Issues of mineral resources base restoration in Titanium consuming industries of Russia

Fedoseev S.
Saint-Petersburg Mining University, Saint Petersburg, Russia

Sidorov. N.
Petersburg State Transport University, Saint Petersburg, Russia

Nikolaeva O.
Institute of Economic Problem, G.P. Luzina KSC RAS,
Murmansk region, Russia

Tochilo M.
Saint-Petersburg Mining University, Saint Petersburg, Russia

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Abstract

Overview of actual problems in the reconstitution of Russian mineral resource base of titanium dioxide reproduction. Providing the Russian Federation economy with mineral raw materials after the collapse of the USSR, as a whole, has declined substantially, and some types of mineral raw materials became scarce. Among them are titanium-containing raw materials. Therefore, solution of the problem to ensure the long term raw material titanium industry of the country and to strengthen the overall mineral potential - becomes important issue. A comparative analysis of the mineral resource base structure of the USSR and the Russian Federation is carried out. A preliminary assessment of prospects for reconstruction of the mineral and raw material base for titanium consuming industries is presented.

Corresponding author: Tochilo M
Email address for corresponding author: diary.93@mail.ru
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1. Introduction

In the USSR, on an industrial scale have been identified, explored and taken to the deposit balance of all known species of titanium-containing raw materials. The structure of the mineral resource base for geological and industrial types of deposits ores, by the degree of geological exploration and preparedness for industrial use showed the existence, at that time, of opportunity to fully meet current and future needs of the country in its own raw materials (Cherepovitsyn 2016).

All known deposits of titanium ores in their genesis, mineralogical and chemical composition, and technological properties are divided into two industrial types (USGS 2013):

• ores deposits, which after the enrichment process separates in concentrates of "simple" structure (ilmenite-magnetite, ilmenite, rutile, loparite, ilmenite ores of weathering crust, ilmenite placer, leucoxene);

• ores deposits, during the enrichment of which are produced concentrates of complex composition (titan magnetite, perovskite, sphene).

For ores at enrichment of which can be obtained concentrate of "simple" structure, there are cost-effective processing technology or have already been developed and mastered on an industrial scale, their development is carried out without much difficulty (State Report of Russian Federation 2014). For ores at enrichment of which may be obtained concentrates of complex composition, There are no technological schemes of industrial processing of concentrates produced from them, providing a cost-effective extraction of all or most useful components. One of the main criteria for assessing the mineral resources base of titanium consuming industries in the country – is the degree of current and future needs security of the titanium-magnesium, chemical, paint and other industries (Hayes 2011).

2. Analysis of the USSR structure of titanium containing ores

After the collapse of the USSR, many deposits of titanium containing ores (55.4% of balance reserves of industrial development types of the ores) found itself outside the Russian Federation. Most of them are the largest ore deposits, which are exploited for the processing of cost-effective technologies (rutile, ilmenite placer ilmenite ores of weathering crust, ilmenite-magnetite deposits, rutile-zircon-ilmenite placer). Total balance sheet and off-balance sheet reserves of titanium dioxide in Russia have fallen at 17.5% in the USSR (Fedoseev 2015). As a result, supply of the national economy with titanium-containing raw materials has decreased so much that even with a relatively low volume of consumption at the present time in country - the production of titanium products provided with own raw materials only in a small extent. The pigment titanium dioxide has passed into the category of short supply kind of product and the need for it has to be covered by imports (Ritesh Tiwari 2014).

The structure of the reserves of titanium-containing ores by commercial types in the Soviet Union at 1 January 1991 (in terms of titanium dioxide) presented in Figure 1.

Industrial types and kinds of ores	Balance reserves		Off-balance sheet reserves
	A+B+C1	C2	
1. Ores, for which is assimilated technology of processing			
1. Ilmenite-magnetite	25,5	9,6	7,2
2. Rutile	0,3	0,6	-
3. Ilmenite ores of weathering crusts	2,4	3,3	0,1
4. Loparite	2,9	0,2	0,3
5. Ilmenite placer	7,9	1,7	5,4
6. Ilmenit-magnetite placer	0,8	1,0	0,6
7. Magnet-zirconium placers	5,2	0,3	4,3
8. Zircon, rutile, ilmenite placer	18,2	17,4	49,6
9. Leucoxene *	13,0	52,6	17,3
Total amount of ores with the presence of assimilated processing technology	75,2	86,7	84,8
2. Ores that do not have assimilated technology of processing			
1. Titanomagnetite **	6,5	0,1	15,2
2. Perovskite	17,3	13,2	-
Total amount of ores that do not have assimilated processing technology	23,8	13,3	15,2
Total	100,0	100,0	100,0

Fig.1 Structure of titanium containing ore reserves in the USSR (in terms of titanium dioxide),%

* There is technology of rutile processing, but there is no cost-effective technology of extraction rutile from heavy oil.

** The finely-disseminated ores, what enrichment with existing methods cannot provide successful identification and separation of magnetite and ilmenite concentrates.

Analysis of the industrial development of titanium ores deposits showed that in the USSR 14.5% of balance dioxide reserves of categories A + B + C1 belonged to the producing fields and 17% - prepared for operation. This suggests that, on the one hand, in the Soviet Union was created by a reliable mineral resource base for the reproduction of titanium products (metal titanium, ferrotitanium, titanium dioxide pigment), on the other hand, there was a "exploration too much" deposits of titanium-containing raw materials, what required significant investment costs, but has created a great potential for titanium industry development in the future, which were able to meet fully the internal market as well as to ensure the production of competitive products to provide the country's access to the world market.

So, by the end of 2016, the import of titanium dioxide into our country decreased by about 33% compared to 2015 and amounted to 43.5 thousand tons, while the demand for industries in raw materials is about 80 thousand tons. The reduction in the supply of raw materials is primarily due to the increase in prices, due to political sanctions, the increase in export customs duties by countries of raw materials exporters, and the refusal to export to Russia the largest Ukrainian producer of titanium dioxide, Sumykhimprom.

Here is a brief look at some key issues of development and implementation of the development strategy.

An alternative to traditional types of titanium-containing raw materials, on the basis of which the mineral resource base for titanium consuming industries was formed in the Soviet Union, are now indigenous titanium magnetite and perovskite-titanium magnetite ores, titanium magnetite and sphene concentrates, which can be obtained at enrichment of Khibiny apatite nepheline ores. A variety of non-traditional forms of titanium raw materials largely united by common properties - in particular, they have a favorable quantitative and qualitative parameters to certain conditions while providing a basis for the formation of a reliable mineral resource base of titanium-consuming sectors of the Russian industry (Russian Academy of Sciences 2013). One of those conditions – is industrial development of efficient processing technologies. Developing of new types of titanium-containing raw materials is required by their complex use through advanced resource-saving technologies (Porter 2014).

The use of such technology – is the main decisive factor in the implementation of the new strategy for mineral and raw material base formation, and also, is the transition from resource-consuming to resource-saving type of mineral resource base reproduction. Implementation of this strategy will translate new types of titanium-containing raw materials from the category of inefficient or ineffective in the category of highly performed, to expand and strengthen the mineral and raw material base by engaging in industrial production new types of mineral raw materials, and to ensure acceleration of the reproduction process of mineral resource base for the titanium sector of the country.

The development strategy of the mineral resource base for titanium consuming sectors of Russian industry includes the following items:

1. A significant (two-three times) increase in the volume of exploration work with a simultaneous expansion of scientific and industrial research and development work in order to transfer to economically viable amounts probable reserves of discovered and explored deposits of titanium raw materials in reserves of industrial categories.
2. Alignment of the quantitative and qualitative parameters of the mineral resource base structure with the structure of titanium consuming industries.
3. The most complete extraction from subsoil and the integrated use of all, which are having industrial importance types of titanium-containing raw materials through the use of modern cost-effective resource-saving technologies.
4. The additional involvement in the turnover, along with traditional types of ores, new types of titanium-containing raw materials.

5. Conducting more proactive state policy in the field of development and implementation of the state preferential system in order to create favorable conditions for the reconstruction of the mineral resource base for titanium consuming industry in the country.

3. Analysis of the Russian Federation structure of titanium containing ores

Analysis of mineral resource base of titanium-consuming sectors of Russian Federation industry indicates that, in the first place, has sharply decreased resource potential overall of all mineral resource base (State report, Moscow 2014). Secondly, the structure of the balance reserves containing titanium ores, the ratio of ore classification for its industrial development, types and other parameters are not currently consistent with the structure of industries, which provide production of titanium products. Fig.2. In these circumstances, taking into account the need to ensure the sustainable economy of the Russian Federation, the titanium-containing raw materials and high inertia of the whole mineral resource sector there is a need to develop and implement a new strategy of development of mineral resource base of titanium consuming industries.

Industrial types and kinds of ores	Balance reserves	
	A+B+C1	C2
1. Ores, for which is assimilated technology of processing		
1. Ilmenite sands	2,34%	0,00%
2. Ilmenite - titanomagnetite	1,46%	0,86%
3. Apatite-ilmenite-titanomagnetite	15,26%	2,41%
4. Loparite	9,12%	5,43%
5. Placer	1,81%	1,06%
6. Apatite nepheline	5,62%	3,29%
7. Titanomagnetite	25,75%	8,55%
Total amount of ores with the presence of assimilated processing technology:	61,36%	21,59%
2. Ores that do not have assimilated technology of processing		
1. Leucoxene quartz sandstone oil	24,59%	45,60%
2. Perovskite	14,05%	32,81%
Total amount of ores that do not have assimilated processing technology	38,64%	78,41%
Total	100,0	100,0

Fig.2. the structure of the titanium containing ores reserves of the Russian Federation as of January 1, 2014 (in terms of titanium dioxide), %

The deposit of ilmenite-titanomagnetite ores "Southeast Gremyakha", located 20 km south-west of the town of Murmashi and belonging to the Gremyakha-Vymers massif complex, with the ore quarry productivity, is attractive from the point of view of industrial development according to preliminary technical and economic estimates. In 2 million tons per year and obtaining 300 thousand tons of ilmenite concentrate. The existing technology for the production of titanium dioxide will produce highly profitable products and cover the country's domestic deficit. Fig.3.

The African giant deposit, located 1 km from the village of Afrikanda (Kandalaksha region), also belongs to the perspective for the development of titanium dioxide deposits, due to its favorable location near the Kola nuclear power plant and the October railway. Taking into account the variety of types of titanium-rare-earth raw materials, a complex of combined technological processing schemes has been developed at IHTREMS allowing to meet both economic and environmental safety requirements, availability of chemical reagents, and the possibility of obtaining the product of the required branded composition. According to preliminary calculations, the creation of the "Titanium Pigments" LLC of the integrated production of perovskite concentrate processing will yield 45 thousand tons of pigment raw material per year (Kalinnikov , V. T. and Nikolaev 1996).

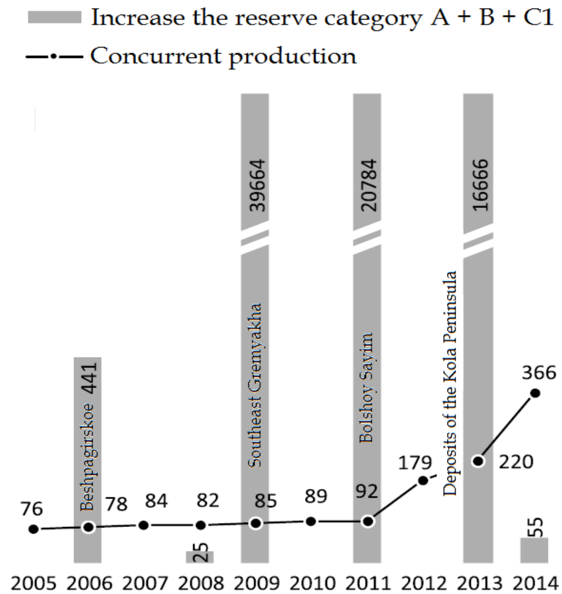

Fig.3. Dynamics of increase in exploration of titanium dioxide deposits in the Russian Federation, mln. Tons.

4. Discussion and conclusion

In the Russian Federation and abroad have accumulated many years of experience in the field of integrated industrial use of various kinds of titanium-containing raw materials and created a large scientific groundwork for the development and implementation of effective resource-saving technologies, the use of which may give intermittent, breakthrough effect (Middlemas 2016). In particular, the use of integrated technology indigenous titanium-magnetite ores, which is based on the principle of resource conservation, provides: ore concentration by dry and wet magnetic separation with separation of collective titaniferous magnetite (iron-titanium-vanadium) of the concentrate; pelletizing the concentrate and calcining it for pre-reduction of iron oxides (A review of the production 2014); electros melting metallized pellets in ore-thermal furnaces to produce a pig iron and vanadium-titanium containing slag; blowing BOF vanadium iron, thereby producing intermediate steel and vanadium slag (Gazquez 2014); intermediate processing of steel for the production of high-quality natural-vanadium alloy steel and titanium; processing of titanium containing slag by sulfuric acid technology with the release of the pigment titanium dioxide; processing of vanadium slag to produce ferrovanadium (Ponomarenko 2016).

Described technology has the following advantages:

1) Based on it - new types of titanium-containing raw materials are involved in the use;
2) The final products are of much higher quality compared to the quality of similar products manufactured by traditional technology from traditional forms of titanium raw materials;
3) The range of useful extracted components is quite expanding;
4) There are no resource-intensive processing, one-time and ongoing costs per unit of output are summed;
5) Applied technological equipment can be mass-produced by national industry.

Qualitative assessment of all open and explored deposits of titanium-containing raw materials are located in the area, which is available for development, according to the position of the value of stocks, the development of mining conditions, mineral and chemical composition, development degree of its integrated use technology - allows to conclude that a cardinal solution to ensure stable production of high quality raw material titanium dioxide pigment production is the creation of a new type of artificial titanium raw materials - high-titanium slag produced during pyro metallurgical processing of titanium-magnetite ores (Sahu 2006).

Thus, the final solution to the problem of reconstruction in the Russian Federation, reliable mineral resource base to provide the production of high-quality competitive titanium products in the volumes, which could cover the internal market and possible export, could be accomplished by industrial development and integrated use based on the modern efficient technologies of open indigenous titanium magnetite deposits, perovskite titanium-magnetite ores and concentrates of titanium-magnetite sphene, which can be extracted at enrichment of Khibiny apatite-nepheline ores (Tronox 2014).

It became necessary to revise the stereotypical views on types of titanium-containing raw materials, which can play a decisive role in the reconstruction and development of a reliable mineral resource base of titanium consuming sectors of the Russian industry.

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