

Global rare earth resources and scenarios of future rare earth industry

CHEN Zhanheng (陈占恒)

(Academic Department, The Chinese Society of Rare Earths, Beijing 100081, China)

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Abstract: It is known to all that China is abundant in rare earth resources. But rare earth deposits are really not that rare in the earth crust. In the five continents, i.e. Asia, Europe, Australia, North and South America, and Africa, there are about thirty four countries found to have rare earth deposits; Brazil might surpass China and rank the first in rare earth deposits. At present, investment in rare earth production was surged, there have been about 200 projects, and the total production for 25 of them would be more than 170 thousand tons after 2015, a multi-supply system on rare earths is being established worldwide. Cautions on the investment of rare earth production are involved.

Keywords: rare earth elements; deposit; resources; reserves; rare earth industry

It is known to all that rare earth elements (REEs) are the seventeen elements in the Periodic Table, including fifteen elements with atomic numbers from 57 to 71, i.e., from lanthanum to lutetium ("called lanthanides"), plus scandium (21) and yttrium (39). The rare earth elements can be grouped as light rare earth elements—La, Ce, Pr, Nd, and middle & heavy rare earth elements—Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Y. Sc is of dispersed elements, and Pm does not exist in nature^[1].

Quite different from their name, rare earth is really not that rare, they are relatively plentiful in the earth crust. There are rare earth reserves in about 34 countries. For China, in the past, it was always claimed that China was abundant in rare earth deposits, and had been the largest producer, consumer, and exporter of rare earth products. But thing has been changed with the discovery of new deposits worldwide and the exploitation of China itself through these years. From 1987 to 2010, more than 1.6 million tons of rare earth reserves (count as oxides) were produced. Normally, the recovery rate was about 20%–30%. It can be estimated that about 530–800 t of rare earth resources have been mined. The proved rare earth reserve of China was 43 million tons. So the residue of rare earth reserve should be 3 500–3 770 t. If the deposit in Vietnam is included, the proportion of China rare earth reserve will be reduced to 32.72%^[2].

China have contributed too much rare earth products to the world. But, China was definitely not the only supplier of rare earth products. There are abundant rare earth deposits besides China.

1 Global rare earth distribution

Rare earth elements are distributed widely in the Earth^[3–7] (Fig. 1).

In Asia, fourteen countries have rare earth deposits. Japanese companies are constructing joint ventures with five of them, including Vietnam, India, Mongolia, Kazakhstan and Kyrgyzstan; Lynas is establishing a processing factory in Malaysia.

In Europe, six countries have been found to have rare earths. In that, Greenland is getting into production; its product will be rare earth concentrate and aim to have 20% of the market in the future. Estonia has a production capacity of 3 000 t oxides and metals with concentrate from Russia.

There are plenty of rare earth reserves in Australia, but no processing plant could be built for environmental problems. But Lynas will move its separation and smelting factories to Malaysia. Another company Arafura Resources Ltd. will produce rare earth oxides in 2013; its deposit is highlighted with heavy rare earth elements.

In north America, the United States has just finished its rare earth deposits survey, and its producer MolyCorp is ready to accelerate its rare earth production. For Canada, there are many small scale rare earth reserves with good heavy rare earth elements contents for economic exploitation, and have attracted many investors. One of its mining companies, the Great Western Group is developing its rare earth production in South Africa.

In South America, mainly in Brazil, there also has plenty of rare earth reserves. Brazil is one of the oldest countries to produce rare earths. It is said that Brazil has begun to produce rare earths since 1884.

As to Africa, there are 10 countries found to have rare earth deposits at present. It can be assured that rare earth deposits are widely distributed in Africa. South Africa is establishing a Joint Venture with Canada-Great Western Group. And the most interesting deposit is rare earths associated with diamond and gold mine in Sierra Leone.

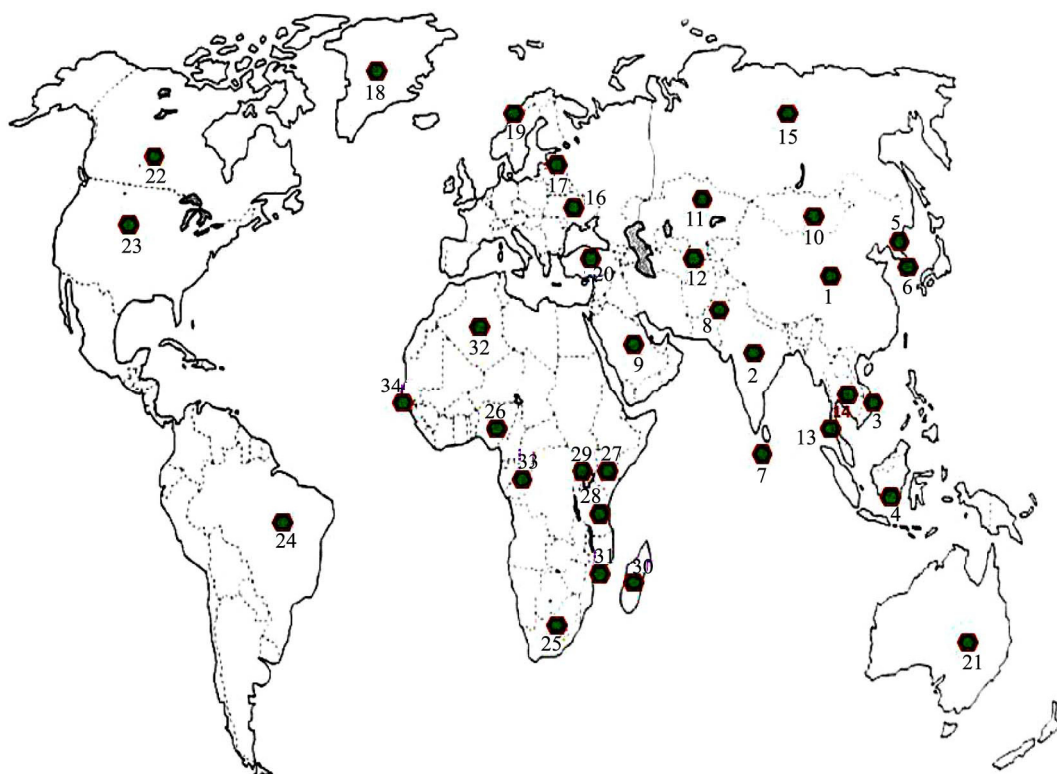


Fig. 1 Global rare earth resources

In General, There are about 34 countries with rare earth deposits in the world. So rare earth elements are widely distributed in the Earth. It is really not that rare! With time going, it is believed that more rare earth deposits will be discovered.

According to the United States Geological Survey^[2], in 2009, the whole world has about 99 million tons of rare earth reserves (Fig. 2). In that, China ranks the first with 36%, the second is CIS-Commonwealth of Independence States-former Soviet Union, which has about 19%, and the third is the United States with 13%. And, only 0.05% for Brazil; but based on the released data from USGS rare earth report (2010), there is an interesting situation on rare earth sources for Brazil.

Based on USGS rare earth deposits survey released on

November 16th and open data on China, CIS and India rare earth resources, the rare earth industrial reserves in Brazil rank the first with a proportion of 37%, China is the second with 25%, the third is CIS with 13%, and Vietnam ranks the forth with 10% (Fig. 3).

According to USGS report 2010, the terminology “deposit” is just rare earth resources, and the terminology “reserve” is defined as rare earth resources for industrial production. Regarding rare earth deposits, Brazil still ranks the first with 32%, the second is China with 22%, about 12% in CIS ranks the third, 9% in Vietnam to be the fourth, 8% in Australia, and 7% is in the United States (Fig. 4).

Above all, Rare earth elements resources are distributed among many mineral deposits, but only a proportion will

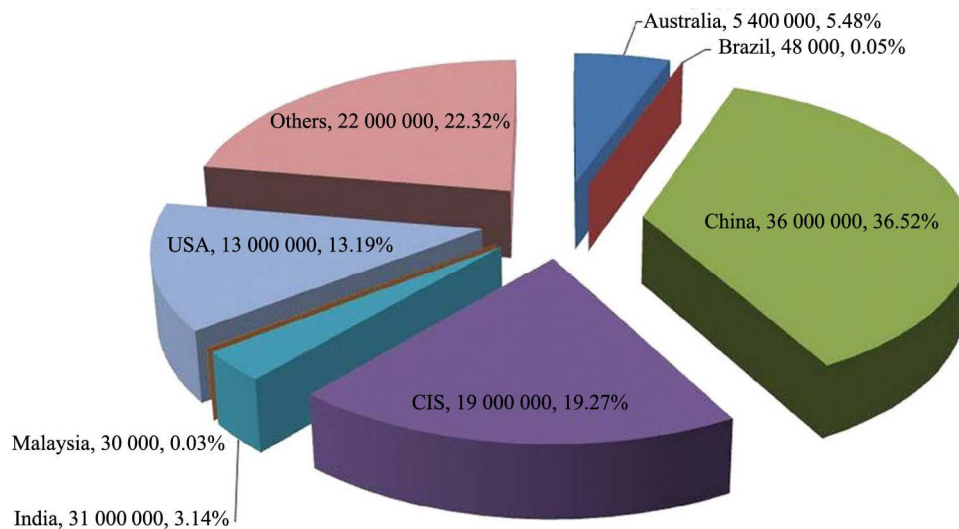


Fig. 2 Global REEs Reserves 2009

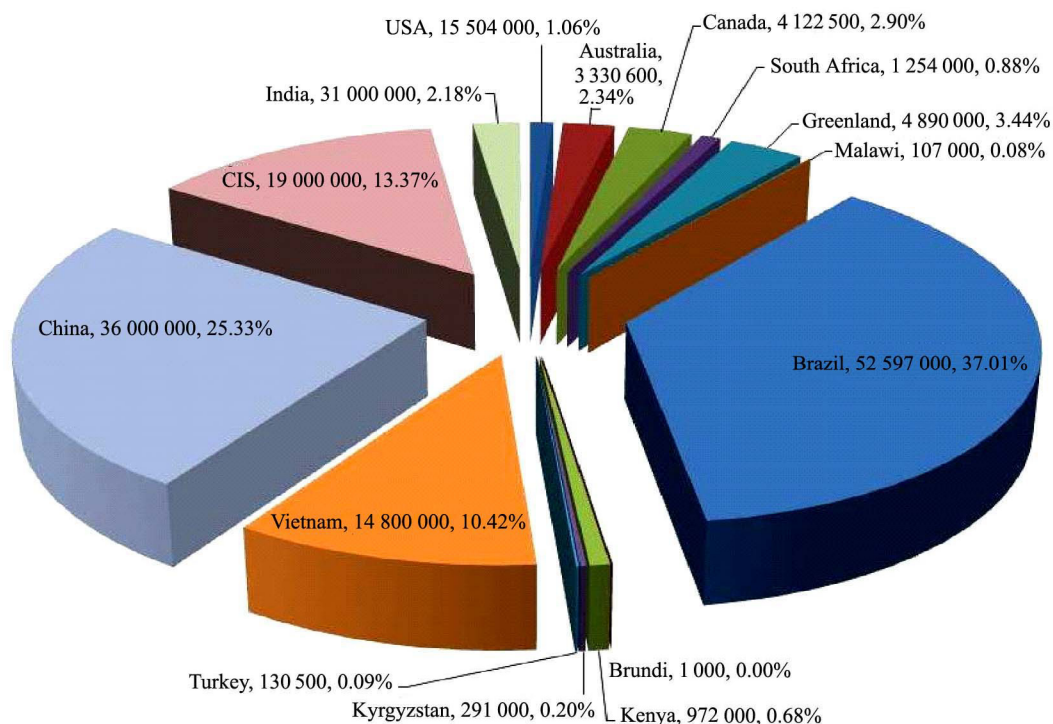


Fig. 3 Global REEs reserves 2010

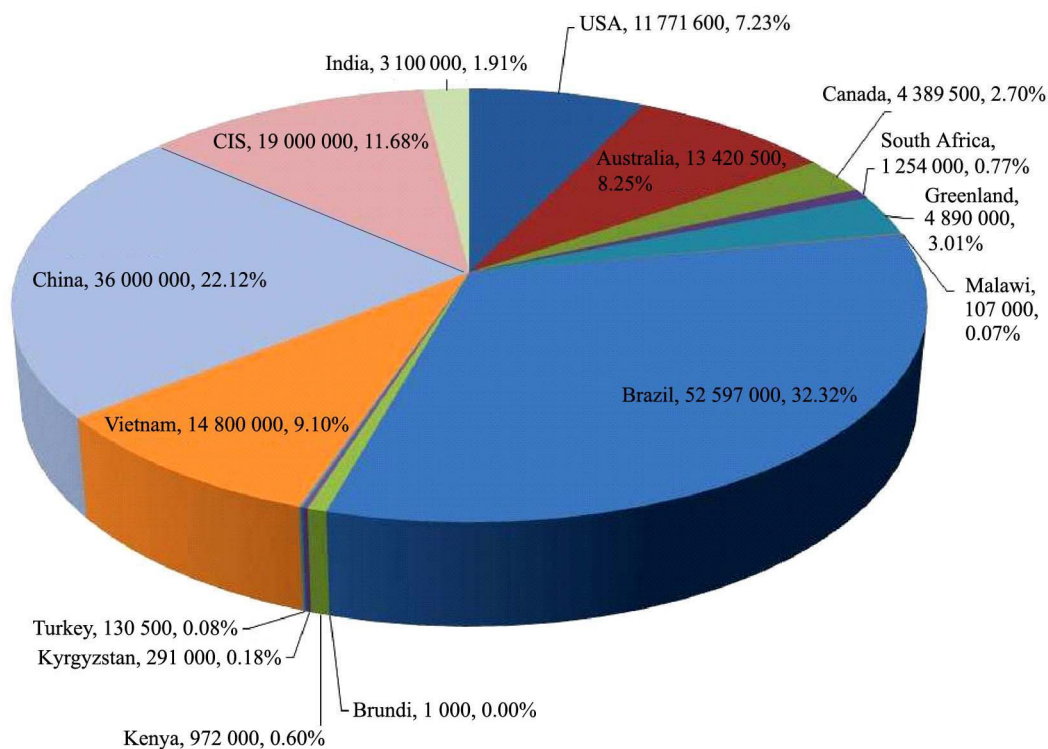


Fig. 4 Global REEs deposits 2010

be economic to develop and mine. Only those quite abundant deposits can be called rare earth reserves, but not those only in rare earth amount that make them practical or economical to mine.

Table 1 is the rare earth elements distribution in eight selected main rare earth deposits^[8], three of which is from China, including the most famous one, Bayan Obo Mine, three from USA, one from Malaysia, and the other one from Canada. There are some boldfaces in Table 1, the more the

boldfaces, the more economic and valuable the deposits. The deposits in Lehat Malaysia and Longnan China with plenty of yttrium are the kinds of middle and heavy rare earth deposits. Normally, if a rare earth deposit is rich in yttrium, then it will be highlighted in middle and heavy rare earths with small contents of light rare earth elements. The deposit in Strange Lake of Canada is not too heavy and not too light, a very nice rare earth deposit. And the rest five are the kinds of light rare earth deposits. Though rare earths are not that

Table 1 Distribution of rare earth elements in selected deposits

Atomic No.	Elements	Mountain pass	Bayan Obo	Green cove spring	Lehat	Longnan	Xunwu	Bear Lodge	Strange Lake
57	La	33.8	23	17.5	1.2	1.8	43.3	30.4	4.6
58	Ce	49.6	50	43.7	3.1	0.4	2.4	45.5	12
59	Pr	4.1	6.2	5	0.5	0.7	7.14	4.7	1.4
60	Nd	11.2	18.5	17.5	1.6	3	30.15	15.8	4.3
62	Sm	0.9	0.8	4.9	1.1	2.8	3.9	1.8	2.1
63	Eu	0.1	0.2	0.2	—	0.1	0.5	0.4	0.2
64	Gd	0.2	0.7	6	3.5	6.9	4.21	0.7	2.5
65	Tb	—	0.1	0.3	0.9	1.3	—	0.1	0.3
66	Dy	—	0.1	0.9	8.3	7.48	—	0.2	8.2
67	Ho	—	—	0.1	2	1.6	—	0	1.7
68	Er	—	—	—	6.4	4.9	—	0	4.9
69	Tm	—	—	—	1.1	0.7	—	>0.01	0.7
70	Yb	—	—	0.1	6.8	2.5	0.3	0.5	4
71	Lu	—	—	—	1	0.4	0.1	>0.01	0.4
29	Y	0.1	—	2.5	61	65	8	>0.01	52.7

*The values in boldface are adjusted slightly from that in the reference.

rare in the Earth, the heavy rare earth elements, such as Eu, Tb and Dy, are really rare.

2 Scenarios of future rare earth industry

At present, about six countries can provide the world with rare earth products. Fig. 5 is based on 2009 USGS report and report from Ministry of Industry and Information Technology of China. In that, China supplies about 94% and 6% from Russia and Estonia, USA, India, Malaysia and Brazil.

With the world economy recovering from Financial Crisis and the boom of rare earth market, to invest rare earth industry has been the hotspot. It is said that there are about 200 projects on rare earth exploration, under preparation and exploitation. Among so many projects, about 25 projects are promising to be the competitors of future multi-supply^[9,10].

Eight of them are former producers (Table 2), including a producer in Brazil, can produce rare earths right now with a production capacity at least 9 500 t.

Seven companies are under preparation (Table 3) with a total target production capacity of 24 900 t in 2013. Four of the seven are Japanese joint ventures in Vietnam, India, Kazakhstan and Brazil Pitinga Mine, the other three are Lynas,

Great Western and Alkane Resources of Australia.

And 10 projects are in the stage of exploration with a target capacity of 13 000 t in 2013.

The most promising producers out of China which could get into production recently should be MolyCorp, Lynas, Simelt of Estonia, Great Western Group, and three Japanese joint ventures in Vietnam, India and Kazakhstan. The total production capacity out of China after 2015 should be more than 170 thousand tons.

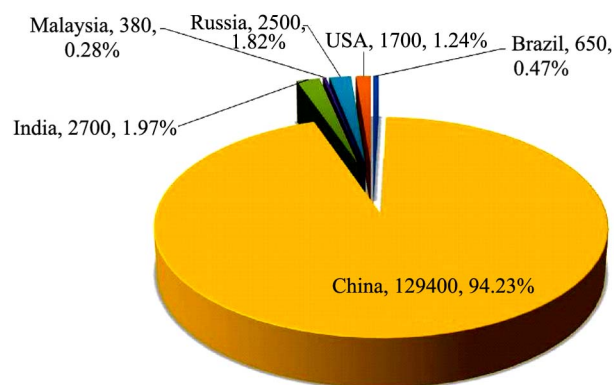


Fig. 5 Rare earth supply in 2009

Table 2 Current producers out of China

No.	Company	Location	Country	Current capacity (tpy REO)	Target capacity after 2015 (tpy REO)
1	MolyCorp Minerals	Mountain Pass, CA	USA	3 000	40 000
2	Lovozersky Mining Company	Kamasurt Mine, Kola Peninsula	Russia	3 000–4 400	15 000
3	Solikamsk Magnesium Works	Solikamsk Processing Plant, Urals	Russia		
4	Indian Rare Earths	Orissa, Tamil Nadu and Kerala	India	100	10 000
5	Toyota/Sojitz/Gov. of Vietnam		Vietnam	1 800–2 000	>2 000
6	Neo		Thailand		
7	Lynas/Malaysia	Gebeng, Malaysia	Malaysia		
8	Indústrias Nucleares do Brasil S/A (INB)	Buena Norte	Brazil	1 500	>1 500
Total				9 500–11 000	>68 500

Table 3 Under preparation producers

No.	Company	Location	Countries	2011-2013 Capacity (tpy REO)	Target capacity after 2010 (tpy REO)
1	Lynas Corp	Mount Weld, Western Australia, and a processing plant in Gebeng, Malaysia	Australia	10 500	21 000
2	Rareco/Great Western Minerals Group	Steenkamskaal, South Africa	South Africa/Canada	3 000	5 000
3	Sumitomo/Kazatomprom/SARECO JV	Kazakhstan	Kazakhstan/Japan	3 000	15 000
4	Toyota/Sojitz/Govt. of Vietnam	Dong Pao, Vietnam	Vietnam/Japan	300	5 000
5	Toyota/Indian Rare Earths jv	Orissa, India	India/Japan	5 000	10 000
6	Mitsubishi/Neo Material Technologies	Pitinga, Brazil	Japan/USA/Canada/Brazil	500	1 000
7	Alkane Resources	Dubbo, NSW, Australia	Australia	2 600	6 000
Total				24 900	63 000

Table 4 Exploration-candidate supplier

No.	Company	Location	Countries	2011-2013 Capacity (tpy REO)	Target capacity (tpy REO) in 2015
16	Avalon Rare Metals Inc	Nechalacho deposit rich in HREEs in NWT, Canada	Canada	0	5 000
17	Quest Rare Metals	Strange Lake and others in Quebec/Labrador, Canada	Canada	0	0
18	Ucore	Bokan-Dotson Ridge project, Alaska	USA	0	0
19	Matamec	Kipawa deposit in Quebec, Canada	Canada	0	0
20	Arafura	Nolan's project, Australia	Australia	10 000	20 000
21	Great Western Minerals Group	Hoidas Lake, Canada	Canada	3 000	5 000
22	Rare Element Resources	Bear Lodge, Wyoming, USA	USA	0	0
23	Stans Energy Corp	Kutessay II Mine, Orlovka Kyrgyz Republic	Kyrgyz Republic	0	0
24	Greenland Minerals and Energy	Kvanefjeld-Greenland	Greenland	0	10 000
25	Japan-Mongolia JV	Mongolia	Mongolia	0	0
Total				13 000	40 000

If most of the projects out of China could run smoothly, a reasonable multi-supply system world would form. It can be supposed that after consolidation and with effective total production control of 85 thousand tons in 2013, China will reduce its supply proportion to 64%, and leave the rest 36% to those producers out of China.

At present, about 50 thousand tons of rare earths are needed per year out of China. With a rate of 15% demand increase, then in 2015, the total demand out of China should be at least 80 thousand tons on the basis of the world economy continuous increase. Considering Quota for 2010 of at least 32 990 t, if Quota for 2011 to 2015 will be 32 000 to 35 000 t per year, the Demand Balance out of China should be 18 000 t to 50 000 t. There will be a great space for new producers.

3 Concluding remarks

Above all, the future for rare earth industry is very promising. It is time to invest rare earth production. But there are still some important cautions.

(1) Regarding not all the deposits are economic to mine, a strict geological research should be performed at first. If your rare earth deposit is rich in heavy rare earth elements, then good luck! You will make more money and have little investment risk, because the production of light rare earth is about 75% of the total production.

(2) The products could be rare earth concentrate and compounds like oxides, metals and alloys; it depends on your target consumer and the rare earth contents in the deposits. To produce only rare earth concentrate is not that profitable, but easy to control.

(3) Environment concerns must be paid; almost all the deposits contain the radioactive element thorium. Environmental cost is related to your market competitive force. (4) It is very important that current rare earth market with profitable prices is greatly stimulated by the strict quota control of China and curb of smuggling to limit the supply. Therefore, so all producers should pay great attention on the adjustment of future quota amount. But it is believed that the government of China will have the far-sight to encourage the establishment of diversified supply of rare earths and will

control the quota within a reasonable range so as to keep present market price level.

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