exemptions on the
property created under the implementation of the national project and creating domestic technologies for profitable development of the Bazhenov formation. According to the State Program of the Khanty-Mansi Autonomous Okrug-Yugra the planned amount of funding totals 10 billion rubles within the period of 2019-2020.

6. The use of man-made deposits and landfill waste of subsoil use. Man-made deposits are accumulated industrial wastes in closed or conserved production of a mining complex; they may be considered to be the state property [30]. Technogenic deposits may also include unused industrial wastes at existing mining enterprises; their legal status is determined by special consideration. Industrial wastes used at mining enterprises are not technogenic deposits and are reported as their property.

Subsoil users who have undertaken the development of technogenic deposits (old unused industrial waste) are entitled to rely on the government encouragement for the reducing of the anthropogenic load on the environment; for example, by reducing the income tax. The use (development) of technogenic deposits is a replenishment of the country’s mineral resource base [31] and should also be encouraged by the state.

7. Digitizing of processes in subsoil use systems. Digitizing of processes (digital economy) in the system of subsoil use includes the formation of relevant databases on subsoil use, management of information resources and the implementation of programs, procedures and algorithms for organization of the efficient production.

The State program of the Khanty-Mansi Autonomous Okrug-Yugra “Reproduction and use of the natural resources” provides for the creation of 70 databases in the field of subsoil use.

All elements of the digitizing of subsoil use management (elements of the digital economy) with a view to national security and information protection (RF Law "On Information, Information Technologies and Information Protection”) should be built on Russian technologies, on Russian DBMS, on a national platform with applied service software (SS) [32-34].

Coordination of the automated subsoil use management system with the automated control system of the whole mining complex is carried out at a new scientific and technical level: an object-oriented 6th generation DBMS based on the network-centric principle, block-chain technology, “foggy” computing, voice and graphic control by robotic devices, encryption, modeling.

8. The society involvement into effective form of organization and management of subsoil use. The implementation of the considered ways of innovative development of subsoil mining complex provides for extensive involvement of employees at all levels into new type of work, built on consistent and well considered communication, conducting of training activities on process optimization, ensuring of effective management infrastructure, shaping the way of thinking and behavior of employees of subsoil management systems in accordance with conceptual provisions of sustainable development of territories.

An important point is that the innovative development of mining complex should follow all environmental restrictions, since ignoring them (especially in economic terms) becomes accustomed (which is already taking place in a market economy); and the future correction of this “ecological drug addiction” will respond to society with very big troubles.

4. Conclusion
The main directions of innovative development of subsoil mining complexes are the following. The volume of mineral mining is determined by the urgent domestic necessity; the increase in production is caused by strategic necessity; the possibility of subsoil mining for sale abroad and making a profit cannot be a priority basis. The organization of mineral mining technologies should ensure minimization of disturbance of the natural ecosystems. Creation of new technologies of "unmanned" and "low-harmful" production based on robotization and intelligent systems. Advancing the world level in geomechanical, geodynamic, geochemical methods of mining. Development of public-private partnership in high-risk breakthrough technologies in geological exploration. The use of man-made deposits and industrial waste. Digitalization of subsoil use systems based on implementation of
programs, procedures and algorithms for organization of production. Involving of society into an effective form of subsoil use management based on the formation of a way of thinking and behavior of subsoil user teams in accordance with the conceptual provisions of the sustainable development of territories.

5. References

[1] Kozlovskiy E A 2015 Natural resources in the economy of Russia and in the world Gornyy zhurnal 7 47–52
[2] Order of the Ministry of Industry and Trade of the Russian Federation dated May 5 2014 No 839 Approval of the Strategy for the Development of ferrous metals industries for 2014-2020 and for the future until 2030 Approval of the Strategy for the Development of non-ferrous metals industries for 2014-2020 and for the future until 2030 Retrieved from ConsultantPlus online database
[3] Natalenko A E, Pak V A, Stavskiy A P The basic directions of development of the mineral-raw-material base of the Russian Federation Mineral Resources of Russia Economics and Management 1 126–134
[4] Glaziev S Yu 2009 World economic crisis as a process of substitution of technological modes Voprosy Ekonomiki 3 26–38
[5] L'vov D S 2002 Development economics (Moscow: Ekzamen)
[6] Lebedev Yu V, Kokarev K V, Aref'ev S A, Krylov V G 2017 Associative links in the field of subsoil use Izv. VUZov Gornyy zhurnal 8 108–115
[7] Lebedev Yu V, Kovalev R N, Kokarev K V 2018 Technological forecasting of the innovative development of the subsoil mining sector (Ekaterinburg: UGGU)
[8] Shtyrov V A 2018 Arctic Greatness of the project Zavtra 5-7 6
[9] Boldyreva Yu Yu 2013 How to avoid civil war (Moscow: Algoritm)
[10] Yushina T I, Petrov I M, Grishaev S I, & Chernyy S A 2015 International rare earth metals market and processing technologies: State-of-the-art and future prospects Gornyy zhurnal 2 59-64 3 76-81
[11] Vasilevskaya M A, Khabarov V V 2014 Oil and gas potential of Bazhenov formation of Irtysh-Turtass zone of the south of the Tyumen region Proceedings of International Scientific and Practical Conference 133-143 (Khart-Mansiysk)
[12] Hotelling H 1931 The Economics of Exhaustible Resources Journ. Polit. Econ. vol 39 137-175
[13] Sollou, Robert M 2000 The economics of resources or the resources of economic Srichard T. Ely lecture vol 3 (St. Petersburg: Ekonomicheskaya shkola)
[14] Gorshkov V G 1995 Physical and biological foundation of the life sustainability: vol XXX VIII (Moscow: VINITI)
[15] Borzakovskiy B A, Grinberg A Ya, Tolmachev B N 2012 Experiences of liquidation of failure in earth’s surface over a flooded potassium mine Gornyy zhurnal 2 65–68
[16] Boldyrev Yu Yu 2019 Women's «extremism» Literary newspaper 9
[17] Chernyshev N M 2012 How to protect Hopper AiF- Chernozem region 49
[18] Lebedev Yu V 2017 Environmentally sustainable development of territories: patriotic soviet look (Ekaterinburg)
[19] Podinovskiy V V, Gavrilov V M 2016 Optimization on consistently applied criteria (Moscow: Lenand)
[20] Kaplunov D R 2014 Theory basis of designing of subsoil mastering: formation and development Gornyy zhurnal 7 49–53
[21] Mawby, Maurice R W J 2013 Australasian mining and metallurgical operating practices The Sir Maurice Mawby Memorial vol 2 Carlton. Vic.: Australasian Institute of Mining and Metalurgy
[22] Dubinski J 2013 Sustainable Development of Mining Mineral Resources Sustain Min vol 12 1 1–6
[23] Trubetskoy K N 2018 Addressing the challenges of environmentally balanced mining of
ground-based geotechnology Gornyy zhurnal 6 17–24

[24] Adibi N, Ataee-pour M, Rahamanpour M 2015 Integration of sustainable development con-cepts in open pit mine design J. Clean. Prod. vol 108 Part A 1037–1049

[25] Zubov V P 2017 Resource-saving technologies of underground development of stratified deposit Gornyy zhurnal 4 49–56

[26] Davis G A, Newman A M 2008 Modern strategic mine planning Proceedings of the Aus-tralian Mining Technology Conference, AuslMM (Carlton, Australia) 129–139 http://inside.mines.edu/~gdavis/Papers/CRC_Mining_Conference_Paper.pdf

[27] Erzurumlu S S, Erzurumlu Y O 2015 Sustainable mining development with community using design thinking and multi-criteria decision analysis Resources Policy vol 46 1 6–14 https://doi.org/10.1016/j.resourpol.2014.10.001

[28] 2010 Talvivaara sotkamo mine – bioleaching of a polymetallic nickel ore in subarctic climate Nova Biogeotechnologica 1

[29] Nazarova Z M, Kas’yanov V A, Kalinin A R, Desyatkin A S 2018 Prospects for geologic exploration in Russia: Western way or native development model? Gornyy zhurnal 11 42–47

[30] Kubarev M S, Strovskiy S V, Balashenko V V 2017 Classification of technogenic mineral formations as a condition of waste management Izv. VUZov Gornyy zhurnal 6

[31] Barkhatov V I, Dobrovol’skiy I P, Kapkaev Yu Sh 2015 Rational use of natural resources of the Cheyabinsk region (Chelyabinsk: ChGU)

[32] Veduta E N 2018 Rationalization Zavtra 33

[33] Evtushenko S 2019 Development or cyber robbery? Zavtra 6

[34] Skorikov D S, Solovev D B 2018 Consideration of an Ecosystem From the Standpoint of Theory and Practice of Managing Production Systems IOP Conference Series: Materials Science and Engineering 463 paper № 022003. [Online]. Available: https://doi.org/10.1088/1757-899X/463/2/022003

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