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## ВЛИЯНИЕ КИТАЯ НА ГЛОБАЛЬНЫЙ РЫНОК И РОССИЙСКОЕ ПРОИЗВОДСТВО НАУКОЕМКИХ РЕДКОЗМЕЛЬНЫХ ПРОДУКТОВ

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В статье выполнен анализ влияния Китая, являющегося монополистом на глобальном рынке редкоземельных металлов, на производство и потребление, а также цепочек поставок и формирования добавленной стоимости наукоёмкой продукции на основе РЗМ. Рассмотрены проекты производства РЗМ в России. Подтверждается тезис о том, что редкоземельные металлы стали глобальным экономическим и политическим инструментом.

**Ключевые слова:** Китай, редкоземельные металлы, производство, потребление, цепочка добавленной стоимости.

## THE INFLUENCE OF CHINA ON THE GLOBAL MARKET AND RUSSIAN PRODUCTION OF SCIENCE-INTENSIVE RARE EARTH PRODUCTS

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The present article analyzes the influence of China as a monopolist in the global rare earth market its production and consumption, supply chains and added value of science-intensive rare earth products. Russian projects of rare earth production are considered. One of the main theses is confirmed: that rare earth metals have become a global economic and political instrument.

**Key words:** China, rare earth metals, production, consumption, added value chain.

Today rare earth metals[1] role is very important and grows every year because this type of raw material is used in many technologies and science-intensive products. For examples, REMs are used in household appliances such as TVs, cell phones, computers; vehicles such as cars, planes, submarines, tanks; science-intensive areas such as lasers, superconductors, high-temperature ceramics, high-quality optical glasses. The most dynamically developing technologies are energy-saving and nature-conservation technologies (they are often named "green technologies"), for example, wind turbines, solar panels, electric cars, etc.

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[1] Rare earth metals (REM) or Rare Earth Elements (REE) are group of 15 lanthanides having serial numbers from 15 to 71 in the periodic table (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium) as well as yttrium, sometimes scandium (serial numbers 39 and 21, respectively). There are three groups of REM depending on atomic weight: light, average and heavy (Rare Earths is often divided into two groups in the different literature: only light and heavy). Taking into account the configuration of electrons in atoms REM are divided into cerium and yttrium groups [1]

The global production of such products is asymmetric. First of all, as a rule, light rare earth elements (LREE) make up a significantly larger proportion in an ore than heavy rare earths (HREE), and this proportion doesn't correspond to demand and its dynamics produced by the global market (in this case we are talking about the balance problem or the problem of balancing [2]). Secondly, LREE's consumption volume in natural terms is about 92% in recent years, and HREE – 8% (Table 1, Table 2); in cash terms LREE's market is about 67%, and HREE's market – 33%, correspondingly. Thirdly, China has become a key player in the market. It has successfully transformed geological rare earth potential into a global monopoly and controls up to 80% of the world supply volume of raw materials. Moreover, China has necessary knowledge, technological and production chains within national borders allowing to use more 70% of the world consumption in its high-tech industry.[2]

*Table 1*

World rare earths production and reserves, thousand tonnes

| Country | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Reserves[3] |
|---|---|---|---|---|---|---|---|---|---|---|
| China[4] | 89,2 | 93,8 | 93,8 | 93,8 | 105 | 105 | 105 | 105 | 120 | 44 000 |
| Australia | - | 2 | 3 | 3 | 8 | 12 | 15 | 19 | 20 | 3 400 |
| Russia | 2,3 | 2,5 | 2,4 | 2,5 | 2,6 | 2,8 | 2,8 | 3 | 2,6 | 18 000[5] |
| Brazil | 0,14 | 0,14 | 0,11 | 0,33 | - | 0,88 | 2,2 | 1,7 | 1 | 22 000 |
| Thailand | 5,6 | 3,1 | 0,12 | 0,13 | 1,9 | 0,76 | 1,6 | 1,6 | 1 | - |
| India | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,7 | 1,5 | 1,5 | 1,8 | 6 900 |
| Malaysia | 0,38 | 0,41 | 0,1 | 0,18 | 0,24 | 0,5 | 0,3 | 0,3 | 0,2 | 30 |
| Vietnam | 0,17 | 0,2 | 0,2 | 0,1 | - | 0,25 | 0,22 | 0,1 | 0,4 | 22 000 |
| USA | - | - | 3 | 5,5 | 5,4 | 5,9 | - | - | 15 | 1 400 |
| Burma (Myanmar) | - | - | - | - | - | - | - | - | 5 | - |
| TOTAL | 99,5 | 104 | 105 | 107 | 126 | 130 | 130 | 133 | 170 | 120 000 |

Nowadays the main question is the following: will China be a reliable rare earth metals supplier for the rest of the world? Moreover, it is more important to HREE deliveries. Beijing's desire to improve the environmental situation in REE industry, to eradicate illegal mining may significantly affect REE deliveries and first of all heavy group. Since these elements are basically obtained from poor quality ion-adsorption clays in Southern China (particularly Jiangxi and Guangdong), where illegal mining was widespread with all the ensuing environmental consequences [3]. In addition, detailed estimations of REMs reserves, conducted explorations, technical and economic indicators of REM's projects are not published at the state level.

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[2] REE's consumption in other countries: Japan - 10 - 11%, USA - 8 - 9%, EU - 6 - 7% and other - up to 6% [3].

[3] According to Chinese production quotas, which don't include illegal supply.

[4] According to mineral-resources classification of USA.

[5] According to Russian mineral-resources classification by $A + B + C_1 + C_2$ categories there are more than 26,9 million tonnes in the country [4].

*Table 2*

The world rare earth consumption structure by applications in 2013–2014 (in rare earth oxides), % [5]

| Applications | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Y | Other | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magnets | | | 23,4 | 69,4 | | | 2 | 0,2 | 5 | | | 100 |
| NiMH batteries | 50 | 33,4 | 3,3 | 10 | 3,3 | | | | | | | 100 |
| Metallurgy | 26 | 52 | 5,5 | 16,5 | | | | | | | | 100 |
| Autocatalysts | 5 | 90 | 2 | 3 | | | | | | | | 100 |
| Petroleum cracking catalysts | 90 | 10 | | | | | | | | | | 100 |
| Polirite | 31,5 | 65 | 3,5 | | | | | | | | | 100 |
| Glass additives | 24 | 66 | 1 | 3 | | | | | | 2 | 4 | 100 |
| Phosphors | 8,5 | 11 | | | | 4,9 | 1,8 | 4,6 | | 69,2 | | 100 |
| Ceramics | 17 | 12 | 6 | 12 | | | | | | 53 | | 100 |
| Other areas | 19 | 40 | 4 | 15 | 2 | | 1 | | | 19 | | 100 |

According to the statistics from United States Geological Survey (USGS), the legal production of REMs were more than 130–135 thousand tonnes per year (in oxides) in 2015–2017 years in the world (Table 1), and consumptions – 160–170 thousand tonnes per year (in oxides) which correspond to about $ 5–9 billion in our estimation (Figure 1) [6].

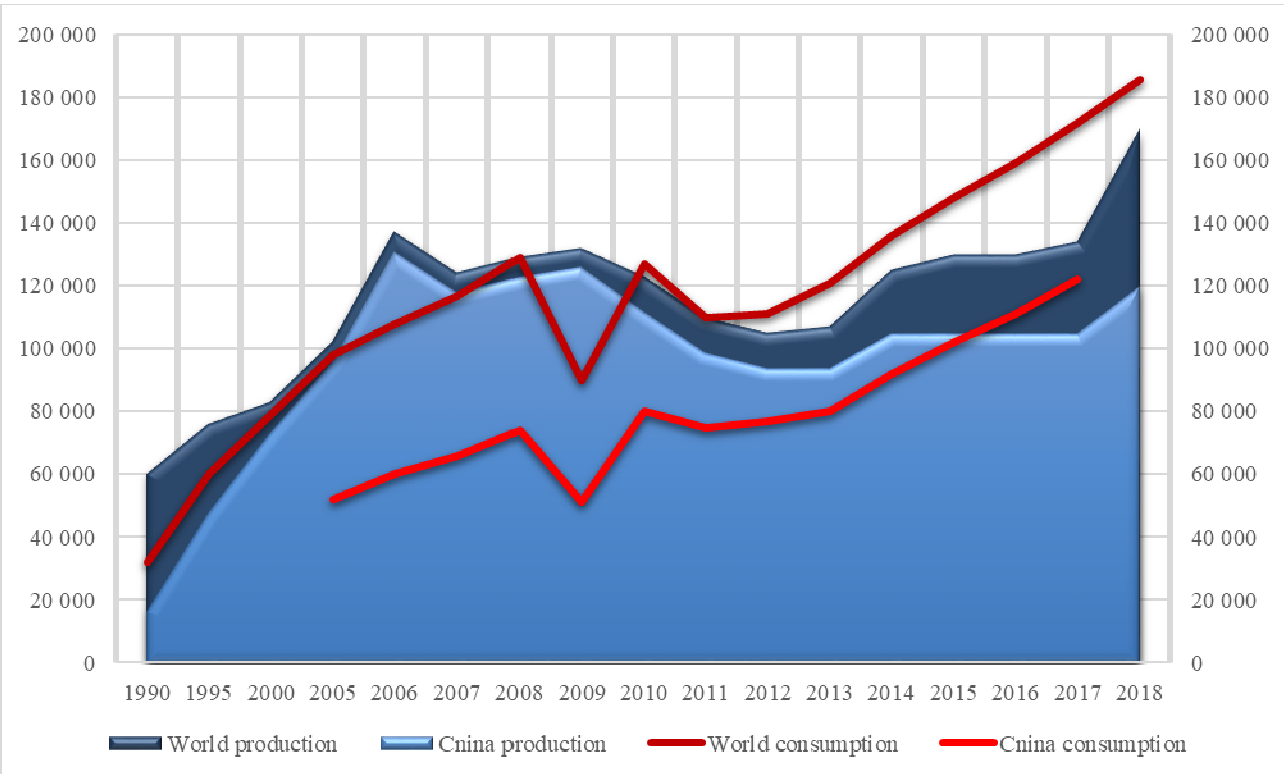


Figure 1. The world and Chinese production and consumption of REMs (in oxides), tonnes

At the same time, the entire global market of science-intensive rare earth products was about $ 1,5–2 trillion, which correspond to 9–12%whole of the world trade (Figure 2).

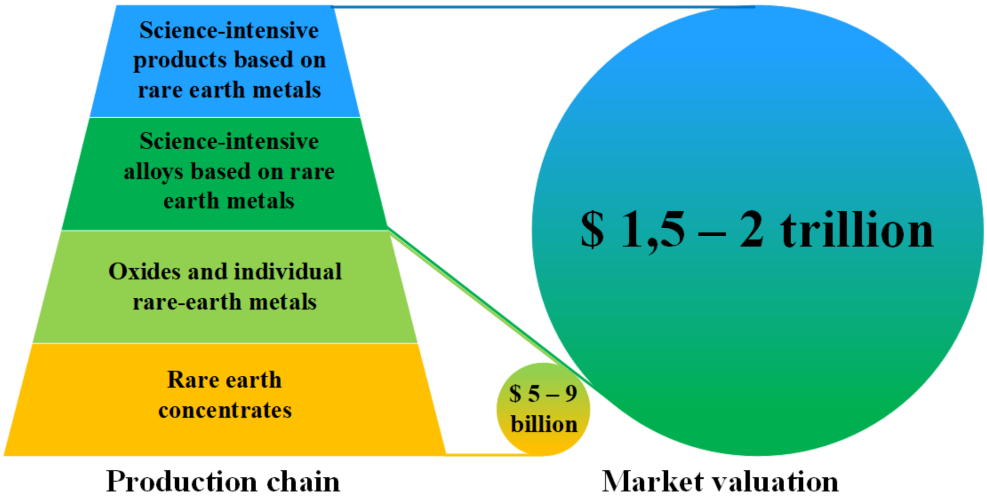


Figure 2. The global rare earth market valuation by stages of the production chain

In recent years, it has become clear that the Chinese government will pursue a policy of retaining the entire production chain and added value of science-intensive rare earth products within the county because it's considering this type of resource a national heritage (not only strategic). Therefore, they created storage facilities for LREM in Baotou in 2009 and HREM in Southern China in 2012 in order to regulate both the national and global rare earth market and pricing [7, 8, 9].[6] Chinese officials are able to convert abolished quotas and taxes in other financial and fiscal instruments after the World Trade Organization's intervention in 2012–2014, for example, in domestic subsidies or benefits (including access to rare-earth reserves) without breaking existing rules of international trade.

It confirms one of the main thesis that rare earth metals have become global economic and political instrument (more and more controlled by the Chinese). The Chinese government showed how it could be used for achieving national interests in 2010-2011.[7] Moreover, it is time when the high-tech world creates science-intensive products based on REE at a fast rate and world rare earth production can't support rapidly growing demand (Figure 1). According to USGS statistic, the average annual global increase of rare earth consumption is about 7% and the average annual global

[6]For example, Chinese government purchased 20 from 21 thousand tonnes (in oxides) at the State Reserve [3].

[7]For example, there was strong reduction of export rare earth quotas in 2010 and suspension of delivery of REM and their products to Japan during territorial controversy about the Senkaku islands (The Diaoyu archipelago in Chinese).

increase of rare earth production – 4% since 2005. If this trend continues, the average annual global increase of consumption would be about 250–280 thousand tonnes per year by 2025 (production – 180–200 thousand tonnes per year) and 350–380 thousand tonnes per year by 2030 (production – 210–250 thousand tonnes per year).

Thus, today it is necessary to develop new projects of mining REE deposits, complex technologies for processing waste and recycled materials and such projects are currently starting to appear. For example, the Australian company Lynas and Threibacher Industrie AG have made an entire production chain of creating science-intensive rare earth products outside China and demonstrate outstanding development results (Table 1) [10].

Russia has a huge potential to create a whole production chain. However nowadays the Lovozero mining and processing plant in Murmansk region has capacity of processing rare earth ore into loparite concentrate. Then it is delivered to the Solikamsk Magnesium Plant (SMZ, Perm region) where concentrates in the form of chlorides and carbonate of rare-earth metals is obtained from loparite concentrate. In their turn, new concentrates are delivered to the AS Silmet in Estonia to produce oxides and individual metals. The American company Neo Performance Materials (earlier Molycorp) has owned this plant since 2011. The estimated total supply is 3–5 thousand tons per year (in oxides) that needs of US high-tech industry.

Several pilot rare earth projects were launched in Russia in recent years. One of the biggest world producing mineral fertilizers (Acron Group) has launched a project of complex processing of apatite-nepheline ores at one of the sites of the North-Western Phosphoric Company (SZFK) in Veliky Novgorod. The capacity of pilot production of cerium oxide, lanthanum oxide, neodymium oxide, concentrates of light, medium and heavy groups is about 200 tons per year. There are plans to create large-scale production in the SZFK and the Dorogobuzh plant (Smolensk region) in the future [11, 12].

Processing waste of mineral fertilizer production (phosphogypsum) are another way of obtaining REM. Nowadays there are about 200 million tonnes of these substance in plant facilities tailings in Russia which contain 80-98% gypsum and about 100 thousand tonnes of REM. The phosphogypsum annual increase is 10–15 million tonnes. The company “Laboratory of innovative technologies” (LIT) will solve this problem. It includes in the holding Skygrad (Moscow region).Probably the PhosAgro will be the main supplier to the LIT Company with which the corresponding agreement has already been signed. The phosphogypsum processing capacity is planned at the level of 20 thousand tonnes per year. In addition, there are plans of a rare earth concentrate to process from the Solikamsk Magnesium Plant at the level of 2–4 thousand tonnes per year in 2019 [13].

The unique niobium-rare-earth deposit Tomtor (Sakha Republic) can become another potential project for the national industry development. It contains a score of both traditional minerals such as iron, phosphorus, titanium, vanadium and rare elements such as niobium, yttrium, scandium and a group of lanthanides, whose reserves can provide Russian needs for hundred years [14]. The company “ThreeArc Mining” has plans to locate metallurgical production for processing Tomtor ores in the

Priargunsky Industrial Mining and Chemical Union territory (Krasnokamensk, Trans-Baikal Territory) [15]. They are planning to produce until 10 thousand tonnes per year (in rare earths oxides) by 2021 and occupy a dominant position in the European market, providing until 10% of the global rare earth metal supply [16].

Unfortunately, there are no high-tech production in Russian industry, which use REM. As a result, there are no initial demand for these strategic science-intensive mineral resources. For example, starting from the 2000s a sharp push of demand for individual REMs started development of green and renewable energy; first of all, wind power stations and electric vehicles, which are not produced in the Russian Federation.[8] These areas can become unprecedented drivers of growth in rare-earth metals consumption. Therefore, all national producers will be forced to focus on export and foreign markets. And it will certainly lead to competition with Chinese rare earth products.

Obviously, the Chinese authorities will continue their strategy, aiming to develop the REM mining sector and vertical expansion and gradually integrate the upstream stages of the value chain to cover a larger share of added value. For example, according to UNCTAD, the kilogram value of a$Nd_2Fe_{14}B$ compound (neodymium permanent magnets) is about 18 times greater than the kilogram value of the corresponding concentrate [9].

Today it becomes obviously that sustainable economies can be those where companies form the whole production chain within the national rare earth industry (including vertically integrated companies). It allows countries to avoid the influence of China'saggressive pricing policy and help diversify suppliers. It is especially relevant for the light group of rare-earth metals because these elements are abundant in the world market without the key elements of this group – neodymium and praseodymium (these elements are in short supply in the market). The confirmation is that prices high-tech products (such as neodymium magnets, catalysts, batteries, etc.) remained stable when oxides and individual rare-earth metals prices were falling in 2010–2011.

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