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Canada's Rare Earth Deposits Can Offer A Substantial Competitive Advantage

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Introduction

On March 13, 2012, the United States, the European Union and Japan filed a complaint at the World Trade Organization (WTO) against China over its restrictions on exports of rare earth elements, also referred to as rare earth metals.

China controls 97.3 per cent of the world's production of rare earths,[1] leaving importing countries vulnerable to supply disruptions.

Few of us have heard of these metals. With names like lanthanum, promethium and praseodymium, they sound more like city-states in Ancient Greece. Although often needed in small quantities, these metals are essential to the production of many technologically sophisticated products that are important to the daily lives of consumers. They are also in high demand by the defence and renewable energy industries.

1 U.S. Department of the Interior. "Mineral Commodity Summaries, 2008-2011." *U.S. Geological Survey*. 2011. India accounts for the other 2.0 per cent of mine production, Brazil 0.4 per cent and Malaysia 0.3 per cent.

The Canadian Chamber is committed to fostering a strong, competitive and profitable economic environment that benefits all Canadians. This paper is one of a series of independent research reports covering key public policy issues facing Canada today.

We hope this analysis will raise public understanding and help decision-makers make informed choices. The papers are not designed to recommend specific policy solutions, but to stimulate public discussion and debate about the nation's challenges.

Rare earth elements are found in hybrid and electric cars, fluorescent lights, plasma screens, portable computers, hand-held electronic devices, wind power generators and optical and medical devices. Several rare earth elements are essential constituents of automotive pollution control catalytic converters and petroleum fluid cracking catalysts. Rare earth elements have a wide variety of defence applications, some of which are critical to countries' national security. They are used in precision guided munitions (missiles and smart bombs), lasers, satellite communications, jet fighter engines and radar systems.

But the story of rare earth elements is far more interesting. It is story about a country—in this case, China—embracing a strategic culture that focuses on "very straightforward, pragmatic, long-term-oriented decision-making that prizes a set of objectives that might be pursued over a long period of time."[2] China's dominance of the rare earths market is not by accident. It is part of a far-sighted government policy going back decades that envisaged the rare earths as "the oil of the twenty-first century."[3]

China's early recognition of the value of rare earth elements and keen forward-thinking ability enabled the country to change its resource advantage into a competitive advantage. It has built a strong foundation focused on the study and research and development of rare earth elements and their application to achieve economic superiority.

The United States, once self-reliant in rare earth elements production, is now dependent on imports, with over 90 per cent sourced from China.[4] For the United States, an adequate, stable and reliable supply of rare earth metals is critical for economic well-being, industrial production and national security (because of the various defence applications). Its competitive edge in high tech has been threatened as manufacturers have been shifting operations to China to gain access to an uninterrupted supply of low-cost rare earths.

Canada is an enviable position. Not only does it have oil, it has some of the world's largest rare earth deposits and expertise in processing them.

The question remains: Will Canada "develop the kind of strategic culture that allows it to punch at its weight or above its weight?"[5]

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2 Global Brief Magazine. "On States, Strategy and Strategic States." *Interview with Fareed Zakaria*. October 19, 2009.

3 The Economist. "The Difference Engine: More precious than Gold." September 17, 2010.

4 U.S. Department of the Interior. "Mineral Commodity Summaries, 2008-2011." *U.S. Geological Survey*. 2011. The U.S. sources 91 per cent of rare earth elements from China, three per cent from France, three per cent from Japan, one per cent from Russia and two percent from other nations.

5 Global Brief Magazine. "On States, Strategy and Strategic States." *Interview with Fareed Zakaria*. October 19, 2009.

What in the world are rare earth elements?

Despite their name, rare earths are neither rare nor earths. They are moderately abundant in the earth's crust. Some are even more abundant than copper, lead, gold and platinum. However, they occur in relatively low concentrations so they are not easily exploitable economically.

The term *rare earths* refers to a series of 17 chemically similar metals, consisting of the 15 elements known as the lanthanides, plus yttrium and scandium. They have unique chemical, magnetic and fluorescent properties.

"Perhaps the most important application of rare earth metals is in the production of the world's strongest permanent magnets. Two rare earth elements, neodymium and dysprosium, are used to manufacture magnets which have high magnetic strength but lower weight. This means that they are used in electric motors to produce higher power and torque with much lower size and weight. These characteristics make them very useful in the development of hybrid and electric vehicles, as well as in the miniaturisation of hard disk drives used in many electronic devices."[6]

6 Davies, Simon. "Applications of the Rare Earth Elements." *Chemistry@suite 101*. January 8, 2010.

The trade tussle over rare earth elements

Over the past several years, China has been raising duties on some rare earth exports and reducing export quotas of rare earths—from about 65,600 tonnes in 2004 to around 30,300 tonnes in 2012.[7] However, exporters only filled roughly half the quota last year.

The Office of the United States Trade Representative stated: "Because China is a top global producer for these key inputs, its harmful policies artificially increase prices for the inputs outside of China while lowering prices in China. This price dynamic creates significant advantages for China's producers when competing against U.S. producers—both in China's market and in other markets around the world. The improper export restraints also contribute to creating substantial pressure on U.S. and other non-Chinese downstream producers to move their operations, jobs, and technologies to China."[8]

China's foreign ministry spokesperson, Liu Weimin, responded: "Based on environmental protection and in order to achieve sustainable development, China carries out management policies over the export of rare earths."[9]

The mining and processing of rare earths can cause considerable environmental damage. Commercial-grade rare earth deposits tend to be found in the same ore bodies as radioactive thorium and uranium (which are not a rare earth element). In China, thousands of gallons of acid are pumped into streambeds to extract and separate the rare earth minerals. The radioactive sludge laced with toxic chemical compounds is discharged into rare earth lakes or reservoirs not far from the Yellow River watershed that supplies drinking water to much of northern China.

The Chinese government has taken steps to better regulate the industry and improve environmental and mining practices. It is limiting production by closing smaller and illegal operations and consolidating larger ones under the control of state-owned enterprises. Stricter control of the industry will also make it easier for Chinese authorities to curb smuggling. According to the Xinhua News Agency (September 14, 2009), about 20,000 tonnes of rare earth was smuggled from China in 2008. Customs statistics showed that in 2008 the country exported 47,449 tonnes of rare earth oxide. This means smuggling accounted for about 30 per cent of the total volume of rare earth leaving China.

7 Sources: China Ministry of Land and Resources, U.S. Geological Survey and Ministry of Commerce of China.

8 The Office of the United States Trade Representative (USTR). "United States Challenges China's Export Restraints on Rare Earths." March 13, 2012.

9 Business Spectator. "China defends rare earth export quotas." March 14, 2012.

How China has come to dominate the market

The Mountain Pass rare earth mine in southeastern California (owned by Molycorp Inc.) was once the largest rare earth supplier in the world. The mine closed in 2002 in response to both environmental restrictions and stiff competition from China. The United States was once the leader in both the innovation and trade of rare earth elements. American research led to groundbreaking uses for rare earth elements both for commercial and military uses.

In the 1980s and 1990s, China embarked on a mission to become a global leader in the production of rare earth elements. Between 1978 and 1989, China increased production of rare earth elements by an average of 40 per cent annually, making it one of the world's largest producers.[10] With rare earths at the center, China focused on research and development, education and innovation to give the country a decisive competitive advantage.

In 1986, as part of its strategic plan to become a world leader in high-tech innovation, China introduced the National High Technology Research and Development Program, known as Program 863. A great deal of money has gone toward researching rare earths. The Program's objective during the 10th Five-year Plan period is to "boost innovation capacity in the high-tech sectors, particularly in strategic high-tech fields, in order to gain a foothold in the world arena; to strive to achieve breakthroughs in key technical fields that concern the national economic lifeline and national security; and to achieve 'leap-frog' development in key high-tech fields in which China enjoys relative advantages… Through efforts made in the 5 years, the program will greatly enhance China's high-tech innovation capacity in selected fields and improve the international competitiveness of major industries."[11]

The Chinese leadership has long recognized that this valuable resource confers a strategic advantage like no other. In 1992, former Chinese President Deng Xiaoping famously said, "There is oil in the Middle East; there is rare earth in China."[12] In 1999, President Jiang Zemin wrote: "Improve the development and application of rare earth, and change the resource advantage into economic superiority."[13] This is precisely what China has done.

In 1997, China introduced a second program known the National Basic Research Program of China, or Program 973. "The strategic objective of the Program is to mobilize China's scientific talents in conducting innovative research on major scientific issues in agriculture, energy,

10 Minnin, Wang and Dou Zuehong. "The History of China's Rare Earth Industry" in C.H. Evans' *Episodes from the History of the Rare Earth Elements*. Netherlands: Kluwer Academic Publishers. 1996.

11 Ministry of Science and Technology of the People's Republic of China. http://www.most.gov.cn/eng/programmes1/200610/t20061009_36225.htm

12 Baotou National Rare Earth Hi-Tech Industrial Development Zone. "Rare Earth: An Introduction." http://www.rev.cn/en/int.htm

13 Ibid.

information, resources and environment, population and health, materials, and related areas."[14] The study and research and development of rare earth elements and their application is a significant component of Program 973.

There are two state laboratories in China that focus exclusively on rare earths: The State Key Laboratory of Rare Earth Materials Chemistry and Applications (affiliated with Peking University in Beijing) and The State Key Laboratory of Rare Earth Resource Utilization (affiliated with the Changchun Institute of Applied Chemistry, under the Chinese Academy of Sciences, located in Changchun).[15]

There are also two institutes in China dedicated to rare earth elements. The Baotou Research Institute of Rare Earths—the world's largest rare earth research and development institution—and the General Research Institute for Nonferrous Metals.

While the laboratories and institutes complement each other, they each focus on a particular research area.[16]

Finally, two journals published in China—the *Journal of Rare Earth* and the *China Rare Earth Information Journal*—are the only two publications globally that focus almost exclusively on rare earth elements.[17]

In summary, China used its vast resources of rare earths and knowledge gained from basic and industrial-applied research of rare earth elements to advance technology-based manufacturing. Many high-tech manufacturers from across the globe have relocated to China to ensure adequate supply of rare earths and to take advantage of the growing pool of engineers, scientists and researchers focused on the development and application of rare earth elements.

"The rest of the world was seemingly asleep as China grew to become a goliath in the rare earth industry. It took the rest of the world nearly 20 years to suddenly wake up to the realization that the future of high technology could be in the hands of this one supplier."[18]

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14 Ministry of Science and Technology of the People's Republic of China. http://www.most.gov.cn/eng/programmes1/200610/t20061009_36223.htm

15 Hurst, Cindy. "China's Rare Earth Elements Industry: What Can the West Learn?" Washington D.C.: The Institute for the Analysis of Global Security. March 2010.

16 Ibid.

17 Ibid.

18 Hurst, Cindy. "China's Rare Earth Elements Industry: What Can the West Learn?" Washington D.C.: The Institute for the Analysis of Global Security. March 2010.

The world finally takes notice

While China controls production today, sizable rare earth deposits exist in Canada, the Commonwealth of Independent States (i.e. Russia and former Soviet republics), the United States, Australia, India, Brazil and South Africa, among other places.[19] The challenge is to put in place the infrastructure and processes necessary to mine and process rare earths economically and in an environmentally-friendly way. This can take years.

The West has accelerated efforts to develop alternatives to China. There are now two main rare earth mining operations outside of China, one run by U.S.-based Molycorp Inc. and the other by Australia-based Lynas Corp.

In late 2011, Molycorp Inc. restarted rare-earth-mineral production at its flagship Mountain Pass mine in California (which closed in 2002) and is expanding its operations.

In February 2012, Molycorp Inc. announced the sequential start-up of the new Project Phoenix rare earth manufacturing facility at its Mountain Pass operation. The facility takes fresh rare ore mined on the site and feeds it into a new crushing facility. Mechanical completion of the initial cracking facility has been achieved and feedstock from stockpiled material has been fed into the system. Other operations in the Project Phoenix facility will be brought online over the coming months, including milling and mineral extraction, expanded cracking, impurities removal, rare earth oxide separations, product finishing and paste tailings processing and storage.

In March 2012, Molycorp announced that is buying Neo Material Technologies, a Canadian company with cutting-edge technologies that's also one of the world's main rare earth processing companies. Neo Material takes fairly pure rare earth feedstock from mines (mainly those located in China) and processes them into high-tech materials in the company's factories in China and Thailand. Molycorp has indicated that it would ship some of its rare earths from California for processing at Neo Materials Technologies' factories. Molycorp will also gain access to Neo Materials' sales channels in China and Japan, two of the world's largest rare earth-consuming nations.[20]

In Western Australia, Lynas Corp.'s Mount Weld mine is set to provide a new source of supply when production comes online in the second quarter of 2012. Lynas is also constructing a rare earths processing plant in Malaysia that will be supplied with rare earth material from the Mount Weld mine. The processing plant has capacity to meet one-fifth of the world's demand.

19 U.S. Department of the Interior. "Mineral Commodity Summaries, 2008-2011." *U.S. Geological Survey*. 2011.

20 Bradsher, Keith. "Molycorp, a Rare Earth Mining Firm, Is to Merge With a Processor, Neo Material." *New York Times*. March 8, 2012.

Japan, the world's biggest importer of rare earths, because it is home to several of the world's major high-tech manufacturers, has been shaping a national strategy on rare earths centered on increasing stockpiles, recycling from discarded electronics[21] and finding new sources. The Japanese government has also introduced a US$1.31 billion plan to develop new technologies in the hope of reducing the country's reliance on rare earth imports by 30 per cent in the medium-to-long term. It is also pursuing joint ventures with other countries with known rare earth reserves (such as Vietnam and Canada), providing financial support for the development of new mines and refineries.

Researchers from the University of Tokyo, the Japan Agency for Marine-Earth Science and Technology, and the Tokyo Institute of Technology have found abundant, rich deposits of rare earth elements at numerous sites in the Pacific Ocean. The rare earth elements are on the surface layer of mud and can be recovered by acid leaching—i.e. using solutions of hydrochloric or sulphuric acid.[22]

End users of rare earths, like General Motors, Toyota, Volkswagen, General Electric and many other U.S. and foreign manufactures, are actively looking for alternatives to rare earth metals. In January 2012, 12 major German manufacturers, including Daimler and Bosch, announced an alliance intended to ensure their supply of rare earths.[23] "The alliance has the goal of taking shareholdings in commodity projects to achieve a long-term improvement in the supply of raw materials to industry."[24]

21 According to a report ("Recycling Rates of Metals", May 2011) published by the United Nations Environment Programme, less than one per cent of rare earth metals are recycled today globally. While recycling is a highly promising source of future material, the logistics and processes are complicated and will require greater consumer awareness and participation, and extensive R&D. See Molycorp Inc., http://www.molycorp.com/Technology/RareEarthRecycling.aspx

22 Nature Geoscience. "Deep-sea mud in the Pacific Ocean as a potential resource for rare-earth elements."July 3, 2011.

23 Rosenbaum, Andrew. "A Rare-Earth Opportunity." *The Wall Street Journal*. March 12, 2012.

24 Reuters. "12 companies join German commodity alliance." March 30, 2012.

The rare earth opportunity for Canada

Canada has 1.1 billion pounds of rare earths locked in black shale deposits (the Alberta Black Shale Project) worth an estimated $206 billion that were previously not recoverable unless large amounts of cyanide and arsenic were used to liquefy the ores—a process that is considered dangerous and illegal in many parts of the world. Now, a new, more cost-effective and environmentally friendly technology that uses water, air and microbes (a technique known as bioheap leaching) can be used to release the rare earth from the black shale deposits.[25] The new technology has a limited track record—only one mine (operated by Finland's Talvivaara Mining Company Plc.) is producing metals through bioheap leaching. Toronto-based DNI Metals, a junior mining company, has said it needs $1 billion to get the project going.[26]

Several other Canadian mines show great potential.

- Avalon Rare Metals Inc.'s Nechalacho Rare Earth Element Project, located at Thor Lake in the Mackenzie Mining District of the Northwest Territories, has exceptional wealth of heavy rare earth elements. It contains some of the largest deposits of light and heavy rare earth elements outside of China. Avalon estimates a possible start date of 2015 for full capacity production.

- Great Western Minerals Group Ltd.'s Hoidas Lake Project, located in northern Saskatchewan, has one of the highest proportions of neodymium present in any known rare earth deposit. This makes it strategically important to the permanent magnet industry. The company is working on designing an optimal concentration/leaching process with the goal of starting production in 2015–16. Great Western Minerals is also exploring the heavy rare earth-enriched Red Wine Property northeast of Churchill Falls, Labrador; the Benjamin River Property near Bathurst, New Brunswick; and the Douglas River area of Saskatchewan.

- In July 2011, Midland Exploration Inc. started exploration with state-backed Japan Oil, Gas and Metals National Corp. (JOGMEC) on its Quebec rare earth project, Ytterby. The Japanese Ministry of Economy, Trade, and Industry is investing in projects worldwide to receive access to stable supplies of rare earth elements.

- Pele Mountain Resources is focused on the sustainable development of its Eco Ridge Mine Uranium and Rare Earth Elements Project, located in Elliot Lake, Ontario. The government of Ontario has recently granted two renewable 21-year mining leases for Eco Ridge, giving Pele the exclusive right to mine in the leased areas.

- Matamec Explorations Inc. is currently exploring its Zeus property, located in the Temiscamingue region of Quebec. Toyota Tsusho Corp. has signed a non-binding

25 Absolute Wealth Contributor. "Rare Earth Mineral Stocks." February 23. 2012. Also, Commodities Reporter. "Massive Mine in Canada." September 20, 2011.

26 Gordon, Julie. "DNI Metals enlists ore-munching bacteria to extract base metals—PDAC." *REE-Investor*. March 5, 2012.

memorandum of understanding with Matamec to fast-track the development of the Kipawa deposit to secure a supply of heavy rare earths, which are used in the production of Toyota's hybrid and electric vehicles.

- Quest Rare Earth Mineral Ltd. is currently advancing several rare earth projects in the Strange Lake and Misery Lake areas of northeastern Quebec. The mineral deposits are exposed at surface and are amenable to a low-cost open pit mine with the potential to provide a long-term, stable supply of separated and refined heavy rare earths.

- Cache Exploration Inc. is exploring the Welsford rare earth properties in New Brunswick and the Cross Hills and Louil Hills rare earth properties in Newfoundland.

- Kirrin Resources Inc. operates rare earth exploration projects in Newfoundland and Labrador and in Quebec.

- Rare earth potential has been confirmed on Forum Uranium Corp.'s North Thelon Project in Nunavut.

Other Canadian-based rare earth explorers and miners are developing mines in Canada and around the world. Nova Scotia-based Ucore Rare Metals Inc. is exploring a project on Bokan Mountain on Prince of Wales Island in Alaska. Toronto-based Stans Energy Corp. is progressing heavy rare earth properties in areas of the former Soviet Union, and Great Western Minerals Group is focused on putting the Steenkampskraal mine in South Africa into production.

Conclusion

"Everyone has started to search for rare earth elements…The Japanese are desperately searching all over. Europe has a new strategic plan to secure rare earth elements too. It all started with concerns over China's monopoly, triggering a race to find new deposits and mine them,"[27] said Michel Jebrak, a mineral resources specialist at the University of Quebec in Montreal.

Canada has been blessed with great geology. Many Canadian mining companies are actively exploring for and delineating rich, rare earth deposits in a number of geographic regions across the country.

"Rather than being the unassuming neighbour of the United States the hunger of the world's economy for resources may mean that Canada will increasingly have political leverage and influence."[28]

27 Pouliot, Gaétan. "Canadá entra en la carrera por tierras raras, claves para la alta tecnología." *Agence France-Presse (AFP)*. December 19, 2011.

28 Blachford, Kevin. "The Canadian Pivot to China?" *The Montréal Review*. March 2012.

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