

# Analysis of Competitiveness and Development Strategy of Rare Earth Industry in Jiangxi Province

## ——Research based on improved "diamond model"

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**Abstract**—There are many factors that influence industrial competitiveness in different industries or different stages of growth of the industry, and the decisive factors vary greatly. Based on Potter's "Diamond Model", this article is to build the theoretical framework of competitiveness analysis of rare earth industry, systematically evaluate the current situation of competitiveness of rare earth industry in Jiangxi Province, analyse the existing problems and reasons thereof arising out of the development of rare earth industry in Jiangxi Province and put forward solutions to the problems and strategies of promoting the development.

**Keywords**—component; rare earth industry in Jiangxi province; Diamond Model; competitiveness

### I. INTRODUCTION

The rare earth includes 15 lanthanides in the periodic table of chemical elements and two elements associated therewith, the scandium and yttrium. At present, the rare earth is widely used in petroleum, chemical industry, metallurgy, textile and other fields. In today's world, almost every 3-5 years people will find a new use of rare earth, and one out of every four new technology is related to the rare earth. Dysprosium, terbium, yttrium and other rare earth elements are indispensable raw materials in creating sophisticated weapons. The rare earth for the country, therefore, is a kind of very important strategic supplies. Jiangxi Province is the birthplace of medium- and heavy-ionic rare earth, and it is also the most important province of rare earth industry in our country. Among all the rare earth depositing in the world's proven reserves, reserves of the heavy rare earth almost all concentrates in the five southern provinces of China and Jiangxi Province accounts the most, for 35% of the national reserves. In addition, Jiangxi valuable rare earth elements are in high-grade content, supplying 90% of the world's heavy rare earth, which makes it one of the main suppliers of international market. For a long time, exports of a large number of low price rare earth have led to the loss of nearly 2/3 of the rare earth resources in China. It is estimated that China's heavy rare earth reserves can only last for 15~20 years, and then we must rely on imports to meet domestic demand. Facing the increasing importance of the rare earth resources and growing scarcity, in-depth analysis of rare earth industry competitiveness and development strategies of Jiangxi Province is not only

conducive to rational utilization of the rare earth resources in Jiangxi Province, but also to the benefit of improving China's rare earth industry status in the international rare earth industry.

### II. THE THEORETICAL FRAMEWORK OF COMPETITIVENESS ANALYSIS OF RARE EARTH INDUSTRY

Michael E. Porter concluded the main factors that affect industrial competitiveness. They are four endogenous variables—the production factors, the requirement conditions, the strategy and structure of related and supporting industries and enterprises, the competition environment, and another two main factors—the opportunities and the government. Based on these, he proposed the classical “diamond model” theory 错误！未找到引用源。。 However, this model is more applicable to analyze the industrial competitiveness in developed countries. In addition, this paper points out that the main factors of affecting the competitiveness are different for different industries or different stages of industrial growth. Therefore, it considers the characteristics of the rare earth industry to make the following amendments and supplements to the “diamond model”. (1) To introduce the knowledge absorptive capacity and innovation ability as core factors. The key factors which are contribute to develop the international competition of a industry include the continuous innovation capability and the core technology of the important field. For the rare earth industry, the innovation capability is particularly important in improving the added value of products. (2) To weaken the effect of support industry, and to specially reflect the agglomeration coupling effect of the related industries. The support industries of rare earth industry mainly include the industries for the supply of raw material and rare earth smelting separation, etc. Their products with low added value contribute little to rare earth industrial competitiveness, but the deep processing applications of rare earth downstream industries are the reflections of the core competitiveness. (3) To remove the factor of opportunity and add the factor of the cost of environment. The effect of opportunity in “diamond model” on the rare earth industry is not obvious for its contingency and unconventionality. The analysis of rare earth industry competitiveness needs to find its internal universal laws. Meanwhile, the environment pollution can be easily caused by the mining and smelting separation process of the rare

earth 错误！未找到引用源。。 Therefore, adding the cost of environment factor can make the model more realistic.

To summary, the improved "diamond model" is a systematic analysis model which includes a core factor, four important internal factors and two external factors (Figure 1).

The core factor is the knowledge absorptive capacity and innovation ability. Four important internal factors are factor conditions, demand conditions, the agglomeration coupling of related industry, and the corporate strategy. Two external factors are the government and environmental cost.

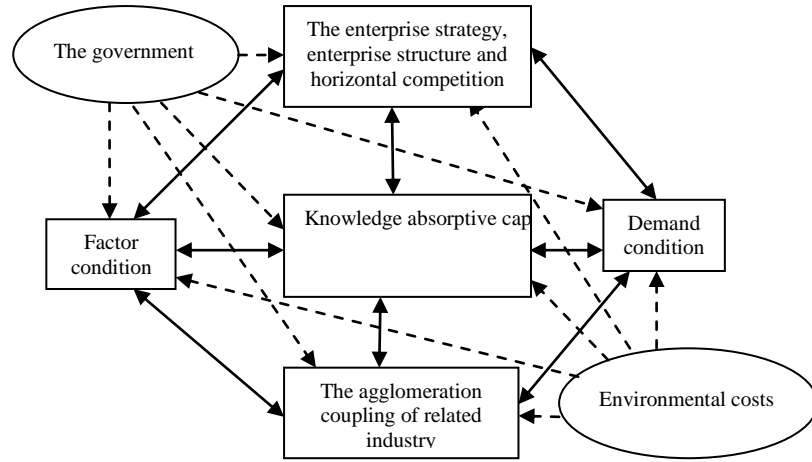


Figure 1. The theoretical framework of competitiveness analysis of rare earth industry

### III. COMPETITIVE ANALYSIS OF RARE EARTH INDUSTRY IN JIANGXI PROVINCE

#### A. Knowledge Absorptive Capacity and Innovation Ability

The evaluation of the knowledge absorptive capacity and innovation ability of the rare earth industry in Jiangxi Province mainly considers the technological innovation, added value of products, talent cultivating mechanism, stock of human capita, etc.

In the matter of technological innovation, Jiangxi Province has mastered much self-dependent innovative technology of the field of mining and smelting separation. But in the field of high-end applications of downstream, the production technology is relatively backward, and the economic benefit of high-end rare earth material of downstream is low. In the year of 2010 and 2011, the total output value of rare earth industry was 13.56 billion and 32.9 billion Yuan respectively, which accounted for 31.63% and 58.6% of the total industrial annual output value of Jiangxi Province. But in these two years, the total annual output value of rare earth high-tech material accounted for 0.32% and 1.17% of the total industrial annual output value respectively. This shows that the rare earth industry plays an important role in industrial production of Jiangxi Province, but the high-tech material contributes much less.

In the matter of rare earth product, further processing and application products of rare earth in Jiangxi Province are mainly concentrated on the field of rare earth permanent magnet, hydrogen storage material, etc. But in these fields, the development is still on primary stage. In 2010, the sales revenue of further processing and application products of high value-added and high technology accounted for 10% of the total sales revenue of rare earth industry. In 2011, the

sales revenue increased slightly, but no more than 20% of the total sales revenue of rare earth industry.

In the matter of talent cultivating mechanism, Jiangxi Province has quicken the cultivation of rare earth professional talent in many methods, such as Jiangxi University of Science and Technology which is the first in China to set the course for professionals of rare earth engineering, Xinlongkang rare earth company and Xinsheng rare earth company which have established technical cooperation respectively with Jiangxi University of Science and Technology and East China Institute of Technology, etc.

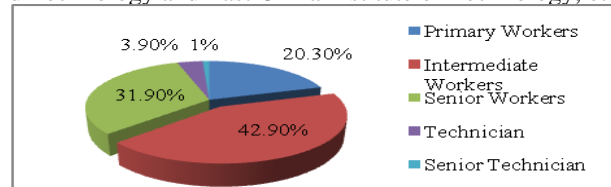


Figure 2. The talents distribution pie chart of Jiangxi province in 2011

In the matter of the stock of human capital, the number of high-skilled talents who are senior than senior workers in Jiangxi Province are much less than the 47% in China. As it can be seen from the Figure 2, the number of technicians and senior technicians only accounts for 4.9%, which is 1.5% lower than the average in China. Meanwhile, the managerial force of Jiangxi rare earth industry is mainly middle-aged and old-aged people(Figure 3), this may cause the lack of innovation of rare earth company.

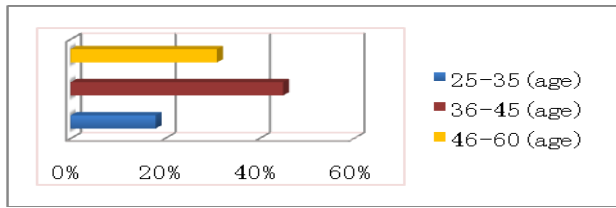


Figure 3. The age distribution histogram of management personnel of Jiangxi rare earth industry

From the above, the overall level of knowledge absorptive capacity and innovation ability of Jiangxi rare earth industry is low, especially the technological innovation and stock of human capital of rare earth industry of downstream.

#### B. Factor Conditions

Jiangxi Province is located on the north of Guangdong Province and the west of Zhejiang Province, with Jiangsu Province and Shanghai City to its northeast. The advantages of radiation and stimulation, which are from the convenient water transportation and Zhegan railway transportation, to the industries in Jiangxi Province are beyond comparison by other cities. What's more, Jiangxi Province lies in the two large metallogenic regions<sup>[3,4]</sup>—the lower Yangtze region and the southern part of China, which is the precondition in the conditions of being a good metallogenic region. China's

rare earth mineral resource is distributed in sixteen provinces, in which Ganzhou of Jiangxi gets the most. In Zhangzhou, the area of rare earth mine is nearly 6,000 square kilometers, including 2,534 square kilometers of the planning area of rare earth mine, the maintain reserve is 0.336 million tons, which is more than 60% of domestic maintain reserve of the same rare earth resource, and ranks the first in all the same type minerals at home and abroad. Jiangxi ions rare earth is rich in many heavy rare earth elements, such as samarium, europium, terbium, arrowhead, yttrium, etc. These elements are the indispensable important elements in the production of rare earth permanent magnetic material and rare earth luminescent material. So Jiangxi Province has 45 mining rights of 67 in nationwide.

As it can be seen, there are three kinds of advantages in the aspect the elements of Jiangxi rare earth industry, which are the geographical advantage, transportation advantage and resource advantage.

#### C. Demand Condition

The China's production and consumption of rare earth ranks the first in the world. In 2005, China's annual consumption of rare earth was more than 50% of the total world consumption, and it raised to 87025 tons in 2010 which was 64.9% of the total world consumption of rare earth.

TABLE I. THE CONSUMPTION OF CHINA'S RARE EARTH IN DIFFERENT AREAS FROM 2003 TO 2011(REO,TON)

Year		2003	2004	2005	2006	2007	2008	2009	2010	2011
Traditional field	metallurgy/machinery	5410	5000	9738	10085	10994	10370	11000	11200	10100
	oil/Chemical industry	4935	4000	6000	6800	7548	7520	7500	7500	7500
	glass/ceramics	6000	6200	6500	7607	7872	7160	7200	7600	7000
	Textile industry	3155	2300	5000	7600	7686	7120	7000	6900	3500
	total	19500	17500	27238	32092	34100	32170	32700	33200	28100
The new material	Permanent magnetic material		10750	15404	18095	22250	20100	23000	34125	36600
	Hydrogen storage material		2000	4333	5000	6200	6160	6200	6300	4430
	Liquid crystal polishing				2000	2800	3500	4100	4600	4800
	Fluorescent material		2135	2825	3106	4490	2870	3700	5000	4800
	Catalytic materials		1020	2100	2500	2710	2880	3300	3800	4380
	total	10000	15911	24662	30701	38450	35510	40300	53825	55010
The total consumption		29500	33411	51900	62793	72550	67680	73000	87025	83110

In addition, it is can be seen from the Table 1 that the rare earth consumption has increased year after year, especially from 2004, the rare earth had applied in frontiers in China. Its consumption presents a sharp increase trend, especially the permanent magnet material that increased from 10,750 tons in 2004 to 36,600 tons in 2011 with the growth rate of 70.6%. And Association of China Rare Earth Industry predicted that this quantity will increase to 210,000 tons in 2015. The quantity demand on rare earth permanent magnetic materials, rare earth catalyst of automobile tail gas and oil catalytic of cracking agent will increase by the rate of 10%-16% and 6%-8% per year respectively in the future

years. Therefore, the increase of worldwide demand for rare earth will provide a better chance for Jiangxi rare earth industry.

#### D. The Enterprise Strategy, Enterprise Structure and Horizontal Competition

Before 2005, most of the rare earth enterprises in Jiangxi Province applied the low cost strategy and underselling strategy to fight for market shares, which made the competition in this industry worse. From the September 2010, enterprises of the central group such as Minmetals, Chinalco and Baotou Rare Earth, etc, joined in the process of merger

of rare earth industry in Jiangxi Province. The restructuring effects have occurred. However, currently the effect of reorganization is still not obvious. There are still a lot of problems such as the unbalance of product structure, the similarity of the process and the slowness of the development of highly processed products and application product. Therefore, another barrier for impeding the improvement of competitiveness of the rare earth industry in Jiangxi Province is that the synergistic effect of rare earth after the corporate restructure has not reached its maximum.

#### *E. The agglomeration coupling of Related Industry*

The agglomeration effect of rare earth related industry has a great effect on boosting the development of rare-earth industry in upstream and downstream. The related industries of Jiangxi rare earth industry mainly include processing industries, such as the luminescence materials, nickel metal hydride batteries and NdFeB, related industries, such as logistics and financial service, etc. At present, Jiangxi province has 14 permanent magnetic materials production enterprises, four hydrogen storage alloy production enterprises, seven rare earth phosphor powder and the fluorescent material production enterprises. High accumulation effect of rare earth industry and the progress of science and technology in Jiangxi Province have brought new opportunities and challenges.

#### *F. The Government*

The guidance of government's policies to rare earth industry in Jiangxi province is mainly manifested in the following aspects: In 2011, the Ministry of Land and Resources announced that, the first batch of national rare earth planning mining area in Ganzhou is about to be founded. In 2012, Jiangxi Province got 17.8 million Yuan of central government budget to support the transformation and upgrading, and independent innovation of rare earth industry. However, the lack of resource management in rare earth industry makes serious waste of resources. With rare earth prices soaring in 2010, rare earth smuggling is restrained repeatedly but useless. Through the contrast of customs statistical data at home and abroad, the exports of smuggled rare earth were more than 20,000 tons in 2011. Therefore, the lack of supervision of the Jiangxi Provincial Government will further promote the deterioration of the competitive environment of the rare earth industry, and go against to enhance the competitiveness of Jiangxi rare earth industry.

#### *G. Environmental Costs*

The mining of rare earths is easy to cause the destruction of the environment. It is calculated that 5 Yuan is needed to deal with the waste water caused by the mining of rare earths. The preliminary estimates by the National Environmental Protection Agency shows that, only in Ganzhou, the rare earth mining has resulted in 302 waste mines, 97.34 km<sup>2</sup> contaminated forest areas. Environmental governance need to spend 380 billion Yuan, and up to 70 years to manage. The internalization of environmental costs will be inevitable with introduction of the "Emission Standards of Pollutants from Rare Earths Industry" and a series of policies and

regulations. In the short term, it will increase the cost of production of rare earth manufacturing, and influence its competitive advantage.

### **IV. ANALYSIS ON THE PROBLEMS AND REASONS IN THE DEVELOPMENT OF JIANGXI RARE EARTH INDUSTRY**

Through the analysis on the current situation of the competitiveness of Jiangxi rare earth industry, this paper proposes that, there are the following aspects of the problems and reasons in the development of Jiangxi rare earth industry at present:

#### *A. Lack Of Rare Earth High-End R&D Talent, Weak in Innovation Capability of Deep Processing Application Product*

It is can be seen from the development of entire industry chain of Jiangxi rare earth industry that, the main advantages are mining, smelting and primary processing. However, because of the lack of high-end professionals in the aspect of research and development of rare earth materials, the high value-added rare earth products are underdeveloped. To the reasons, on the one hand, Jiangxi Province has a weak economic foundation and serious livelihood issues, which have bad effects on the introducing and retaining talents, and limit the capacity of knowledge assimilation and innovation. No one company has the intellectual property of product innovation. On the other hand, the rare earth industry is invested less money in mining and smelting, which is with low risk and high profit. However, it is invested more money in the research and development of application production in downstream industry, which is with high risk. Therefore, it leads to the a weaker capacity of innovation of deep processing application production in downstream industry.

#### *B. Unobvious Effects of Restructuring and Synergy of Rare Earth Enterprises, Slow Promotion of the Collective Economic Effect*

Jiangxi rare earth industry is speeding up the restructuring work, but the restructuring synergistic effect is far from maximum. The main reason goes to the confliction of the different patterns of ownership of different enterprises, and the differences of enterprise culture, management and operation, etc. These lead to the unsmooth internal information transformation, make the decision making more difficult and the management out of control, etc. At last, the promotion of group's overall economic performance is very slow. What's more, each group has focused attention on the battle of scrambling earth resources in Jiangxi Province for their own interests, which results in serious excess capacity in mining, smelting, and without their own advantages in the application production in downstream industry to seek the differentiation strategy. So the product homogeneity is very high, which blocks the promotion of collective economic effect.

*C. Lack of Supervision With High Profits Temptation and the Serious Phenomenon of Illegal Exploitation of Rare Earth*

Since China implemented the policy of rare earth export quotas, the rare earth price has been soaring. Facing the great benefits temptation, the three large groups, which once controlled metallurgical industry, non-ferrous metals industry and nuclear industry, construct a lot factories repetitively to produce more, which leads to serious unauthorized mining. What's worse, some enterprises steal the minerals, and sell in the underground market. Meanwhile, industry supervision needs more human and financial resources, because Jiangxi rare earth resource mainly distributes in the mountains, and the annual finance of Jiangxi Province is limited, which leads to the limited investment in supervision. So the problem of unauthorized mining and smuggling happen frequently causing serious lost of rare earth resource.

*D. Serious Environmental Pollution, Difficult in Environmental Management*

The environmental protection standard of mining rare earth resources in Jiangxi Province is low, and the cost of pollution treatment caused by the mining and separation of rare earth is not included in the cost of production. This not only makes the environment of products competition worse, but also causes serious local ecological damage. From the past to the present, Jiangxi rare earth mining processes have adopted leaching, heap leaching and the in situ leaching. The two formers are simple and cost less, but they will result in the destruction of vegetation and serious soil pollution. The separation of each ton of rare earth oxides will destroy 160-200 m<sup>2</sup> of vegetation, and produce 1,000-1,200 tons of waste water 错误! 未找到引用源。 . Even though the present more advanced in-situ leaching method also cannot avoid in polluting environment.

V. RECOMMENDATIONS TO ENHANCE THE COMPETITIVENESS OF RARE EARTH INDUSTRY IN JIANGXI PROVINCE

Considering the problems in the development of rare earth industry in Jiangxi Province, this article proposes solutions in the following four aspects to enhance the competitiveness of rare earth industry in Jiangxi Province:

*A. To Strengthen Construction of Talent Group and Improve the Capability of Independent Innovation*

Firstly, the talent introduction policies should be implemented to attract talents, such as housing policy, the daily sports activities, children's education policy and personnel re-education policy, which can greatly reduce the cost of living, enrich the content of their life and improve their degree of happiness. At the same time, by the cooperation between research institutes and rare earth enterprise and enterprise personnel performance appraisal system, it can encourage research specialist staff to carry out innovation activities. Secondly, the personnel training mechanism should be optimized to train talents, such as

selecting rare talents to study abroad, training advanced managers and high-level R & D personnel, uniting enterprises and schools to train professional, skilled, practiced and innovative talents and encouraging the combination of enterprises, universities and research institutes to train a number of high-quality scientific research team and improve the ability of independent innovation.

*B. To Enhance Synergies Between Enterprises and Promote the Overall Economy of the Group to Maximize the Effect*

As for the various problems in the reorganization of rare earth industry in Jiangxi Province, the group should focus more on recombination of the downstream in rare earth industry and the development and planning of high additional value products. China Minmetals Corporation and Aluminum Corporation Of China can focus on the development of processing applications of the rare earth, in particular, searching for differentiation development strategy of their alloy technical advantages respectively, extending the industrial chain and improving the group's overall economic effects. The reorganized enterprises should mainly focus on improving their synergies. Through enhancing synergistic effect of the strategic development, the cultural, and system coordination, the rare earth market will be concentrated, and structural problems of rare earth industry will be solved, and finally the rapid industrial upgrading transformation can be achieved.

*C. To Strengthen Industry Management and Ensure the Reasonable Use of Resources*

Firstly, governments at all levels should fully exercise the management functions, actively cooperate with each other, control the total amount of rare earth mining, regulate the rare earth mining process and plan the flow direction of resources, achieving to the value maximization of rare earth resource utilization. Secondly, the government should set itself as an example to others, implement the regulatory responsibility, strengthen the supervision of investment, establish agencies for specialized protection, implement the effective management of the existing mines and severely punish excessive excavation and other illegal mining activities, ensuring the rational development and the utilization of the rare earth resources. Thirdly, the government should raise the tax rate of rare earth resources, reduce the waste of rare earth resources, curb uncontrolled mining behavior effectively and encourage the enterprises to take the initiative to develop the deep processing, achieving the sustainability of the development of rare earth industry.

*D. To Promote the Internalization of Environmental Costs and Reduce the Environmental Damage*

At present, China's rare earth mining and separation technology has been at the leading level at home and abroad, but it can still cause very serious damage to the environment. In order to reduce environmental burden and protect ecological environment, an effective method is to the internalize environment cost, which is to take the environment cost into the enterprise's production costs to

restrain enterprise excessive mining of the rare earth. On the one hand, It can eliminate the enterprises of backward production capacity. On the other hand, it can make enterprises strengthen technological improvement, optimize technological process, actively improve the level of secondary resources recycling, reduce the consumption of used chemical raw materials for mining and reduce "the Three Wastes"—industrial wastewater, waste gases and residues fundamentally. At the same time, the enterprises should strengthen the consciousness of environmental protection, supervise and urge enterprises to carry out the environmental law, strengthen solid waste resource utilization, govern the mines which have been developed, promote ecological recovery, effectively manage the "the Three Wastes" of overproduction and the tailings refining, prevent soil erosion and finally realize the sustainable development.

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