

Main Directions and Problems of Development of the Minerals and Raw Materials Sector in the Republic of Buryatia

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Received January 10, 2017

Abstract—An analysis is made of the distinctive features in the formation and development of the minerals and raw materials sector of the Republic of Buryatia which hamper its advancement. It is shown that it is a traditional branch of the region's economy endowed with a large number of deposits of diverse raw materials, yet their industrial development is inadequate. It is determined that, along with the adverse conjuncture, the crisis phenomena, lack of funds, a severe climate, seismicity, difficult topography and a weak infrastructure have a negative influence. A critical impediment in the form of special ecological requirements in the Baikal natural territory is analyzed. A number of measures which would strengthen a further development of the minerals and raw materials complex of Buryatia are suggested. In the near future there is a need to revive the reproduction of the raw materials base in gold mining, launch the Ozernyi deposit and to start large-scale development of the Khiagda uranium ore field.

DOI: 10.1134/S1875372819010116

Keywords: minerals and raw materials complex, Buryatia, negative phenomena, Baikal factor, gold, polymetals, uranium.

THE MINERALS AND RAW-MATERIALS BASE

Buryatia possesses an abundant base of minerals and raw materials (Table 1). The territory of the republic has over 700 proven deposits, and more than 600 of them are included on the State Balance Sheets of Russia and on the Territorial Balance Sheets of the Republic of Buryatia. The balance mineral resources are estimated at 5305.2 billion rubles. The total value of probable resources is estimated at 5510.6 billion rubles [1].

The subsoil of Buryatia is the home for balance reserves of thallium: 95.9% of Russia's reserves, raw nephrite – 94.9, nephrite – 92.8, zinc – 48.8, volcanic glass – 44.6, cadmium – 35, molybdenum – 32.3, lead – 24.4, tungsten – 20.4, barite – 17.2, pyrite sulfur – 16.3, fluorite – 16.3, asbestos – 15.3, apatite – 13, beryllium – 11.3, silver – 8, uranium – 6.5, and quartzites – 5.2% [1]. Among the deposits discovered are 247 gold fields (28 placer, 16 ore and 3 complex deposits). The reserves of gold amount to 137.62 t, and the probable resources are 1633.12 t. The list of strategic types of minerals includes seven tungsten deposits, 13 – uranium, 4 – lead and zinc, 2 – molybdenum, beryllium, copper and nickel each, 1 bauxite deposit, and 1 tin deposit (*see figure*).

The uranium reserves are no less than 39.83 thou. The Khiagda uranium deposit is operated by using an economical and environment-friendly method of underground leaching within the framework of experimental industrial exploitation.

Out of 23 brown and bituminous coal deposits, 13 are included in the State balance sheets, and 6 are in operation: Daban-Gorkhonskoe, Gusinoozerskoe (the Kholbol'dzhinskii and Bain-Zurke mines, Zagustaiskoe, Okino-Klyuchevskoe, Talinskoe and Khara-Khuzhirskae. The balance reserves of coal are 2.6 billion tons.

The Ozernyi lead-zinc deposit is one of the world's largest: the ore reserves are 135 mil. t [2]. The zinc content in the ore is high, 6.12%, along with 1.16% of lead and 45.6 g/t of silver. The deposit occupies the second place in Russia in the reserves of zinc (13.5%) and cadmium (12.7%), the third place in lead (7.8%), and the fifth place in silver (4.1%).

The territory of Buryatia has Russia's largest Inkurskoe and Khotosonskoe tungsten deposits as well the Malo-Oinorskoe tungsten-molybdenum deposit with rhenium. The Orektikanskoe deposit is among the five world's largest, 30% of ores are rich, and the molybdenum content makes up 0.138%. The

Table 1. Mineral resources of Buryatia as of January 1, 2014

Mineral resources	Total		Distributed fund	
	reserves (A + B + C ₁ + C ₂)	resources (P ₁ + P ₂ + P ₃)	reserves (A + B + C ₁ + C ₂)	resources (P ₁ + P ₂)
Bituminous coal, thou t	843 557	0	174 803	0
Brown coal, mil. t	1746	0	155	0
Uranium, thou t	39	70	39	15
Beryllium, thou t BeO	28.89	0	15.33	0
Bismuth, t	384.5	0	384.5	0
Tungsten, t WO ₃	362 464	8 500	239 862	8500
Indium, t	216.6	0	216.6	0
Cadmium, t	59 202	0	58 684	0
Copper, thou t	126.7	0	51.8	0
Molybdenum, t	560 656	0	404 734	0
Lead, thou t	5006.6	400	4922.6	0
Zinc, thou t	29 966.1	700	29 850.2	0
Gold, t				
total	137.62	1633.12	126.17	213.22
vein gold	114.62	1568.12	112.93	193.22
placer gold	23	45	13.25	0
Silver, t	9007	0	8729.6	0
Nephrite, t, high-quality	6608.3	0	4294.8	0

Note. Here and in Table 4: compiled from data of the Territorial Geological Information Fund for the Siberian Federal District (Republic of Buryatia).

Zharchikhinskoe molybdenum deposit is located in the economically developed region. The Chaiskaya and Dovyrenskaya areas, with the total volume of nickel resources being 407 thou t, demand further study.

Buryatia has alumina raw materials, in very short supply in Russia. Aluminum smelters of Irkutsk oblast, Krasnoyarsk krai and Khakassia depend on imports. The Boksonskoe bauxite deposit is located in the Okinskii district (the maximum thickness of the seam is 25–30 m, and the content of Al₂O₃ constitutes 41.2%). The Severo-Baikalskii district includes the Synnyrskii massif of nepheline pseudo-leucite syenites (synnyrites) of the area of 585 km². Synnyrites contain alumina (averaging 22%) and K₂O (up to 20%), and comprise the body 4.5 km in length and 200–300 m in thickness (the Kalyumnoe deposit). A waste-free technology as developed for processing synnyrites into alumina and chlorine-free potassium and phosphorus-potassium fertilizers, cement, components for explosives, and feldspar concentrate. The Mukhal'skoe deposit of ores in the Bauntovskii district is promising where urtites (25–28% Al₂O₃) and ijolite-urtites (19–25% Al₂O₃) correspond to nepheline ores of the Kiya-Shaltyrskoe deposit processed by the Achinsk alumina plant. In the residual reserves of ore of the Ermakovskii fluorite-beryllium deposit, the BeO content averages 1.28% (the highest in the world).

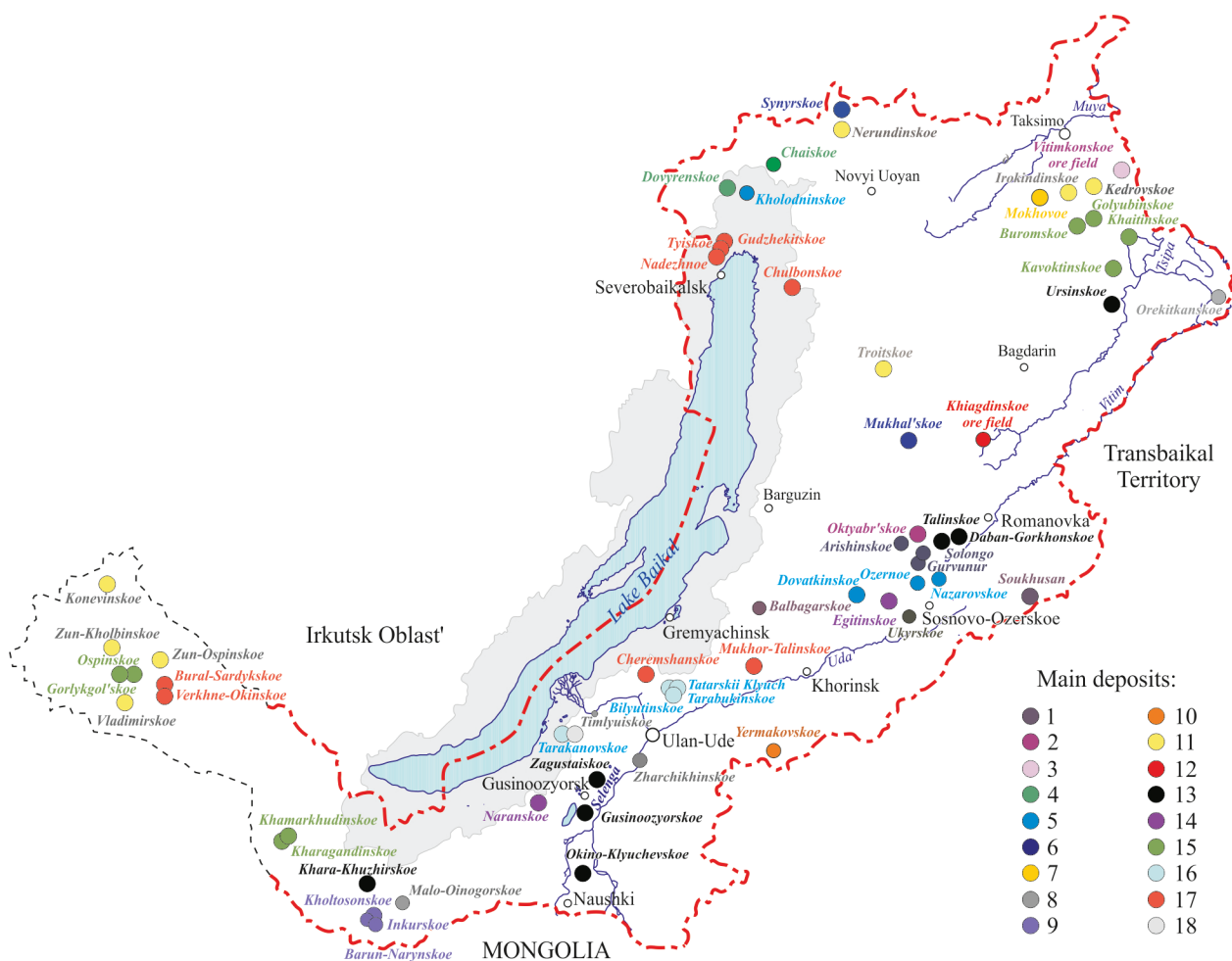
Buryatia has unique (in reserves and purity) quartz raw-materials base. It includes the Bural-Sardykskoe, Goudzekitskoe, Atarkhanskoe and other deposits.

The reserves of phosphate raw materials are impressive. On the outskirts of Ulan-Ude there is the Oshurkovskoe apatite deposit with 108 568 thou t of P₂O₅ balance reserves with the mean content of P₂O₅ making up 3.8%, and the phosphorite deposits are located in the Ukhagol'skii and Kharanurskii districts. Their development and exploitation are retarded by the ecological characteristics of the Oshurkovskoe deposit [3], and by the geographical-economic conditions of Eastern Sayan.

For 16 nephrite deposit the reserves of category C₁ were registered: 5387.8 t of raw nephrite (1620.6 t of high-quality nephrite), and for category C₂: 17168.2 t of raw nephrite (4987.7 t of high-quality nephrite, including 205.5 t of jewelry nephrite).

The balance sheets of the reserves include 154 deposits of common minerals (CM): 58 deposits of loams and clays with the total balance reserves of 59.95 mil. m³; 39 deposits of building stone of 320.27 mil. m³, and 47 deposits of sand and gravel mixture with the total balance reserves of 219.39 mil. m³ [4].

The water resources are significant. More than 30 thousand rivers total 150 thou km in length. The mean



Location map of the main deposits on the territory of Buryatia. The central ecological zone of the Baikal natural area is highlighted in grey.

Deposits: 1 – iron ore, 2 – manganese, 3 – titanium, 4 – copper-nickel, 5 – polymetallic, 6 – alumina, 7 – tin ore, 8 – molybdenum, 9 – tungsten, 10 – beryllium, 11 – lode gold, 12 – uranium, 13 – coal, 14 – fluorite, 15 – nephrite, 16 – carbonate rocks, 17 – quartz, 18 – aleurite.

long-term resources of river discharge are 98 km³ and 94.3 thou m³/year (nearly by a factor of 3 more than Russia's average) correspond to one inhabitant of Buryatia) About 35 thousand lakes (Gusinoe, Bol'shoe Eravnoe and Baunt are the largest) have the total water area of 1795 km², with the exception of Lake Baikal on the boundary with Irkutsk oblast which contains 20% of the world's lake freshwater.

Fifty-nine deposits of subsurface waters were prospected to be used for drinking, technical and irrigation purposes as well as five deposits of mineral and thermal waters for balneological purposes. The health-resort resources include more than 360 sources of mineral waters and sulfide silt muds of Lakes Kotokel', Kiran and Bormashevoe. Most of the sources are not used or are exploited spontaneously. They have carbon dioxide magnesium-calcium and calcium-sodium waters with iron and radon;

nitrogenous silicious therms, including with radon and hydrogen sulfide; nitrogenous sulfate sodium therms with silicic acid, radon and hydrogen sulfide; methane hydrocarbonate sodium therms with radon, and ferruginous therms.

However, the existing structure of the minerals-raw materials complex does not reflect the available potential. The undistributed fund of subsurface resources includes the following deposits [5]: Mukhal'skoe of nepheline ores with the ore reserves of 427.4 mil. t and the Al₂O₃ content of 25.1%; the Chaikskoe sulfide copper-nickel deposit with the ore resources of 51.1 mil. t and nickel resources of 303.9 thou t, and the Aiktinskoe and Bolaiktinskoe deposits of cement raw materials with limestone and aleurite reserves of 177.7 and 57.5 mil. t, respectively. Even the Ozernyi and Nazarovskii polymetals deposits, the Kholtosonskoe and Inkurskoe tungsten deposit

and the Ermakovskoe beryllium deposit that are in the distributed fund are not exploited. In connection with the unfavorable world market situation, the drop in process of most of the types of mineral resources and the inadequately high quality of raw materials, the exploitation of most of these deposits has been postponed indefinitely.

DEVELOPMENT OF THE MINERALS AND RAW MATERIALS SECTOR

Prior to the start of perestroika (the year 1985) Buryatia had operated 16 large mining complexes, numerous enterprises extracting placer gold and CM. In the structure of the republican industry, they account for 15% of the output of products, and for 10% of the number of employed [6]. By the mid-1990s, most of the enterprise ceased their activity or decreased their production capacities. The Dzhidinskii tungsten-molybdenum integrated plant, the Novokizhinginskii beryllium mine, the Gusinozersk coal mine and the Kholbol'dzinskii stripping (and other enterprises) were liquidated.

Nowadays, uranium, gold, tungsten, coal, quartzite, nephrite and building materials are extracted on the territory of Buryatia (Table 2). According to data of the Department of Mineral Resources Management for the Central Siberian District as of July 1, 2015, Buryatia registered 317 users of mineral resources and issued 526 licenses (without regard for CM), including 107 licenses for placer gold and 41 licenses for lode gold. Thirty-eight licenses were issued and 17 licenses canceled in 2014.

Industrial development of the numerous prospected and prepared (for exploitation) deposits of different types of minerals is progressing at a slow pace. Use of mineral resources involved 100% of assured reserves

Table 2. Write-off of mineral resources for account of extraction, and increase in reserves for account of prospecting in Buryatia

Mineral resources	Extraction of mineral resources		Increase in reserves for account of prospecting	
	2013	2014	2013	2014
Uranium, t	446	439	17 862	0
Coal, thou t	2852	2814	13 138	0
Tungsten, t	386	891	-158	0
Copper, thou t	0	0	0	8.7
Gold, t	5.813	4.172	3.696	5.993
Silver, t	5	7	-1	2.5
Fluor-spar, thou t	0	1	0	0

Note. Compiled from data of the Department of Mineral Resources Management for the Central Siberian District.

of lode gold deposits, some types of non-metallic resources (graphite and dolomite for metallurgy, limestone for chemical industries, quartzites, glass raw materials and molding materials); most of placer gold (83%), expanded clay aggregates (70%) and mineral paints (98%); partially (6–40%) – nephrite, fluorite and building materials.

Characteristic for the minerals and raw materials sector of Buryatia are all negative factors inherent in the mineral sector of Russia, including the unfavorable conjuncture of the market of mineral resources, crisis phenomena in the world and Russian economy, and a shortage of financial resources.

The development of the sector is negatively influenced by the following problems.

1. Low pace of development of large deposits by users of mineral resources, and violation of conditions for use of subsurface resources as regards the period of development of deposits. The chief reasons are a poor exploration of the deposits, and a shortage of financial resources. It is necessary to enhance control by competent authorities over the fulfillment of conditions of license agreements and to take organizational decisions, including cessation of the right to use subsurface resources.

2. Absence or shortage of infrastructure facilities, which has a negative influence on investments in promising deposits. Construction of infrastructure facilities of mining production (transport and energy), on the one hand, requires significant investments and, on the other, extends the period of development of deposits.

3. Complexity and long duration of the procedure of granting the right to use CM deposits, which does not permit a relevant organization to complete the construction of repairs to motor roads of railroads within the prescribed period.

4. Insufficient and unstable funding (from the federal budget) of geological prospecting efforts on the territory of Buryatia, with the exception of uranium (Table 3).

Investment activity is negatively influenced by the need for significant investments, given the long periods of recoupment; absence of undistributed assured deposits of mineral resources: gold, nephrite and coal; nonconformity of the engineering-and-economic indicators to modern economic conditions, and the need for their reassessment; stringent requirements of foreign investors to the execution of documentation at the stage of decision-making regarding investments, and nonconformity of documentation to international standards, and insufficiently effective measures for State support of the investors' activity (it is necessary to ensure the participation of the State in the construction of the infrastructure, and tax incentives for extraction of mineral resources).

Table 3. Financing of geological prospecting on the territory of Buryatia

Indicators	Years					
	2008	2009	2010	2011	2012	2013
Funds of the federal budget, million rubles	566.3	512.3	536.8	338.6	433.6	599.2
geological survey	129.9	147.4	147.8	22.2	26	31.7
uranium	252.7	313	359	312.5	372	352.5
gold	183.7	51.9	30	0	30	215
non-metals	0	0	0	3.9	5,6	0
Funds of users of mineral resources, million rubles	1257.5	1049.6	2201.4	2003	2104.8	2151
uranium	57.4	227.7	346.6	552.2	415.8	324
ferrous, non-ferrous and rare metals	236.3	60.9	150.9	126.2	214.3	185
gold	946.6	721.9	1663.4	1285.6	1412.3	1600
non-metals	15.1	13.6	10.9	39.0	69.4	42
subsurface waters	2.1	0	0	0	0	0
coal	0	25.5	29.6	0	0	0
Total, million rubles	1823.8	1561.9	2738.1	2341.6	3193.7	2750.2

Note. Compiled from data of the Department of Geology and Licensing for the Republic of Buryatia, Department of Mineral Resources Management for the Central Siberian District.

A further development of the mineral sector of Buryatia is aggravated by the specific natural, climatic and ecological conditions for development of the deposits: a severe continental climate, high seismicity, complicated (mostly mountain) topography, and the poorly developed infrastructure. The high electric energy rates in Buryatia, given a significant energy intensity of extraction and processing of mineral resources, lead to a significant increase in the product cost, and to a decrease in competitiveness of products. In 2017, Buryatia ensured that Minenergo (Ministry of Energy) of the Russian Federation included the republic in the zone of free transfer “Siberia” for an unlimited duration. This led to a decrease in the cost of electric energy for the industry by 25%, on the average: for small business from 6.97 to 4.93 rubles, for middle-sized business from 5.62 to 3.93 rubles, and for big business from 3.59 to 2.84 rubles per kW/hr. Nevertheless, the power rates are high.

The greatest influence on the development of the minerals-raw materials sector of Buryatia comes from the “Baikal factor” [7]: restrictions of the economic activities on the Baikal Natural Area (BNA) as established by the Water Code of RF, the federal laws “On the protection of Lake Baikal” and “On ecological examination”, the Decree of the Government of RF “On approval of the List of the kinds of activity prohibited in the Central Ecological Zone of BNA”.

On December 5, 1996, by resolution of the 20th sessions of the UNESCO World Heritage Committee, Lake Baikal was included on the List of World Natural Heritage sites of UNESCO. In the Central Ecological one of BNA (CEZ BNA; see figure) that coincides with

the World Natural Heritage site (WNHS), the following activities are prohibited: extraction of metallic ores; prospecting and development of new, previously not exploited deposits, and extraction of mineral resources within the water area of Lake Baikal, in its water-protection zone, in the channels of spawning rivers and in their water-protection zones. Furthermore, the turnover of land is prohibited within WNHS.

The ecological requirements aimed at the preservation of WNHS, Lake Baikal, lead not only to an increase in the cost of investment projects but also to the impossibility of developing some of the deposits. Thus, the Kholodninskoe lead-nickel deposit (Russia’s largest, 11.2 and 34.1% of the lead and zinc reserves, respectively), upon being granted the license, found themselves within CEZ BNA, which led to the suspension of the license [8, 9]. On November 28, 2017, the license was withdrawn by Rosnedra ahead of time.

The development of the minerals-raw materials sector of Buryatia is severely affected the prohibition of prospecting and extraction of CM within the boundaries of the water-protection zones. By a Decree of the Government of RF [10], the water-protection zone of Lake Baikal was established (within minor deletions) in accordance with the outline of CEZ BNA. Upon expiration of the period of the license, there will arise problems with the construction of and repairs to buildings, structures and roads. The requirement for the State ecological examination of designing and estimate documentation of all facilities being constructed and reconstructed in BNA caused economic difficulties and retarded the construction of social facilities.

Authorities and geological and mining organizations of Buryatia see themselves as responsible for the preservation of Baikal. The avenues for a further development of the region's mining industry were outlined at the NATO Advanced Research Workshop "Sustainable Development of the Lake Baikal Region. A Model Territory of the World (September 11–17, 1994, Ulan-Ude) [11].

Large-scale expensive measures for the preservation of the natural environment are needed not only for mining operations but also for carrying out all activity of mining enterprises, including the construction, exploitation, recultivation, waste handling, and the preservation of soils, the atmospheric air and surface and subsurface waters. Since environmental measures are necessary for the creation and operation of all industrial and agricultural enterprises, it would be appropriate to grant BNA the status of territory of priority socio-economic development.

MAIN DIRECTIONS OF DEVELOPMENT OF THE MINERALS-RAW MATERIALS COMPLEX

The structure and dynamics of the minerals-raw materials complex of Buryatia are determined by the variants of the set of the most important investment projects. The main sector of the minerals-raw materials sector of Buryatia is production of gold. The share of the balance reserves of gold of Buryatia in the Siberian Federal District makes up 3.2%, and the proportion of production constitutes 12%, which indicates an intense exploitation of the deposits.

The gold production sector of Buryatia is represented by two groups of enterprises. One group includes companies predominantly dealing with lode gold; they are primarily PJSC Buryatzoloto accounting for more than half the production of this metal in Buryatia. The other group operates with placer gold which is characterized by high expenses and low profitability. Placer deposits are located mainly in difficult-of-access areas, have small reserves and low gold content and are not sufficiently profitable. A decline in the world price of gold for such enterprises is a critical factor of existence.

During the period from 1990 to 2004, the volume of gold production increased nearly by a factor of 4

to reach the historical maximum [6]. Later, a decline in production occurred due to the exhaustion of the placer deposits (Table 4). In 2010–2011, a decline in gold production was caused by a decrease in its content in commercial ore. Recently the situation has begun to change for the better. In 2014, compared with the previous year, the volumes of gold output increased by 17.1% (6922.7 kg were extracted). The main contribution to the gold production dynamics is made by PJSC Buryatzoloto. In 2014, the volume of gold output by PJSC Buryatzoloto increased by 22% (against 2013), to 119.7 thou oz, through an increase in gold content in ore (by 18%, to 5.58 g/t), in the volume of ore processing (by 3%, to 686 thou t) and of the coefficient of extraction (by 0.7 percentage points to 92.9%). In 2015, the gold content in ore extracted by PJSC Buryatzoloto averaged 5.45 g/t [12].

The internal factors of development of gold production include the operation of the managerial bodies and enterprises of the gold production sector dealing with its regulation, the reproduction of the minerals-raw materials base and implementation of investment projects aimed at improvement of efficiency of development of the resources. The most dynamical and strongest external factor is the price of gold. In the event of its decrease, the enterprises with high expenditures connected with gold production will cease production. A decline in the prices of gold can lead to the "fading scenario" or, at best, to a stabilization of the volumes of gold production and, at worst, to a loss of one-third to half of the volumes.

The prospects for development of the polymetals subsector in Buryatia are associated with the Ozernyi lead-zinc deposit located beyond BNA, which substantially eases the designing of the enterprise [13]. The East Siberian Metals Corporation forming part of the METROPOL Group is planning to construct the Ozernyi Mining and Processing Plant with the capacity of 8 million tons of ore using X-ray radiometric separation at the ore-preparation stage. It is proposed to create the enterprise with a complete cycle of production of refined lead, zinc lumps, silver, cadmium and sulfuric acid. The mining enterprise with the capacity of 1 million tons of ore was put into commission, and the first ore was extracted. The

Table 4. Extraction of gold in Buryatia, kg

Indicators	Years										
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total volume	8127	7573	6861	6609	6145	6384	5805	5904	7865	6427	6896
Lode gold	5145	5066	4896	4910	4926	5212	5094	4602	6527	4891	4955
Placer gold	2982	2507	1965	1699	1519	1172	711	1302	1138	1536	1941
Proportion of lode gold, %	63	67	71	74	80	82	88	75	83	76	72

experimental-industrial mining and processing plant is being constructed; however, the dates of its putting into service as stipulated by the licensing agreement have been postponed.

Work is being underway on development of the Khiagda uranium deposit (and other deposits) of the Vitimskii ore field. This investment project forms part of the Federal Target Program “Socio-economic development of the Far East and Transbaikalia”. The balance reserves of uranium amount to 40 thou t and are being increased through geological prospecting. It is anticipated that the project of experimental-industrial operations would make it possible to obtain not only uranium but also scandium and rare-earth elements.

Development of the deposits is restrained by abrupt fluctuations in market prices, which makes it impossible to determine the sequence of extraction of separate types of mineral resources. Thus, the “molybdenum boom” that occurred a decade ago was replaced by a lessening of interest in this metal, which led to the abandonment of the license for the Orekitkanskoje deposit and cessation of the operations on the Zharchikhinskoe deposit.

The issues related to the market situation and the price of minerals in demand to date are quite complicated both in this country and abroad. Planning of the long-term development of the minerals-raw materials base of the region is impossible without taking them into account. Only on the basis of the demand for a particular mineral resource is it possible to determine the avenues for the most effective investment of State funds as well as of private capital.

In spite of statements regarding an acute shortage of alumina, chromium and manganese and the need for their import substitution, federal funds on the territory of Buryatia are only invested in searching for gold and uranium. Business entities are interested in placer gold, nephrite and CM and, to a lesser extent, in quartzite and fluorite, the extraction of which does not require large capital investments.

CONCLUSIONS

The minerals-raw materials sector is one of the main economic branches of Buryatia; it accounts for a significant portion of industrial production, tax revenues and employment of people. On the other hand, in spite of the existence of a large number of assured and prepared (for exploitation) deposits of different types of minerals, their industrial development is proceeding at a slow pace.

The negative influence on the development of the sector comes from the unfavorable situation in the market of mineral resources, crisis phenomena in the world and Russian economy, and a shortage of financial resources. The conditions for development of

the deposits in Buryatia are considerably complicated by a severe continental climate, high seismicity, complicated (mainly, mountain) topography and the poorly developed transport infrastructure, and special ecological requirements associated with the fulfillment of the Federal law “On the protection of Lake Baikal” and the status of World Natural Heritage site.

In the present circumstances, the main directions of development of the minerals-raw materials complex of Buryatia should include: reproduction of highly marketable and extremely scarce minerals; rational use of subsurface resources, attainment of completeness and integrity of the extraction of mineral resources, strengthening of the mining-geological and administrative control over the activity of enterprises in the sector; implementation of investment projects aimed at an increase in the production volume and improvement of extraction and processing technologies; concentration of financial resources and formation of mechanisms for the federal/republican participation and support of the sector, and solution of legal, territorial, technological, socio-economic and other issues related to the extraction of mineral resources in the Baikal natural area.

The development prospects for the minerals-and raw materials complex of Buryatia involve restoring in gold production a normal level of reproduction of the raw-materials base; in the polymetals subsector – launching investment projects of development of the Ozernyi deposit, and in the uranium subsector – obtaining representative results for taking the final decision about the construction of the uranium extraction enterprise on the basis of the Khiagda ore field.

This work was done with the financial support from the Russian Foundation for Basic Research (16-17-10129).

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