J. Resour. Ecol. 2017 8(3) 213-222
DOI: 10.5814/j.issn.1674-764x.2017.03.001
www.jorae.cn

Overview on China's Rare Earth Industry Restructuring and Regulation Reforms

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Abstract: Rare earth elements (REEs) that are key to new technologies and green innovations are critical to life in modern societies. China continues to dominate the global REEs market despite several international trade disputes and market fluctuations. Pressured by an increasingly difficult situation, the Chinese government has been carrying out industry restructuring and has introduced regulatory reforms in recent years to promote the healthy development of the rare earth industry. This paper reviews the literature on the development of the rare earth industry and analyzes the reform policies, combining this with an analysis of relevant macroeconomic data. It discusses the current status of China's rare earth industry, the progress of industrial restructuring and the main problems the rare earth industry faces. The paper discusses the evolution of rare earth policies from that of "open production and open supply" to that of "limiting low quality development but encouraging export of high quality rare earths" and then to "integrating rare earth resources trade". Six key policies, including those for export quotas, export duties, environmental laws, resource utilization technology, industry consolidation and stockpiling, are discussed in detail. Policy suggestions based on this discussion are put forward concerning the treatment of small rare earth mines in China: firstly, robust efforts to prevent illegal mining must always be maintained; secondly, it is certain that the formation of large-scale conglomerates should be accelerated in the near future; thirdly, the management of key sections should be reinforced; fourthly, support for technological innovation and the development of the applications industry should continue; fifthly, specific rare earths laws and regulations should be greatly improved. The paper also puts forward some suggestions on revisions to improve mineral resources law: firstly, China must increase the market access threshold and suppress low-end excess production capacity; secondly, the new environmental protection verification must be developed for all rare earth enterprises; thirdly, minimum required indicators for the development and utilization of rare earths resources must be implemented in China. These recommendations can serve as a reference for efforts to promote the sustainable development of China's rare earth industry.

Key words: rare earth policy; industry restructuring; small-scale mining; regulation; China

1 Introduction

The rare earth elements (REEs) industry is very small compared to other industries, but it is strategically important. Due to their unusual physical and chemical properties, such as unique magnetic and optical properties, REEs have diverse applications in modern industry (Bruno, 2012; Grasso, 2013). They are critical inputs for the manufacture of many high-tech products and for technologies key to systems for clean energy, national security, and for military and defense

Received: 2017-02-13 **Accepted:** 2017-04-20
Foundation: National Key Research and Development Program of China (2016YFA0602802); National Natural Sciences Foundation of China (71633006); Project granted from National Geological Library of China (cg12016067A1)
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Citation: SHEN Lei, WU Na, ZHONG Shuai, *et al*. 2017. Overview on China's Rare Earth Industry Restructuring and Regulation Reforms, *Journal of Resources and Ecology*, 8(3): 213–222.

applications (Yang *et al*., 2013). The essential functions of REEs in a range of high-tech products make them strategic items of national relevance.

REEs, of which there are 17 different chemical elements, are divided into light REEs or LREEs (lanthanum, cerium, praseodymium, neodymium, promethium and samarium, with atomic nos. 57–62) and heavy REEs or HREEs (europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, with atomic nos. 63–71) (Connelly, 2005). REEs have higher concentrations in a deposit than copper or iron, which are distributed in low concentrations (Liu and Bongaerts, 2014). Rare earths in fact are not very rare, but it is very difficult to find deposits that can be exploited economically and, because REEs have very similar properties, that allow for simple methods of extraction and separation. Rare earth minerals are quite abundant in the earth's crust and widely distributed in thirty-four countries. According to the data from the US Geological Survey, global rare earth oxide (REO) reserves stood at about 130 million tons in 2014 (USGS, 2015).

China is the world's largest producer and exporter of rare earths products, dominating the global market with an 85 to 95 percent share each year since the late 1990s (Du and Graedel, 2013). China exports its REEs largely to Japan, the United States and the European Union. China has a near monopoly on the production of REE minerals, concentrates and metals (Levkowitz and Beauchamp-Mustafaga, 2010). Nevertheless, citing a need to conserve the environment and to protect exhaustible natural resources, China has been struggling to limit REE exports through quotas, licenses and taxes (Kingsnorth, 2010). In 2014, China's rare earth production was 93800 tons and export quotas were reduced to 31000 tons, especially for dysprosium, terbium, thulium, lutetium, yttrium (USGS, 2015). This restrictive policy resulted in friction with the West and Japan (Eddy, 2012; Massari and Ruberti, 2013; Vateva, 2012). The United States, the European Union and Japan lodged a complaint with the World Trade Organization (WTO) in 2012, arguing that China's restrictions on REEs exports were designed to provide China's domestic downstream industries with protected access to the minerals (Weslosky 2012; Morrison and Tang, 2012). In March 2014, the WTO ruled in favour of the complainants, asking China to remove its export tariffs and quotas or face repercussions (WTO, 2014).

Because of the important role China's rare earths play in the world market, the number of studies focused on China's regulatory framework for rare earths has increased. China has failed in the past to attain pricing power and large profits in spite of its monopoly position (Zhang *et al*., 2015), and has even suffered from the "China discount" problem (Liao and Liu, 2011). These factors created the rare earths policy conflicts between China and the rest of the world (ROW) (Hayes-Labruto *et al*., 2013). From the perspective of the ROW, China's control of the REEs market was one of "resources nationalism" and the regulatory policies that resulted did not comply with WTO rules (Hu, 2012). Political purposes, "unfair competitive advantage", and "an attempt to capture more rents along the value chain" were the three key worries of the ROW (Hayes-Labruto *et al*., 2013). Actually, the Chinese perspective was focused on domestic demand, environmental worries, social upheavals, illegal mining, smuggling, and abiding by international trade regulations (Hao and Liu, 2011). The major drivers behind China's rare earths policies were concerns about domestic resources conservation and environmental protection (Wübbeke, 2013). Actually, the export quotas and export tariffs on rare earth industry were not effective for Chinese rare earth high-tech industries (Tukker, 2014). If China cut off rare earths exports, there would be a shortage in the global high-tech markets and prices would rise sharply (Massari and Ruberti, 2013). It is an indisputable fact that a diversification of suppliers was needed (Stegen, 2015), but the establishment of alternative REE supply chains was truly a challenging and delicate task (Machacek and Fold, 2014). Global availability of rare earths will increase, following the opening of new mines in different parts of the world (Massari and Ruberti, 2013). Therefore, if China were to abolish rare earths export quotas and export tariffs, the control of rare earth exports would be greatly weakened, and the regulation of rare earths in the future could prioritize domestic exploitation and production (Wang, 2011), with resource-related and environmental taxes being the key factor affecting the market supply of rare earths (Han *et al*., 2015).

This article aims to provide an overview of the rare earth industry adjustment in China, focusing on the current status of industry restructuring and the consolidation of small-scale mines, the historical evolution of the policy framework and the potential for changes to current policy. The paper will include a discussion of international markets, the availability of these strategic resources, the possibilities for substitution and recycling, and environmental problems. Finally, some policy recommendations for the future development of China's rare earths industry are provided.

2 China's rare earth industry

2.1 Mining, production and exports

There is considerable uncertainty about the quality and location of rare earth reserves. According to a US source, China accounts for 36.5% of global rare earth reserves, although China contests this and claims it accounts for only 23% (XINHUAnet, 2012). Most of China's rare earth reserves are located in the four regions: Inner Mongolia, Sichuan, and Shandong provinces, and seven provinces that share borders in southern China (Jiangxi, Fujian, Guangdong, Guangxi, Hubei, Hunan and Yunnan). The deposits in Inner Mongolia, and Sichuan contain mainly LREEs. Inner Mongolia's Baiyun Obo is the biggest mining reserve in China, accounting for 83.7% of total REEs reserves (Yang

et al., 2013). In southern China, particularly in Jiangxi and Guangdong, deposits in ion-adsorption-type clays contain high concentrations of the precious and expensive HREEs (Wübbeke, 2013).

Most rare earth enterprises in China are located in the areas where there are rare earth mines. Three major bases include:

a. The northern production base for rare earths, dominated by Baotou mixed rare earths, with a separation capacity of 80000 tons;

b. The medium and heavy rare earth production base in Jiangxi and the other six southern provinces, dominated by ion-type rare earths, with a separation capacity of 60000 tons;

c. The production base for bastnaesite in Mianning, Sichuan, with a separation capacity of 30000 tons.

There are two production systems for rare earths: one is the northern light rare earths process, dominated by products like rare earth concentrates, rare earth alloys, mixed rare earth compounds, enrichments and metals, various single rare earth compounds, rare earth polishing powders, and some value-added products like permanent magnetic materials and hydrogen storage alloys. The other process for medium and heavy rare earths is found in the south and produces various high-purity single rare earth compounds, enrichments, mixed metals and alloys.

Rare earths smelting and separating enterprises in Inner Mongolia area are mainly concentrated in the Baotou area (Liu and Xie, 2008). There are some 60 rare earth enterprises at present, including 20 key enterprises. Baotou has two enterprises with annual processing capacity of more than 10000 tons of rare earth concentrates, five backbone enterprises with more than 5000 tons of capacity, and 12 enterprises with 2000–3500 tons of capacity; the remaining enterprises have less than 2000 tons of processing capacity. The Inner Mongolia Rare Earth High-tech Company is the largest Chinese enterprise for rare earth mineral production and rare earth smelting and processing.

Of the 104 mining rights certificates in the southern provinces and regions of China in 2013, 88 were owned by Jiangxi Ganzhou Rare Earth Mining Ltd, an enterprise with 20 rare earths separation firms and annual capacity of 60000 tons (Wu, 2011). This company, which is located in Ganzhou city and produces mostly medium and heavy rare earths, is responsible for the integrated exploitation, production operations and management of rare earths, and for all investment and foreign cooperation. The China Minmetals Corporation has established a China Minmetals Rare Earth Co., Ltd. in Jiangxi Province with an investment of CNY 2 billion over 5 years. The company is aiming at annual separating capacity of 13500 tons and is looking to become the world's largest integrated enterprise group for the mining, processing, and application of rare earths. In Sichuan Province, there are 28 rare earths enterprises engaged in mining, smelting and separating. Only two or three enterprises can be considered large scale; the remainder are small and responsible for considerable environmental pollution and damage to resources.

At present, there are more than 500 legally registered enterprises in China engaged in rare earth mining and production, of which 123 have mining permits. A conservative estimate shows that capacity for rare earth separation has reached 170000 tons, but actual capacity may be over 200000 tons. The Ministry of Commerce of the People's Republic of China (MOC) declared that China has been satisfying more than 90% of global demand for decades (MOC, 2014a). REEs exports increased from 150 tons in 1978 to a peak of 57400 tons in 2007, and then decreased to 16800 tons in 2011, with 56% of exports going to Japan, 14% to the USA, and 10% to France. To date, REO has accounted for more than half of rare earth exports, while rare earth salts, and rare earth metals only made up small parts. Global rare earth demand reached 210000 tons in 2015, while Chinese domestic demand was 138000 tons; by 2020, China's gross domestic consumption is expected to reach 190000 tons, of which 130000 tons will go to high-tech applications, accounting for 68% of the world's total consumption.

In 2004, China began implementing a series of restrictive policies to control rare earth exports. The sharpest decrease in export quotas occurred in 2010, when quotas decreased by nearly 40% compared to 2009. This decrease of rare earth exports led to nervous trade relationships between China and importing countries. The main importing countries complained that China's policies violated free trade rules and artificially inflated global prices. The MOC announced that China would abolish export quotas beginning in 2015 (MOC, 2014b). On January 21, 2015, the MOC reported that China's rare earth export tariff would be abolished on May 2, 2015 (XINHUAnet, 2015).

2.2 Progress restructuring

In 2013, as a result of restructuring, China set up a total control quota of 93800 tons (REO) for rare earth mining and planned to use 90400 tons for smelting and separation products. Actual annual production output was only 80400 tons and 83300 tons went to smelting and separation products, accounting for 85.7% and 92.1% in the planned targets, respectively. Both Jiangxi Province and the China Minmetals Corporation reduced production partly due to environmental transformation and price suppression. Also in 2013, China set an export quota for rare earths of 24000 tons (equivalent to the physical volume of 31000 tons), but the actual annual export volume was only 22900 tons of product, accounting for an increase of 36.3% and having a value of US $603 million. According to the official statistics for 2013, China's rare earth industry had operating income of CNY 76.9 billion showing growth of 7.9%, and realized a

profit of CNY 7.74 billion, a decrease of 28.1%, which was the result of lower prices. New rare earth materials have become the main driving force in the Chinese rare earth industry.

At present, Inner Mongolia, Guangdong, Jiangxi, Fujian and other provinces have basically completed integration of the mining, smelting and separating of rare earths, and formed large scale enterprise groups for rare earths. Giant state-owned enterprises like China Minmetals, China Aluminium Corp (also known as Chalco) and others have intensified structural adjustments and enhanced their industrial scale and comprehensive strength.

In an environment of special support and guidance for rare earth industry adjustments and upgrades, China has constructed six comprehensive public technology service platforms, and is engaged in a number of high-end materials and devices projects. The quality and performance of the majority of rare earth raw materials have reached international levels and the added value of the products has increased significantly. The expectation is that within a few years asset reorganization and mergers will result in less than 20 rare earth enterprises (Wang *et al*., 2015).

2.3 Major issues

Since March 2012, the trade dispute concerning China's exports of raw materials has placed rare earth resource products in the teeth of a storm. Small-scale mining and cut-throat price competition have brought difficulties to the domestic rare earth sector over the years (XinhuaNew, 2014). Still, there has been some of the root reasons and self-development problems of the rare earth industry in China, including especially a long-term downturn in prices that began in the year 2007, extensive mining, serious environmental pollution, excess processing capacity, and a lack of self-development ability (See Fig. 1).

Moreover, some extremely urgent issues are at hand. First, illegal, unplanned production occurs frequently, resulting in chains of black interests involving mining, production, circulation, and smuggling. This has seriously disrupted market order and led to a substantial decline in the price of rare earth products. Second, excess rare earth smelting and separation capacity is a serious problem; and third, preventing the illegal production and circulation of rare earths is made more difficult due to deficiencies in the legal and regulatory framework.

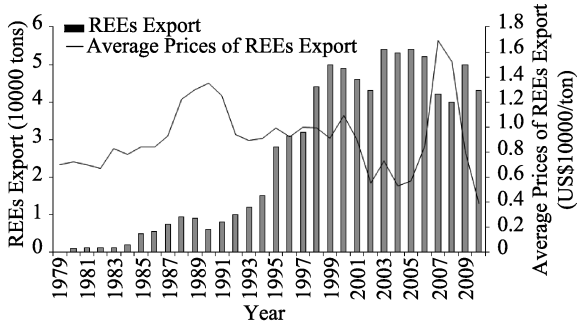

Fig.1 Annual exports and changes in average price of rare earths in China from 1979 to 2010

Data sources: USGS (2001–2013); CSRE Yearbook (2007–2014)

Irrational exploitation of rare earth resources has caused serious damage to local ecologies. Here we cite two of the numerous examples. In Baotou, Inner Mongolia, water pollution due to illegal mining threatens the water quality and safety of downstream sections of the Yellow River, while in Ganzhou, Jiangxi, excessive mining and extraction of rare earths in Ganzhou have severely damaged the Dongjiang River where it is estimated that ecological restoration will cost at least CNY 38 billion. It is estimated that each kilogram of rare earths produced in China has an environmental cost of US $5.60, whereas the sale price of rare earths was only US $5.50 per kg from 2002 to 2005. Even though rare earth prices have increased 1.5 times from 2005 to 2007, this increase is far less than price increases for gold, copper and iron ore during the same period. As a result, the gap between the price and the actual value of rare earths is great.

Disorderly, illegal mining is conducted repeatedly by small-scale mines. In 2013, the Ministry of Industry and Information Technology (MIIT) joined with the Ministry of Public Security (MPS), the Ministry of Land and Resources (MLR), the Ministry of Environmental Protection (MEP) and other seven agencies to launch a special action aimed to curtailing illegal rare earths activities. According to publicly available information, 46 illegal pilfering cases were investigated, 126 illegal production enterprises were ordered to stop production and be rectified, 161 enterprises business licenses of rare earths enterprises were revoked, and more than 19000 tons of rare earth ore and illegal products were seized.

The smuggling of rare earth products is rampant. In 2011, the volume of rare earth smuggling reached 22320 tons, far more than the volume exported by legal channels. In 2013, there were five cases in which Chinese customs seized a total of 2330 tons of smuggled rare earths products valued at CNY 52.5 million. As part of its effort to protect resources and the environment, the Chinese government has imposed export duties and management measures for quotas on rare earths and related products. Nevertheless, these policies were identified by WTO as not conforming to WTO principles that China has committed to. As a result, the Chinese government has to regulate the industry at the source where rare earths are mined. Today, rectification work in some areas of provinces (or regions) has achieved remarkable results. Rare earth mining areas in Baotou have implemented closed fence management. Advanced video monitoring systems have been installed in the major mining areas of Ganzhou and Mianning. In Ganzhou, a number of violations of laws and regulations involving rare earths have been investigated and dealt with. As rectification activities have intensified, market order in China's rare earths indus-

try has improved markedly.

The benefit game between rare earths stakeholders was obvious. A new concept for establishing north and south rare earth groups was being considered as early as 2002 (Hayes-Labruto *et al*., 2013). It was only in 2010, however, that the MIIT and National Development and Reform Commission (NDRC) put plans on the policy agenda to integrate the rare earths industry, choosing several state- owned and backbone enterprises to be the vehicles for integrating all rare earth resources. After several years of efforts, there is a consensus that it is very difficult to move forward with the integration process for the rare earth industry. The key reason lies in the games played many stakeholders, including the benefit games between the central and local governments, between regions, and between some main enterprises of rare earths as well.

3 Rare earth policy evolution

3.1 Historical evolution of rare earth policy

China's rare earths production started in 1957 at the Bayan Obo iron mine in Inner Mongolia (Tse, 2011). Production was no more than 1000 tons for the next 20 years. Since the reform and opening policies were introduced in 1978, China's rare earth industry has experienced rapid development. In 1986, China surpassed the US as the world largest REEs producer with a total REO output of 11860 tons. Currently, China can produce over 400 varieties of rare earth products with more than 1000 specifications and has total production of 95000 tons (Fig. 2), even though its share of global production decreased to 86% in 2014.

The Chinese government has implemented several policies to manage rare earth production and to control exports. Management policies for rare earth production have been readjusted several times since 1970, beginning with policies that supported free development and then moving to policies that restricted and controlled development. China's rare earth industry policy has also gradually changed from one of local strengthening to one of comprehensive management.

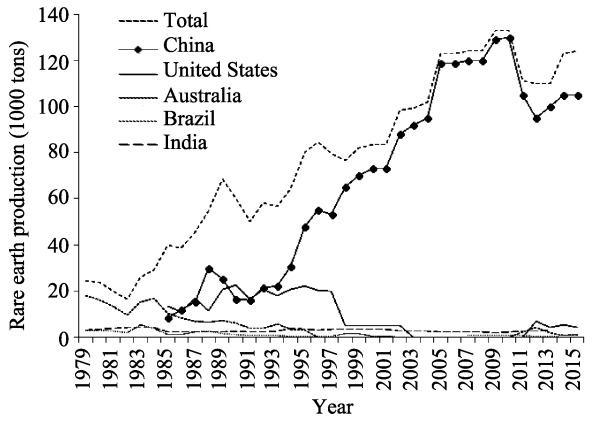

Fig.2 Global rare earths mining production (1979–2015)
Data sources: USGS (2015)

Policy developments can be roughly divided into three stages:

(1) The first stage from 1978 to 1998 was characterized by a policy of *"open production and open supply"*. Because global demand for rare earths was enormous, as was the potential for profits, China's production and export of rare earths expanded rapidly during this stage. Production increased by an average of 40% per year between 1978 and 1989. Chinese rare earths entered the international market in the 1980s. During the 1990s, China's rare earth production increased sharply and, by the mid-1990s, China had surpassed the USA as the world largest producer of REEs. During this time, China treated rare earths as a general resource and a tool to earn foreign exchange from export sales. Export tax rebates on rare earth products acted as "rare earths for foreign currency". In the early 1980s, China's export volume of rare earths was only 20 tons, but in 2006 it reached its highest level of 53313 tons, accounting for 97% of the world total (see Fig. 1).

(2) The second stage from 1998 to 2005 saw a policy of *"limiting low quality but encouraging high quality rare earths exports"* aimed at restricting the export of raw materials and roughly processed rare earths while encouraging the export of deep processed rare earths products. During this stage, policies to limit mining were adopted, including rare earths export quota licenses, export quota controls, the reduction and gradual elimination of export tax rebates, and mining quotas. At the same time, the Chinese government developed a plan to solve the problem of overcapacity in rare earth industry and to address the chronic difficulties caused by a continuous price slump. But in fact, total export quotas in each year of this stage exceeded world market demand. It can be seen that before 2005 the Chinese trade policy considered rare earths to be general export products, the key role of which was to earn foreign exchange.

(3) The third stage, which began in 2005 and continues today, has implemented a policy of *"integrating the management of rare earth with new trading"*. Since 2006, China has put into place a series of rigorous policies to control the rare earth industry. These policies include controlling the total quantity of production, continuously raising the export tariffs on rare earth products, promulgating the "rare earth industry development policy" (China Daily, 2012) and "the long-term development plan for the rare earth industry", issuing "rare earth industrial pollutants emission standards (GB 26451-2011)" and "rare earth industry access conditions", establishing a system of strategic reserves for rare earths, and strictly controlling all approvals of rare earths projects. At the same time, the ministries of the State Council have carried out various special actions to crack down on smuggling of rare earths, to ensure the orderly development of the rare earths industry, and to coordinate actions focused on rare earth mining, production, environmental protection and anti-smuggling operations. Comprehensive plans are in place to maintain the sustainable development of rare earth

industry and protect the environment in China.

To address existing problems and because of the rapid development of the rare earth industry in China, the Chinese government has implemented a targeted control policy. This control policy is divided into phases. It should also be noted that China started to decrease the volume of rare earth exports in 2006, citing as reasons increased domestic demand and concerns about environmental degradation. As a result of these actions, critical supply uncertainties were created among key industries worldwide and significant price increases were noted beginning in 2009 (Morrison and Tang, 2012).

3.2 Key components of rare earth policy

Several policy measures, which have played critical roles during a given period, can be identified:

(1) Export quotas. In 2009, China's rare earth export quotas included: 20 general trade enterprises with a first batch export quota of 15043 tons and a second batch quota of 16267 tons; 11 foreign-invested enterprises with a first batch export quota of 6685.1 tons and a second batch quota of 10160 tons. In 2013 and 2014, rare earth export quotas remained almost the same as they were in 2010 but were significantly less than those in 2009.

Since 2012, China has been implementing an allocation system for the rare earth export quota; however, the MOC divided export quotas into two groups for the first time, with classified management for LREEs and HREEs. In 2012 the first batch was 10546 tons, including 9095 tons of LREEs and 1451 tons of HREEs. At the same time, China began to implement a strict environmental verification system targeting rare earth export enterprises. For example, rare earth export enterprises that did not pass an environmental protection audit given by the MEP were not allocated any quota. On 26 December, 2011, the MOC published the list of rare earth export enterprises in 2012 and issued the first batch of rare earth export quotas. The 11 enterprises that passed the environmental audit were given a quota of 10546 tons, but the rest of the quota of 14358 tons was reserved for enterprises that had not passed the environmental audit. If these enterprises had passed the audit in July, 2012, they were going to be allocated a quota of 14358 tons. On 16 August, 2012, six enterprises obtained a quota of 9770 tons for a second batch of rare earth exports, including 8537 tons of LREEs and 1233 tons of HREEs.

As shown in Table 1, the export quota amount for 2010 was only about 60% of the 2009 quota, a significant decrease. The rare earth export quotas in the years 2010, 2011 and 2012 remained relatively stable. In the years 2013 and 2014, the total quota remained almost the same, but some small changes in the structure occurred: the 2013 quota of 3617 tons for HREEs decreased by 257 tons in 2014, and the 2013 LREEs quota of 27384 tons increased by 262 tons.

Table 1 China's export quotas for REEs from 2009 to 2014 (tons)

Items	2009	2010	2011	2012	2013	2014
First Batch	21728	22283	14446	21226	15499	15110
Second Batch	26427	7976	15738	9770	15502	15500
Supplement	1990					
Total	50145	30259	30184	30996	31001	30610

(2) Export duties. China began to implement an export tax rebate policy on rare earth products in 1985. As of January 1, 2004, the export tax rebate for rare earth metals had been adjusted from 13% to zero and the tax rebate rate for inorganic or organic compounds from the rare earth metals scandium, yttrium, and their mixtures had also been changed from 17% or 13% to 5%. After May 1, 2005, export tax rebates on rare earth metals, rare earth oxides, rare earth salts and other products were eliminated altogether. In 2007, the duty rates were set at 10% and applied to a few products. The export duties levied on rare earth products since June 1, 2007, have aimed to control the type and quantity of rare earths being shipped outside of China. Over the years, duty rates have increased and now range between 15% and 25%. An example of these elevated rates can be found in China's 2011 export duty schedule that imposes a 25% export duty on ferroalloys that are more than 10% REEs.

(3) Environmental laws. Over time, China has steadily improved its control of high polluting and resource-based products with an eye to protecting the environment. As of 2015, in principle at least, no new rare earth smelting or separation projects in China will be approved and rare earth smelting or separation capabilities will not increase. More rigorous requirements will be imposed on the scale of production and the equipment enterprises use for rare earth smelting or separation, and strict standards will be implemented for environmental protection, production technology, resources and energy consumption. Existing enterprises are required to focus more on research and development, technological transformation, and equipment investments in order to improve product quality and implement cleaner production.

(4) Technology for resources. China is encouraging the use of rare earth products in high-tech fields, especially in the fields of information technology, environmental protection and the development of circular economies. This new policy initiative fits remarkably well with China's goal of moving the rare earth business to higher value-added, more technically advanced sectors. Private and small-scale firms, however, have difficulties taking advantage of this initiative.

(5) Industry consolidation. The Chinese government has made it a priority to close down small-scale rare earth operations and consolidate larger ones. The policy goal stated in "*Plans for Developing the Rare Earth Industry 2009-2015*" called for the establishment of three large rare

earth production areas, one in the north (Inner Mongolia and Shandong), one in the south (Fujian, Guangdong, Guangxi, Hunan, and Jiangxi) and one in the west (Sichuan), and two production systems, one located in the north, the other in the south. Another goal is to reduce the number of enterprises engaged in mining and processing rare earths to around 20 through mergers, phasing out small-scale, unlicensed mines and reversing the trend towards lower export prices of precious minerals.

(6) Stockpiling. There is a consensus that China should set up a stockpiling system for rare earths and thorium (for energy) and support leading domestic producers like Baogang, Minmetals, and Jiangxi Copper in implementing such a system (Hurst, 2010). Similarly, China should build a national strategic base for rare earth resources in northern China. The plan is to store all of the REEs that are excavated but not used in a given year in order to maintain price levels. As of 2008, a new rare earth industry base was being constructed in an effort to allow more efficient regulation of rare earth pricing and to guarantee future supplies.

3.3 Implications of small-scale rare earth element mining

The current policy adjustment of the rare earth industry in China is facing serious challenges with respect to the regulation of small-scale rare earths mines. It is likely that small-scale REEs mining will continue to have a significant negative impact.

(1) Pressure against illegal mining will be maintained.

China is strengthening supervision as the MIIT works jointly with public security, land, environmental protection, customs, taxation, safety supervision and other agencies to increase inspections in problem areas. A regional linkage mechanism involving rapid communication, coordination and unified actions was established to help control the illegal production of LREEs and HREEs. A special rare earth invoice for data sharing, an optimized reporting system and other means have been introduced to identify and solve a number of major problems. Regional supervision responsibility has also been implemented, with local governments urged to investigate and deal with illegal behaviours. Other measures have also been taken, including focusing more on the supervision of local governments to prevent collusion and illegal project approvals, and strengthening the management of public opinion by reporting positive cases and exposing negative cases.

(2) The formation of large-scale conglomerates will be accelerated in the future.

The current industry pattern of mergers and acquisitions based on the six large rare earth conglomerates, including Inner Mongolia Baotou Steel Rare Earth Hi-Tech, Xiamen Tungsten Co. Ltd, China Minmetals Corp., Aluminum Corp. of China, Ganzhou Rare Earth Group Co. Ltd and China National Nonferrous Metals Industry Guangzhou Corp., needs to be consolidated and expanded. This consolidation will integrate domestic rare earth enterprises related to mining, smelting and separating. It will force the closure of illegal enterprises, reduce the number of rare earth separating enterprises, and resolve overcapacity problems. During this process, rare earth industry restructuring must adhere to the principles of government guided, corporate-led, multiple-investment, market-oriented operations. Market mechanisms must play a decisive role in the allocation of resources, and all institutional obstacles need to be eliminated by the comprehensive application of economic, technical, legal and administrative means. In this way an industry structure based on large-scale rare earth conglomerates can be developed very soon.

(3) The management of key sections to be reinforced.

The Chinese government will promote management for the comprehensive utilization of rare earth resources. Some comprehensive rare earth utilization projects, such as waste recycling, rescue recycling to overlaid mines, and so on, should be included in the management of the plan to control the total amount of production, with more attention paid to the six conglomerates mentioned above. Moreover, illegal rare earth activities should be severely punished. Management of the LREEs and HREEs classifications will be further implemented and the LREEs planning targets will be improved, while harsher penalties to punish illegal exploration and production will be put in place. Last but not least, Chinese customs will be equipped with more rapid checkout equipment to enhance its capacity to detect smuggling.

(4) Support for technological innovation and the development of the application industry will continue.

Large enterprise groups and research institutes will be encouraged to explore new rare earth materials, to develop high value-added applications, and to promote the optimization of the rare earth industry, under the policies relevant to strategic emerging industries, to major national-level science and technology projects, and the restructuring and upgrading of the rare earth industry.

(5) Laws and regulations for rare earths will be greatly improved.

In order to regulate enterprise production and operations, the MIIT will join with relevant departments to revise inappropriate management measures and develop "Rare Metals Management Regulations".

3.4 The restructuring of regulations

The rare earth industry has undergone a series of reforms in recent years.

(1) The rare earth export quotas seem to be failure.

On December 13, 2013, the MOC announced the first batch of rare earth export quotas for 2014, setting 15110 tons as the total. Of this total, the quota for LREEs was set at 13314 tons, and that of HREEs at 1796 tons. These amounts represented a reduction of 249 tons for LREEs and 142

tons for HREEs, compared to the first batch of quotas in 2013. On December 11, 2013, the Ministry of Finance (MOF) announced its plan for rare earths tariffs; tariff amounts in 2014 remained the same as they had been in 2013. The tax rate for rare metals export was 25%, but rates for the export of REOs exports were 15% for LREEs and 25% for HREEs. These export tariffs were consistent with the levels in 2012 and 2013; the export tariffs for HREEs continued to be higher. Due to weak global demand for rare earths, however, the rare earth export quotas have been ineffective in recent years, with actual exports being less than the amount allocated by quotas. The total volume of actual exports in 2014 did not change much from that in 2013.

(2) The formation of "one plus five" large-scale rare earths conglomerates has encountered difficulties.

After the WTO ruling against China, with respect to the differences in the export management of LREEs and HREEs that has been implemented in recent years, the new export policy is likely to be in accordance with the management principle of "gradually opening up the gross volume of export, but managing LREEs and HREEs differently." Furthermore, because deposits of LREEs are more abundant than those of HREEs, the former will be more volatile in the future. The removal of export limits gives more bargaining power to international buyers and there is likely to be cut-throat competition between rare earth companies.

China's rare earth industry has suffered losses as a result of the WTO ruling against China's export controls. As a result, China must deal with the pressure that results from controlling the supply of rare earths by using market-oriented means instead of administrative means. In order to give play to market-oriented means, it is imperative to prohibit private and small-scale mining, to increase the market access threshold, to suppress excess low-end production capacity, and to accelerate the formation of large rare earths enterprise groups.

In early 2014, the MIIT and other relevant departments met in Beijing to establish large-scale rare earth enterprise groups. At that meeting, the six companies mentioned above were designated to take the lead in merger and reorganization activities. Several months later in August, 2014, the MIIT agreed to form two large rare earth enterprise groups: the Northern China Rare Earth (Group) Corporation founded by the Baogang Group and South China Rare Earth Group founded by the Xiamen Tungsten Corporation. After years of efforts to promote integration, China's rare earth industry is changing from a structure that included large, medium, and small enterprises to a structure dominated by several large-scale conglomerates.

Additionally, the plan to control the total amount of rare earths has also faced challenges. In March, 2014, the United States, Japan and the European Union filed a WTO complaint against China's rare earths export restrictions. Since that time, the domestic rare earth industry has been in a downturn. In July, 2014, the MIIT and the MOF jointly issued "National Fund Management Regulations on the Development of the Internet of Things and the Rare Earth Industry" to provide financial support for the regulation of rare earths mining and high-end applications. Following promulgation of this policy, the Chinese government provided one-time awards to the mining companies that passed environmental audits. Rewards of CNY 1000 per ton for rare earths mining, CNY 1500 per ton for smelting and separating, and CNY 500 per ton for rare earth metals smelting were provided.

(3) A new environmental protection verification procedure has been developed for all rare earth enterprises.

In order to implement *"The opinion of the State Council on promoting the sustainable and healthy development of rare earth enterprises*" (also called the No. 12 code in 2011） and "*The opinion of the State Council on strengthening environmental protection"* (the No. 35 code in 2011), the MEP began environmental inspections of rare earth enterprises in 2011. The Ministry stressed that approved enterprises listed in the announcement should ensure the normal and stable operation of pollution treatment facilities in accordance with the requirements stipulated in environmental protection laws and regulations. Enterprises not listed in the announcement should formulate a scheme for improving their environmental protection performance and take corrective actions as soon as possible. In the future, the ministry will continue its inspection work and publish a list of certificated enterprises. Furthermore, the ministry will review and inspect on both a scheduled and unscheduled basis those enterprises that received certification earlier. If an enterprise no longer meets the requirements, its certification will be revoked and its names will be announced to the public.

(4) China has implemented minimum indicators required for the development and utilization of rare earths resources.

On December 30, 2013, the MLR formulated a trial scheme in which all exploitation and utilization of mineral resources including rare earths must reach the minimum requirement of "three rates". The MLR stressed that the purpose of this scheme was to strengthen the supervision and management of mineral resources and to promote savings and comprehensive utilization of mineral resources. In addition, this scheme was implemented on the basis of *"The Mineral Resources Law of the People's Republic of China"*. The "three rates" are the mining recovery rate, the ore dressing recovery rate and comprehensive utilization rate, all of which form the primary index to evaluate the effects generated by the utilization of mineral resources. We list the minimum indicators as follows:

a. Mining recovery rate

For different types of rare earth mining enterprises that adopt different mining methods, their mining recovery rate should reach the following indicators (Table 2).

Table 2 Indicators of recovery rates of rare earth mining

Type	Mining method	Ore-body thickness(m)	Mining recovery rate (%)
the rock ore type	opencast	thin ore body (＜5)	94*
		Medium thickness ore body (5≤H≤15)	95*
		thick ore body (H ≥ 15)	96*
	underground		90
the ionic rare type	heap leaching		87 (leaching phase) or 70 (full phase)
	In-situ leaching		84 (leaching phase) or 67 (full phase)

"*" Data source: "Modern Ming Handbook" (first version in May, 2011)

b. Ore dressing recovery rate

For rock ore types, and based on differences in difficulty level of the optional performance the ores, the ore dressing recovery rate should reach the following indicators: the rate of easily optional ore is 85%, normally optional ore 75%, and barely optional ore 65%.

For ionic type, the ore dressing recovery rate should not be less than 90%.

c. Comprehensive utilization rate

For other paragenic ore with rock ore rare earths, the comprehensive utilization rate should not be less than 60%;

For associated ore with rock ore rare earth, the comprehensive utilization rate should not be less than 30%;

For ionic rare earth ore, it should be evaluated by leach liquor concentration of rare earth. When a heap or ore blocks stop injecting liquid, the ionic concentration should be less than 0.1g/L.

Other requirements of the scheme stipulate that existing mines should meet the specifications within two years of the publication of the scheme. Provincial departments of land and resources management should urge unqualified enterprises to meet the specifications within the time limit. Those that cannot meet the standard after rectification and reform should not be allowed to pass the annual inspection.

Acknowledgments

This article was presented at the 7th Conference on Sustainable Development in the Minerals Industry (SDIMI), held on July 12–15, 2015, at the University of British Columbia in Vancouver, Canada. It is based primarily on the author's report on "Responsible Sourcing of Rare Earth Elements in China" submitted as recommendations to Apple Inc. in 2014. The author would like to thank Apple Inc. and the Information Research Centre of the Ministry of Land and Mineral Resources (MLR) of the People's Republic of China for providing partial funding for the work underlying this study. This work is jointly supported by the Key Laboratory of Strategic Studies and the Key Laboratory of Carrying Capacity Assessment for Resource and Environment, Ministry of Land and Resources, China. Finally, special thanks go to Centre for Social Responsibility in Mining of the Sustainable Minerals Institute, the University of Queensland, Australia for their assistance in the realizing this task.

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中国稀土产业重组和规制改革研究综述

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摘　要：稀土元素（REEs）已经成为现代社会新技术和绿色创新应用不可缺少的重要原料。长期以来，中国在世界稀土市场上占据着主导地位，但其仍然面临一系列的国际贸易争端和不断变化的市场环境挑战。面对各种严峻的形势，中国政府一直采取各种产业重组和规制改革的措施，旨在促进稀土产业健康发展。本文系统整理和分析了稀土产业发展及其改革政策的相关文献，结合相关宏观数据分析，探讨了中国稀土产业现状、产业重组的进展及稀土产业存在的主要问题，论述了稀土政策从“放开生产和开放供应”到“限制低质量开发，鼓励高质量稀土出口”再到“整合稀土资源贸易”的演变历程，对出口配额、出口关税、环境法、资源利用技术、行业整合、资源储备等六种关键政策进行了具体分析。在此基础上，提出了针对中国小型稀土矿治理的政策建议，包括:继续保持打击稀土非法开采的高压势态、加快组建大型稀土企业集团、加强重点环节管理、支持技术创新和应用产业发展、完善相关法律法规等。同时，也提出了完善矿产资源法修订的有关建议，包括:提高稀土行业准入门槛、抑制低端产能过剩、严格稀土企业的环保核查、严格遵循“三率”最低指标要求，合理开发利用稀土资源。上述建议可为促进中国稀土行业可持续性发展提供借鉴与参考。

关键词：稀土政策；产业重组；小矿；规制；中国