CAN CHINA'S MONOPOLY OF THE RARE EARTH MINERALS MARKET BE BROKEN?

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ABSTRACT

Rare earth elements (also referred to as rare earth minerals, rare earth metals, green elements, rare earths or simply REEs) are comprised of 17 elements of the periodic table. The metals are often found combined together in ores and must be separated into its individual elements.

The numerous applications of rare earth elements can be broadly classified into four major categories, namely: High Technology Consumer Products, Environmentally Friendly Products, Industrial and Medical Devices and National Defense Systems. The demand for such high technology products is rapidly increasing causing an upsurge in the derived demand for rare earth metals as well.

On the supply side, China is currently the largest producer of rare earth elements in the world, mining at least 90% of total world production. Consequently, many countries around the world rely on imports of these REEs to facilitate production of the various systems and products that are dependent on the rare earth metals as raw materials. With one supplier effectively monopolizing the rare earth industry, this imposes severe supply-chain risks to the producers of products that rely on rare earth minerals.

This paper will examine the rare earth industry, China's near-monopoly, global supply-chain risks, and strategies to reduce dependence on China.

INTRODUCTION

Rare earth elements (also referred to as rare earth minerals, rare earth metals, green elements, rare earths or simply REEs) are comprised of 17 elements of the periodic table which include 15 elements from the group known as lanthanides and two additional elements known as scandium and yttrium. The metals are often found combined together in ores and must be separated into its individual elements.

The various applications of rare earth elements are innumerable and can be broadly classified into four major categories, namely: High Technology Consumer Products, Environmentally Friendly Products, Industrial and Medical Devices and National Defense Systems. The demand for such high technology products is rapidly increasing causing an upsurge in the derived demand for rare earth metals as well.

On the supply side, China is currently the largest producer of rare earth elements in the world, mining at least 90% of total world production. Consequently, many countries around the world rely on imports of these REEs to facilitate production of the various systems and products that are dependent on the rare earth metals as raw materials. With one supplier effectively monopolizing the rare earth industry, this imposes severe supply-chain risks to the producers of products that rely on rare earth minerals. These

supply risks have caused concern among many nations who are currently taking steps to mitigate the severity of the potential economic harm associated with these risks.

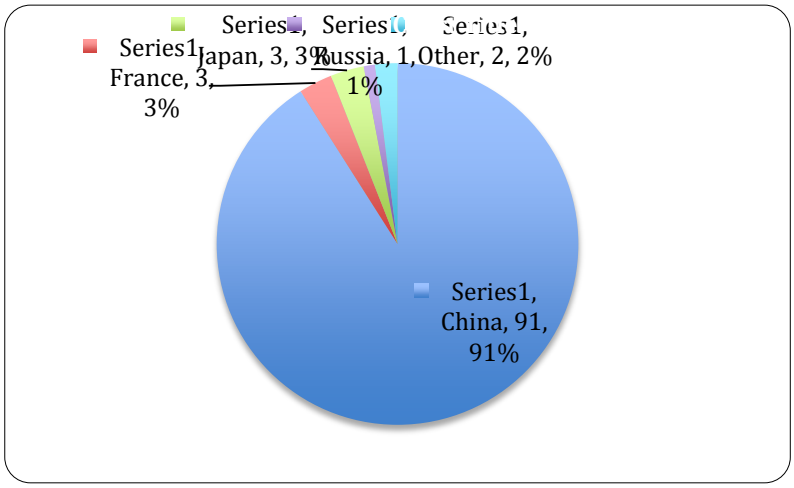
SUPPLY OF RARE EARTH ELEMENTS

At present China is the largest producer of Rare Earth elements in the world, mining, by various estimates, at least 90% of total world production. Consequently, many countries around the world, including the United States and Japan, both directly and indirectly rely on imports of these REEs from China to facilitate production of the various systems and products that are reliant on rare earths as raw material. For example, Japan relies on imports from China to produce the rechargeable batteries used to power the hybrid vehicles and several other products that it exports to the United States and other countries. It is not unreasonable to assume that a contraction in the global supply of rare earth minerals can adversely affect the gross domestic product of nations like Japan.

CHINA'S CURRENT NEAR-MONOPOLY

Rare earth elements are not as rare as the name implies. They are actually reasonably abundant in the earth's crust, even more so than other familiar metals like gold, iron or copper. Thus, the fact that China mines virtually all of total global production is not an indication that the majority of rare earth elements are located in that part of world. As a matter of fact, from as early as 1953, the United States was a major producer of rare earth elements before suspending operations at its 55 acre mine at Mountain Pass located in California in 1998 (Jenkins, 2010). Figure 1 below shows that the United States has become almost fully reliant on Chinese imports.

Figure 1
US SOURCES OF RARE EARTH MATERIAL IMPORTS (2005-2008)



Source: Salazar, K., & McNutt, M. K. (2010). *Minerals Commodity Summaries 2010.* Washington: United States Government Printing Office, 128.

China has managed to capitalize on the rare earth element industry by developing the resources (technology, techniques and an experienced labor force) required to efficiently and effectively mine, extract, separate and refine rare earth minerals at more operationally feasible costs than other countries. As a result, it became more economically viable for countries, such as the United States, to cease

production of rare earth minerals and import these minerals from China. This operational efficiency has caused China to effectively emerge as the leading supplier of rare earth minerals to an extent that could be easily equated to a monopoly. The fact that China controls the global supply of rare earth metal allows the country to effectively control quality, quantity and ultimately the prices of these rare earth elements through export quotas and trade tariffs.

SUPPLY CHAIN RISKS: THE DEPENDABILITY OF THE SUPPLIER

There are several supply chain risks inherent in a global market whereby the supply of virtually all of a raw material (that is rare earth elements) deemed critical to the development of many products that boosts a nation's GDP is largely controlled by one supplier, in this case, China. At present, "both production of rare earth materials in China and export of those materials outside of China are strictly controlled by government imposed quotas" (Molycorp Minerals, 2009). Japan, a country that manufactures and exports many of the parts that use rare earth metals, was exposed to and negatively impacted by one such risk. In September 2010, China placed what seemed to be an unannounced and unofficial embargo on the export of raw earth metals to the Japan—a claim that was repeatedly denied by the Chinese government (Humphries, 2010). The incident was initially thought to be related to longstanding maritime wars between the two countries but was heightened when China subsequently began halting exports to other countries as well. This embargo has led many governments around the world to question China's reliability as a supplier of the critical rare earth minerals and has fuelled the urgency of several nations to curtail China's monopoly on the rare earth metal industry.

SUPPLY CHAIN RISKS: RESOURCE CONSTRAINTS

Although China produces and refines more than 90% of the world's rare earth metal supply, the country possesses a relatively small proportion (approximately 34%) of the 99 million tons of the world's reserves. World reserves refer to the amount of rare earth minerals in the earth's surface that can be economically extracted from mines if the requisite resources and materials were made available to do so. Table 1 below shows the recent data on reserves quantities for various countries. From this table we observe that those countries such as India, Australia and even the United States each have millions of tons of rare earth resources available, presumably enough to satisfy each country's own demand.

It can be argued that there are sufficient world reserves to meet the forecasted increases in consumption for the foreseeable future (Hedrick & Cordier, 2010). However, the wealth of rare earth mineral reserves does not seem to be enough to mitigate the *current* state of crisis regarding an impending supply shortage surging through most countries which rely on rare earths as raw material for production. This is because no matter how abundant world reserves are, without the necessary resources to extract the raw materials from the ground and with continued reliance on a China as the dominant source of supply, production will neither be able to meet nor sustain anticipated future demand.

SUPPLY CHAIN RISKS: EXCESSIVE RELIANCE ON A SINGLE SUPPLIER

Despite the recent impediment placed on Japan and other countries during the month of over the past few months, and the state of emergency placed on the situation by several nations, the contraction of supply of rare earth materials by China is neither a new nor shocking issue. Margaret Hunt (2010) in her article entitled *Rare Earth Dearth* states that "experts have been warning of the dangers of U.S. reliance on Chinese rare earths for many years" (p.2). This assertion came subsequent to announcements of decreases in exports of rare earth minerals by Chinese officials. To further exacerbate the concerns of many nations,

approximately three months before the apparent embargo placed on Japan, China imposed export restrictions on rare earths that resulted in a supply shortage for countries outside of China. In July 2010, "China announced that it will cut exports this year of rare-earth elements (REE) by 40%, leaving demand outside China exceeding the supply for the first time ever" (Service, 2010a).

Table 1
WORLD MINE PRODUCTION AND RESERVES
(Data in metric tons of rare-earth oxide (REO) content)

	Mine production[e]		Reserves[1]
	2008	2009	
United States	— `	—	3,000,000
Australia	—	—	5,400,000
Brazil	650	650	48,000
China	120,000	120,000	36,000,000
Commonwealth of Independent States	NA	NA	9,000,000
India	2,700	2,700	3,100,000
Malaysia	380	380	30,000
Other countries	NA	NA	22,000,000
World total (rounded)	124,000	124,000	99,000,000

Source: Salazar, K., & McNutt, M. K. (2010). *Minerals Commodity Summaries 2010.* Washington: United States Government Printing Office, 129.

[e] Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials.

There are several reasonable assumptions and theories that seek to explain why China would be inclined to restrict exports to other countries. The most evident reason is that as China's demand for rare earth dependent technologies such as cell phones, computers, and flat panel displays screens increase, the country's own demand for rare earth elements is quickly outgrowing its supply. Therefore, as experts agree, imposed export restrictions may not be a malicious attempt by the Chinese government to "starve the world of rare earth metals" (Jenkins, 2010), but may be considered necessary to make the metals more readily available for domestic consumption.

Another theory that has surfaced to explain why China may be impelled to reduce export quotas is the country's possible attempt to stimulate its own economy by increasing domestic production of those products like rechargeable batteries and flat panel screens that are currently dominated by other countries such as Japan and India. Therefore, imposing such restriction on supply inevitably increases the company's competitive advantage for sale of these products. This theory was reinforced by Eggert (2010), professor and director of the Division of Economics and Business at the Colorado School of Mines, who argues that "when China restricts exports of a primary raw material, such as rare-earth elements, it presumably is doing so to create an advantage for those manufacturing industries that use rare earths domestically in goods that will be sold both domestically and internationally" (p. 56).

RISK MITIGATION STRATEGIES

Many countries, including the United States, are readily responding to the increasing demand for and contracting supply of rare earth metals. Eggert (2010) suggests that "users of elements for which there are supply risks have a number of options...they can maintain stockpiles, diversify sources of supply, develop joint-sharing arrangements with other users, or develop tighter relations or strategic partnerships with producers" (p.53). Also, more efficient recycling of rare earth materials can assist in curbing the current shortage.

RECYCLING OF RARE EARTH COMPONENTS

Since rare earth metals are used in a wide variety of products that are upgraded on a continuous basis, the opportunity to extract them from the discarded items presents itself (Tabuchi 2010). Labelled "urban mining," this recycling allows nations with no significant rare earth mining operations to displace some of its imports and reduce some of the supply chain risks. Japan has taken major steps in this direction. After Japanese mining of rare earth elements succumbed to the China's dominance, the country has launched a major initiative to recycle the rare earth metals from the tons of laptops, cell phones, and other products which use them. Japan even imports these used electronics for recycling. Estimates are that used electronics contain as much as 300,000 metric tons of rare earth metals. However, since most of these products contain very small quantities of these metals, the extraction process is complicated and expensive. Yet, it provides some relief from the supply chain risks of total dependence on China. As other countries have recognized the value of these used electronics, they have embraced recycling as an alternate supply source of rare earth metals. China has imposed an export ban on computer mother boards, for example.

STOCKPILE ACCUMULATION

Another strategy proposed by several experts to cover supply shortages is the accumulation of stockpiles of rare earth oxides. Generating stockpiles is particularly important as a means of meeting military demand for national defense and executing the environmental initiatives of the United States government (Humpries, 2010). According to the United States Geological Survey, there are currently no government stockpiles of rare earth metals (Salazar & McNutt, 2010). Retaining no stockpile of rare earths critical to so many high tech defense mechanisms poses a severe risk to the United States military arsenal.

SUPPLY CHAIN DIVERSIFICATION

It is estimated that two-thirds of the world's deposits of rare earths are outside of China. Even though diversifying the supply chain has several limitations, countries have recognized that tapping into their own reserves may be a necessary strategy to satiate growing demand and to counteract the risks of further supply restrictions. There are ongoing plans to set up production facilities at rare earth mines located in countries like India, South Africa and Canada, and arrangements are being made to resume production of the mines located in Mountain Pass, California and Mountain Weld, Australia.

Molycorp Minerals LLC is in the process of opening a separations plant at its Mountain Pass rare earth deposit. The company is in the progress of conducting research is expected allow this production facility to obtain up to 60% recovery of rare earth metals from its ore--almost 30% greater than the current recovery rate currently achieved by China (Jenkins, 2010). According to Jenkins, the production facility is

expected to boost production of rare earth oxides in the United States to 200,000 tons per year in the year 2012.

However, Jenkins argues that the mines annual output may not be sufficient to bridge the gap left by reduced Chinese exports. This is especially true for the "heavy" rare earths, such as dysprosium and terbium, which are critical ingredients for the magnets that operate at high temperatures in motors and turbines. The Molycorp deposits are richest in the "light" rare earth elements that work best in low-temperature applications. In any case, Molycorp has entered an agreement to supply rare earths to Japan's Hitachi Metals, one of the world's leading producers of magnets for applications such as missile guidance systems, hybrid automobiles, and electrical wind turbines (Dove, 2011). Hitachi will have to look elsewhere for its requisite "heavy" rare earth metals (Bourzac 2011).

The rare earth deposits of Australia's Mount Weld are expected to be a significant new source of supply. Owned by the Lynas Corporation, the deposits are considered some of the world's richest. In August, 2011, Lynas opened the first phase of a three-phase development that is expected to eventually produce over 33,000 metric tons annually. Lynas is involved in a joint venture with Siemens, a major player in the market for powerful magnetic devices (Dove, 2011).

Brazil is another country with reserves of rare earth elements though largely in an undeveloped state. The giant Japanese firm, Mitsubishi, and a Neo Material, a Canadian firm, are evaluating the Brazilian deposits which are estimated at around 20,000 metric tons (D'Atorio 2010). Other potential supply sources include Kazakhstan, Vietnam, and India.

THE LIMITATIONS OF SUPPLY DIVERSIFICATION

As was discussed earlier, one way to reduce the supply risks associated with the current rare earth metal industry is to diversify production outside of China. However, there are several limitations associated with supply diversification in this industry.

The same reasons that most countries opted to rely on imports from China in the first place may prove to be the identical reasons that may make it economically impractical to expand production facilities globally—that is, the low cost of operations that currently exists in China. Eggert (2010) acknowledged this likelihood when he pointed out that "the biggest impediment to the opening of rare-earth mines outside of China is the reality that China is and likely will remain the low-cost producer of rare earths worldwide and probably could supply most world demand at prices lower than those necessary to justify new mines" (p. 53).

In addition, it would be difficult for other countries to secure the necessary expertise in the form of chemical engineers in the short period of time required to meet increasing demand. Karl A. Gschneidner Jr., senior metallurgist and one of the world's leading rare-earth experts, told Congressional panellists in March 2010 that "rare-earth research in the United States on mineral extraction, rare earth separation, processing of the oxides into metallic alloys and other useful forms, substitution, and recycling is virtually zero" (Ingebretsen, 2010). This "shortage of talent" as Ingebretson calls it, could severely undermine attempts by the United States and other countries to diversify production and reduce the monopolistic control of the industry by China.

Another constraint on diversification is the need to build or re-build the infrastructure needed for mining and processing rare earth elements. When companies moved their operations to China, they abandoned their existing facilities. New entrants to the industry will have to construct facilities from scratch (Bourzac 2011).

In general, getting the required permits to open or expand rare earth production facilities is a lengthy process, from 4-7 years, in most countries. This is because rare earth mining and processing generates toxic, radioactive residue. Environmental concerns tend to dominate the permitting regulations.

GOVERNMENTAL INITIATIVES

Some argue that government should bear much of the responsibility for facilitating the development of domestic production that would reduce the country's reliance on Chinese imports. The process of mining, extracting and separating rare earth elements efficiently and effectively may require the financial aid of government to stimulate research and development initiatives. In the United States, for example, several bills designed to promote domestic production have been proposed. These include: The Rare Earths and Critical Materials Revitalization Act of 2010 which supports research and development; the Rare Earths Supply-Chain Technology and Resources Transformation Act of 2010 that facilitates domestic production; and the Fiscal Year 2011 National Defense Authorization Act that incorporates governmental strategy for ensuring long term availability of those rare earth metals critical to national defense as well as sourcing means to reduce the dependency of military weapons on rare earth materials (Humphries, 2010, pgs. 10-12).

This approach is an alternative to charging China with trade violations under the rules of the World Trade Organization. Specifically, the imposition of export quotas and other restrictions on the vital raw materials violates the spirit of the WTO and probably breaks a few rules as well. However, such litigation is unlikely to prove fruitful and could be time-consuming.

ALTERNATIVES TO RARE EARTH ELEMENTS

Research to find acceptable alternatives to rare earth metals is still in the early stage. This research is unlikely to develop practical material alternatives in the short-run, if ever. Driving the search for alternatives is the high prices of rare earth materials which had been rising steadily for several years. Another factor has been the conservation of these costly materials by changing production techniques so as to use lesser quantities. Furthermore, the high prices have spurred research into the development of alternative technologies that do not rely heavily or at all on rare earth materials (Bradsher 2011).

Though the prices of rare earths seem to have peaked in June of 2011 and fallen sharply throughout the second half of the year, they remain significantly above what they were just a few years ago. This was due in part to the weak global economy which impacted demand. It was also due to China loosening of its export restrictions. Certainly, high prices for key materials will push the search for cheaper substitutes and technologies. And additional supplies will exert downward pressure on prices. The net effect of these market forces will be determined over the coming years.

REFERENCES

Bourzac, Katherine (2011). The Rare Earth Crisis. *Technology* Review. May-June, 58-63.

Bradsher, Keith (2011a). China Consolidates Grip on Rare Earths. September 16. Retrieved from NYTimes.com AThttp://www.mytimes.com/2011/09/16/business/global/china-consolidates-control-of-rare-earths

Bradsher, Keith (2011b). Prices of Rare Earth Metals are Declining sharply. November 16. Retrieved from NYTimes.com

D'Altorio, Tony (2010). Investing in Rare Earth Elements as China's Exports Decline. Retrieved October 17, 2011 at http://www.investmentu.com/2010/October/investing-in-rare-earth-elements.html

Dove, Justin (2011). A New Trend in Rare Earth Elements. Retrieved October 17, 2011at http://www.investmentu.com/2011/August/a-new-rare-earth-element-trend.html

Eggert, R. G. (2010). Critical Minerals and Emerging Technologies. *Issues in Science and Technology* , 53-56. Retrieved from Academic Search Premier database.

Fessler, David (2011). China's Rare Earth Monopoly: The End is Coming, February 11. Retrieved October 17, 2011 at http:/www.investmentu.com/2011/February/china-rare-earth-element-monopoly-ending.

Hendrick, J. B., & Cordier, D. J. (2010). *2008 Minerals Yearbook: Rare Earths*. U.S. Department of Interior, U.S. Geological Survey http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2008-raree.pdf

Hendrick, J. B., & DiFrancesco, C. A. (2009). *Rare Earths Statistics*. U.S. Geological Survey: http://minerals.usgs.gov/ds/2005/140/

Humphries, M. (2010, September 30). *Rare Earth Elements: The Global Supply.* Retrieved November 5, 2010, from Federation of American Scientists: http://fas.org/sgp/crs/natsec/R41347.pdf

Hunt, M. W. (2010). Rare Earth Dearth. *Advanced Materials and Processes* , 2. Retrieved from Academic Search Premier database.

Ingebretsen, M. (2010). The Global Rare-Earth Race. *Advanced Materials and Processes* , 24. Retrieved from Academic Search Premier database.

Jenkins, S. (2010). Rare-Earth Metals for the Future. *Chemical Engineering* , 17-18,20,22-23. Retrieved from ABI/INFORM Global. (Document ID: 2181276671)

Molycorp Minerals . (2009). *Global Outlook*. Retrieved November 5, 2010, from Molycorp Minerals: The Rare Earth Company: http://www.molycorp.com/globaloutlook.asp

Salazar, K., & McNutt, M. K. (2010). *Minerals Commodity Summaries 2010.* Washington: United States Government Printing Office: http://minerals.usgs.gov/minerals/pubs/mcs/2010/mcs2010.pdf

Service, R. F. (2010a). Chinese Policies Could Pinch U.S. Efforts to Make Electric Vehicles. *Science, 329* (5990), 377. Retrieved from Academic Search Premier database.

Service, R. F. (2010b). Nations Move to Head Off Shortages of Rare Earths. *Science , 327*, 1596-1597. Retrieved from Academic Search Premier database.

Tabuchi, Hiroko (2010). Japan Recycles Minerals from Used Electronics, October 4. Retrieved from NYTimes.com.

United States Department of Energy (2010). Critical Materials Strategy, December.