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Examining Perspectives On China's Near-Monopoly Of Rare Earths

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EXAMINING PERSPECTIVES ON CHINA'S NEAR-MONOPOLY OF RARE EARTHS

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Gregory J. Bryant

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To: Dean Michael R. Heithaus
College of Arts and Sciences

This thesis, written by Gregory J. Bryant, and entitled Examining Perspectives on China's Near-Monopoly of Rare Earths, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this thesis and recommend that it be approved.

Steven Heine

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Thomas Breslin, Major Professor

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The thesis of Gregory J. Bryant is approved.

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Florida International University, 2015

DEDICATION

To Jingyun: my wife, lover, companion, inspiration. Because of you, this thesis has meaning. To my parents, Kevin and Sherlyn: for your unfailing support and encouragement.

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ABSTRACT OF THE THESIS

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OF RARE EARTHS

by

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Professor Thomas Breslin, Major Professor

China's behavior as a near-monopolist of rare earths has come under increasing scrutiny in recent years. This thesis first examines the underlying causes behind China's rise to the status of rare-earths near-monopolist, including government support; lax environmental controls; unregulated production; and relatively low costs compared to the rest of the world. Second, the thesis also examines the preeminent international and domestic factors influencing China's behavior as a near-monopolist of rare earths. International factors include international demand; international trade pressure; international price-setting authority issues; and geopolitical factors. I next identify domestic factors that exert influence over China's rare earths-related behavior: environmental protection; rare earth resource protection; rare earths industry regulation; and protecting and aiding China's domestic rare earths industry. The study concludes with a synthesis of the factors influencing China's rare-earths-related behavior in the overall context of support and direction by China's Central Government.

TABLE OF CONTENTS

INTRODUCTION

In September, 2010, China and Japan were diplomatically at each other's throats, again. The issue of dispute was the collection of rocky atolls known on the Chinese Mainland as the "Diaoyudao islands" (钓鱼岛及其附属岛屿), the "Diaoyutai islands" (釣魚臺列嶼) in Taiwan, and the "Senkaku islands" (尖閣諸島) in Japan. The Chinese trawler "Minjinyu 5179" (闽晋渔 5179) had rammed Japanese coast guard vessels in waters surrounding the disputed islands (an event known as the "2010 Senkaku boat collision incident" or the "Minjinyu 5179 incident"), setting off a small-scale diplomatic crisis. The Japanese coast guard authorities detained the Chinese trawler captain, Zhan Qixiong (詹其雄) and his crew. China responded by cancelling all Sino-Japanese meetings of a ministerial level and above. The diplomatic spat ended in defeat for the Japanese when the Japanese authorities returned captain Zhan to China. The Chinese people, some of whom had taken to the streets in protest on behalf of the "inalienable territory" of the Diaoyu islands, rejoiced at the diplomatic victory; in Japan, leaders were criticized for a weak handling of the crisis.

Though the Chinese government has never directly admitted to its truthfulness, it was widely reported that the key factor leading to the eventual diplomatic defeat of Japan was China's administrative "embargo" of rare earths exports to Japan. Rare earths, the so-called vitamins of modern technology, are mineral elements critical to the production of much of Japan's array of high-tech products, from small electronics to hybrid and electric automobiles. Japan was (and still is, although not to such an extent) highly dependent on cheap rare earths elements from China to fuel its high-tech industry. Thus, China's de facto embargo caught the attention of Japanese leaders—fast—eventually pressuring Japan into capitulating to China's demands for the release of the trawler skipper, Mr. Zhan. Or so the story goes according to major Western media such as *The New York Times* (Bradsher, 2010). Literally overnight, the eyes of the world honed in on a group of little-heard-of elements, the so-called "rare earths".

Regardless of whether or not China actually imposed an embargo on the export of rare earths to Japan, the fact that China, which at the time produced over 90% of the world's rare earths, had a near-monopoly on rare earths, and therefore had the capability of imposing debilitating export restrictions which would have direct negative effects on rare-earths dependent countries, was reason enough for major concern in Japan and the United States—countries that were, and still are, highly dependent on China's rare earths.

Rare earths are considered critical strategic resources by governments around the world. The potential for supply disruption and price hikes has forced world leaders to find alternatives to China's cheap rare earths. In the world outside of China, many saw and see China as a threat in the rare earths realm; whereas China justifies its actions as environmentally protective. The significance of the present study is to examine, on the basis of the current literature, both in the Chinese and English languages, the behavior of China as a near-monopolist of rare earths.

Research Questions

This thesis seeks to answer the following two research questions:

(1) On the basis of the extant literature in the public domain, how did China achieve the status of near-monopolist of rare earths production?

(2) Has China's behavior as a near-monopolist of rare earths been influenced by international or domestic factors?

Findings

The two research questions above have guided the process of examining China's status as a rare earths near-monopolist and its behavior as such. I have found that, in short, the answers to the two research questions can be summarized thus:

Question 1: From my examination of the extant literature in the public domain, China has achieved a near monopoly on rare earths production as a result of the following four factors, discussed in Chapters 1 and 2: (1) Strong support for the development of the rare earths industry by the Chinese government; (2) lack of or disregard for environmental regulations regarding the production of rare earths; (3) illegal and/or unregulated production; (4) relatively low cost of rare earths production in China compared with the rest of the world.

Question 2: China's behavior as a near-monopolist of rare earths is influenced by several factors—both international and domestic. International factors, discussed in Chapter 3, include international demand, which was heightened by production difficulties in several countries outside of China, and low rare earths prices in China; international trade pressure, including strong opposition to China's export restriction policies by several WTO nations; international "price-setting authority" issues, which many Chinese scholars see as evidence that China is actually the "underdog" in the world rare earths pricing scheme; and geopolitical factors, such as the China-Japan dispute over the Diaoyu/Senkaku islands, which gave China the opportunity to use rare earths as a geopolitical bargaining chip.

My research also found several domestic factors that exert influence over China's rare earths-related behavior, which I have outlined in Chapter 4: environmental protection, which in recent years has become a new rhetorical rallying point for the Chinese government with regard to rare earths; rare earth resource protection, which is a principle that underlies nearly all protective/restrictive measures regarding rare earths on the part of the Chinese government; rare earths industry regulation, which is key to China gaining and maintaining ultimate control over rare earths production and export; and protecting and aiding China's domestic rare earths industry, a protectionist reality often denied by the Chinese government.

The study concludes in Chapter 5 with a synthesis of the factors influencing China's rare-earths-related behavior in the overall context of support and direction by China's Central Government. I have found that the entirety of China's behavior as a near-monopolist of rare earths cannot be understood outside the context of the overarching direction of the State. The rare earths industry holds strategic significance to China, and is an indivisible part of China's technological development thrust. As such, the development of rare earths in China not only falls under the wide category of national development—a mantra that China has chanted in earnest beginning with the Reform and Opening Up in 1978—it is a literally irreplaceable part of that development, and has significant implications for China's technological future.

Methodology

In these pages, I have conducted a historical review of the extant literature in the public domain relating to China's near-monopoly on rare earths, using Chinese-language sources not usually accessed by Western researchers. I have analyzed official statements and publications from the various related government organs and news agencies of the People's Republic of China (in Chinese), and official statements, white papers, hearings, and news reports from Western government agencies and news outlets (in English). I have also referenced commercial publications, industrial bulletins, and any other extant official statement with a relation to China's near-monopoly on and exports of rare earths (in Chinese and/or English).

I have examined varied sources—some available in English, and some found only in Chinese[1], and have arrived at a multifaceted, synthetic understanding of the factors influencing China's behavior as a near-monopolist of rare earths. My methodology has consisted of straightforward textual and historical analysis, and the findings of my research are all rooted in my synthesis of the foresaid sources.

[1] If not otherwise noted, all Chinese-English translations are mine.

CHAPTER 1: A HISTORICAL OVERVIEW OF WORLD RARE EARTHS PRODUCTION

In 2010, in the midst of a China-Japan diplomatic struggle, China's alleged administrative halt on exports of rare earths to Japan brought the rarely discussed elements to the front-page news. In 2012, the media spotlight focused on rare earths once again as a joint WTO case was raised by the United States, Japan, and the European Union against China pinpointing China's restrictive export policies and near-monopoly status of rare earths. As of this writing, China was found to be in violation of WTO rules, and as of January 1, 2015, has officially cancelled its export quotas for rare earths elements in a move generally welcomed in the West and criticized in China.

As will be shown in the following chapters, China has a near-monopoly on world rare earths production and exports. China's behavior as a near-monopolist of rare earths, especially with regard to production and export, has become the object of increasing Western concern and scrutiny in recent years, as China has introduced considerable production and export restrictions on rare earths that have had direct and unfavorable consequences on the high technology and defense industries of the rest of the world.

Before discussing China's behavior as a near-monopolist of rare earths (the central focus of this thesis), it is valuable to provide a brief historical introduction of the rare earths themselves, in order to give the reader an understanding of the significance of rare earths to the world, and the history of their discovery and production. The current chapter will outline the nature of rare earths; the circumstances surrounding their discovery; as well as the history of rare earths production worldwide, with a focus on

China in particular. This chapter serves as a historical background for the discussion in later chapters regarding China's rare earths policies, especially those relating to exports.

What Are Rare Earths Elements?

The rare earths elements (REE) are a set of 17 elements, including 15 of which appear in the lanthanide series of the periodic table (atomic numbers 57-71), as well as scandium (atomic number 21) and yttrium (atomic number 39) (Hurst, 2010). Rare earths can be found in low concentrations in many locations in the earth's crust, but "discovered minable concentrations" for rare earths are significantly lower than for other ores. The name "rare earths" was suggested by Johann Gadolin in 1794, precisely because Gadolin believed the minerals to occur only rarely in the earth's crust, and because, as oxides, they had an "earthy" appearance (Massari & Ruberti, 2013). The designation of "rare earths" as "rare" was later proved to be a misnomer (Gambogi, 2014), but the name stuck.

The rare earth elements have applications in various fields and products, such as glass coloring and lighting (including carbon arc lighting used in the film industry); misch metal used to make flints for lighters; metal strengthening in aircraft engines; permanent magnets in hybrid automobiles; luminous paint, atomic batteries, and thickness measurement devices; phosphors used in television sets; metallurgy, neutron therapy, and MRI technology; crystal stabilizers for fuel cells, and naval sonar systems; control rods in nuclear reactors, as well as in Terfenol-D, a material with the highest known room-temperature magnetostriction; fiber optics as an optical amplifier; and laser technology, etc (Green, 2012; Doerr, Rotter & Lindbaum, 2005; Extavour, 2011).

The rare earths are essentially "irreplaceable" ("Rare Earth Elements", 2013) in the many high-tech applications that have benefited both the civilian and military industries for years. According to James R. Clapper, Director of National Intelligence, in his "Worldwide Threat Assessment of the US Intelligence Community", "rare earth elements (REE) are essential to civilian and military technologies and to the 21st century global economy, including the development of green technologies and advanced defense systems" (Clapper, 2013).[2]

The rare earths are the largest chemically coherent group within the periodic table (Haxel, Hedrick & Orris, 2002), and are divided into two main categories: light rare earths (LREEs), which are found in high concentrations in bastnäsite deposits; and heavy rare earths (HREEs), found in higher concentrations in monazite deposits.[3] (See Figure 1) Light rare earths are used in such diverse applications as glass polishing, catalytic converters, catalysts for polyethylene production, magnets for wind turbine generators, and high strength magnets in hybrid and electric automobiles, etc. Compared to heavy rare earths, the light rare earths occur in greater minable quantities, but the heavy rare earths are used for more high tech applications, such as fiber optics, lasers, phosphors, etc.

While it is important to recognize the collective unity of the rare earths elements from a geological perspective, it is also necessary to recognize that the technological use

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[2] In a comprehensive 2013 Yale University study, researchers found that there are currently no reliable replacements for the rare earths (Dennehy, 2013). Though the United States Department of Energy is pressing forward with attempts to find viable replacements (e.g. nanomaterials) for rare earths, especially those that help form permanent magnets, at present, there are still no successful replacements readily available for rare earths, and the recycling rate of rare earths is not particularly high (Piesing, 2013).

[3] LREEs (atomic numbers 57-64) are noted for having increasing unpaired electrons, whereas the HREEs (atomic numbers 65-71 plus atomic number 39) have paired electrons. Scandium (atomic number 21) does not exhibit properties of either LREEs or HREEs, and therefore does not fall under either category (Generalic, 2014).

of rare earths elements is a highly individualized matter. As Du & Graedel (2013) pointed out in their informative research on the end uses of rare earths between 1995 and 2007, “while REE can often be treated as a group as far as geology is concerned, their employment in modern technology largely depends on the chemical and physical properties of the individual elements. Thus, understanding the individual composition in the total end uses helps evaluate the risks in future REE supply, as some industrial sectors use only a single REE, while others employ several”.

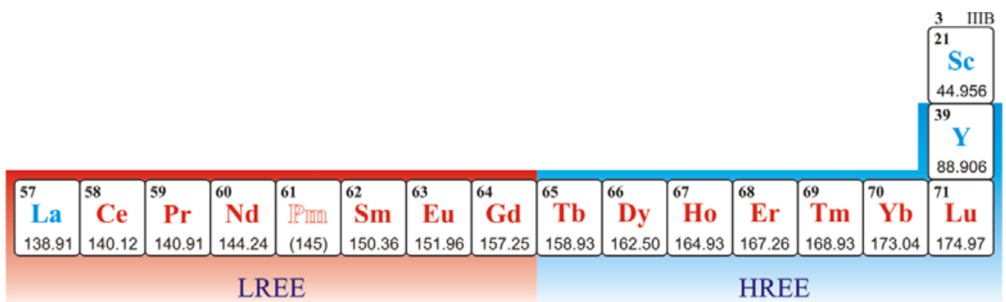

Figure 1. Rare earths elements are divided into Light Rare Earths Elements (LREEs) and Heavy Rare Earths Elements (HREEs).

In 1787, Swedish army lieutenant and chemist Carl Axel Arrhelius discovered a unique black mineral in a feldspar and quartz mine (Hedrick, 2003) near the village of Ytterby, not far from Stockholm, Sweden. The black mineral contained several types of rare earths, including cerium (atomic number 58), the most abundant form of rare earths. During the late 18th and early 19th centuries, chemists from various parts of the globe—predominately Europe[4]—respectively laid claim to the discovery of the other rare earths elements (See Appendix), with the last “straggler”—promethium—being officially discovered in 1945.

[4] The rare earths were discovered by chemists from Austria, France, Germany, Sweden, and the United States, with Swedish scientists making up the majority by far.

Before embarking on the historical review of rare earths production, I must define two key terms which will be used throughout the thesis:

(1) Rare earths resources (稀土资源): A concentration of rare earths in the earth's crust in such a form that economic extraction is considered feasible, either currently or at some future time ("Geological Survey Circular 831"; "Mineral Reserves, Resources, Resource Potential, and Certainty").

(2) Rare earths reserves (稀土储量): That portion of the identified rare earths resources from which usable rare earths can be economically and legally extracted at the time of determination, or the portion that has already been extracted and is held in reserve (储备) (Ibid).[5]

Rare Earths Production Around the World

During the last decade of the 20th century, China would become the primary producer and exporter or rare earths. But from a historical perspective, the worldwide rare earths industry went through an evolutionary process lasting approximately one hundred years before the age of China's supremacy. In the early years (1880s-1940s), rare earths mining, processing, application, and export were parts of the economies of several countries, with the United States eventually taking the lead from the 1950s through the 1970s, and dominating the rare earths scene for most of the 1980s, during the latter part of which China gained competitive advantage in the world rare earths market.

[5] In this sense, "reserve" (储备) is similar to "stockpile". For example, see "the U. S. Strategic Petroleum Reserve", which is "the largest stockpile of government-owned crude oil in the world", "established in the aftermath of the 1973-74 oil embargo" ("Petroleum Reserves").

Since the discovery of rare earths, there had always been a curiosity in the scientific community regarding their possible applications, but it seemed that much regarding rare earths was shrouded in mystery during the early days of discovery and exploitation. During the nineteenth century, production of rare earths was severely impeded because of challenges in separation processes. Rare earths elements are chemically similar, and it was not until the twentieth century that efficient separation methods were developed (Castor & Hedrick, 2006). Sir William Crookes, a noted British chemist and physicist of the nineteenth and early twentieth centuries (Encyclopaedia Britannica, 2014), is claimed to have said the following regarding rare earths (Emsley, 2001):

> The rare earth elements perplex us in our researches, baffle us in our speculations, and haunt us in our very dreams. They stretch like an unknown sea before us, mocking, mystifying and murmuring strange revelations and possibilities.

In 1945, when the last of the rare earths (promethium) were discovered, extraction and production were difficult because of technological constraints, a state of affairs that continued into the 1950s, when rare earths production was limited as a result of production technology mainly consigned to monazite placers. Pre-1965, a vast majority of rare earths were mined from placer deposits in India and Brazil, with South Africa coming on the scene as the largest rare earth producer during the 1950s ("REE – Rare Earth Elements and their Uses").

In 1949, rare earths were discovered in Mountain Pass, California, and production ensued in 1952. By 1966, the Mountain Pass rare earths mine, owned by Molybdenum

Corporation of America (later Molycorp), had become the world's largest miner of rare earths. Production of rare earths at Mountain Pass, California, steadily rose from 1965 through 1985, as demand for the europium (atomic number 63) used in color televisions increased. Substantial environmental and regulatory problems began to compromise the productivity (see Figure 2) of Mountain Pass during the late 1990s (Venton, 2012), and the mine fell into a state of intermittent operation due to pressures and constraints related to waste water management, etc., during the 2000s.

Mountain Pass held the distinction of being the world's most productive rare earths mine until the late 1980s, when China's production exceeded Mountain Pass. As will be discussed in the following section, after a transition period from 1984 to 1990, China emerged as the dominant world producer of rare earths (Haxel et. al., 2002). At present, China plays the role of near-monopolist, "semimonopolist" (Shambaugh, 2013), or "quasi-monopolist" of rare earths (Brumme, 2014) in the world market.

Rare Earths Production in China

Bad news for Molycorp's Mountain Pass mine was the harbinger of good tidings for China's growing rare earths industry, which was not encumbered by as many environmental and regulatory restraints in the 1990s and early 2000s[6]. China's latent potential as a country rich in rare earths found realization during a "perfect storm" of opportunity, namely tougher environmental and regulatory restrictions in the United

[6] China's lax environmental restraints with regard to rare earths mining will be discussed at greater length in Chapters 2 and 4.

States, lax regulations in China, and the resultant cheap Chinese rare earths[7]. As a result of these "favorable" circumstances, China gained the position of near-monopolist of rare earths. In the end, America also found its own position of relative benefit in a rare-earths world dominated by China—a position of importing large quantities of cheap Chinese rare earths (and stockpiling) while choosing not to engage in further mining efforts on American soil.

According to Martin Jacques (2012), China is a country relatively poor in natural resources in relation to the needs of its vast population; the one exception to that rule being in regard to rare earths, the majority of which are produced in China. China is frequently accused of monopolist and mercantilist behavior with regard to rare earths (Shambaugh, 2013), an issue that this thesis will address in later chapters. However, it took more than a few decades for China to emerge as the dominant world producer of rare earths.

Long before China's rare earths supremacy, the situation was much different. When the People's Republic of China was established in 1949, though China had an abundance of rare earth resources, its rare earth industry was non-existent. In 1953, Jinzhou Oil Plant Number 6 began production of thorium nitrate for use as a catalyst in the oil industry. Because of increased demand for automobile light mantles, the Shanghai Yonglian Chemical Plant began processing monazite for the extraction of thorium nitrate. Rare earths produced as a result were set aside in piles as mere byproducts ("Zhongguo Xitu Lishi Huigu", 2013).

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[7] As will be discussed later, for many years, China's rare earths industry had/has not included environmental costs in the overall accounting of rare earths mining and production costs, thereby contributing to lower prices for exported rare earths.

During the mid-1950s, scientists such as Zhong Huanbang 钟焕邦 began research on the separation of rare earths at the Changchun Applied Chemistry Research Institute under the control of the Chinese Academy of Sciences (中国科学院长春应用化学研究所). In July 1958, Beijing's General Research Institute for Nonferrous Metals (北京有色金属研究总院) was successful in separating sixteen different REOs from monazite and brown ytterbium nobium.

In 1960, the General Research Institute for Nonferrous Metals used the ion exchange method and half countercurrent extraction to create favorable conditions for the preparation of sixteen REOs and provided excellent reason for the establishment of smelting works. During the 1960s, the Changsha Plant Number 602, Shanghai Yue Long Plant, and Baogang 8861 Plant came into operation, leading China's rare earths industry out of the chemistry lab and into the chemical plant ("Zhongguo Xitu Lishi Huigu", 2013).

During the politically and socially tumultuous years of the Cultural Revolution (1966-1976), progress was nevertheless achieved in China's development of rare earths processing. Through a series of industrial experiments involving several government research institutes,[8] acid processing and recycling were both improved significantly, and between 1973 and 1979, production at the Harbin Flint Plant, Baogang Rare Earths Plant Number 3, and Gansu Plant Number 903 using first-generation acid processing expanded

[8] The research organizations involved included Beijing's General Research Institute for Nonferrous Metals (北京有色金属研究总院); Beijing Nonferrous Metallurgical Design Institute (北京有色冶金设计总院); Baotou Metallurgical Research Institute (包头冶金研究所); Shanghai Yue Long Processing Plant (上海跃龙化工厂); Changchun Applied Chemistry Research Institute (长春应用化学研究所); and Baogang Rare Earths Plant Number 3 (包钢稀土三厂).

China's production capacity to over 10,000 metric tons of rare earths per year. When second-generation acid processing was introduced in 1979, it constituted a tremendous boost for China's rare earths industry. From this point, China's rare earths production began looking beyond China's domestic market to the international market.

China's rare earths, as so many other things in the vast country, are split between north and south—the north being represented by Inner Mongolia's Bayan Obo (白云鄂博 Baiyun E'bo) mining area, surrounded by approximately 60 rare earths separation plants, 20 of which are quite large (Zeng & Wu, 2012); and the south represented by a broad spread of mines and processing facilities in China's tropical southern provinces (Moran, 2010).

While the majority (83%) of China's minable rare earths are located in Inner Mongolia, rare earths resources have been discovered in a total of 1000 locations (Cheng & Che, 2010) scattered across twenty-two provinces in China, including Fujian, Guangdong, Guangxi, Hunan, Jiangxi, Shandong, Sichuan, etc. China has traditionally split domestic rare earths production figures into the following categories according to geographical location: Inner Mongolia's Bayan Obo region (83%), Shandong Weishan (8%), Sichuan Liangshan (3%), the Seven Southern Provinces (3%), and Other (3%) ("Wu Jingkuang Chengjiao Jiao Pingwen Xitu Yongci Gegu Puzhang").

In early July, 1927, geologist Ding Daoheng 丁道衡[9] (1899-1956), part of the China-Sweden Northwest Scientific Exploratory Mission, discovered shiny black rocks on the side of the road near Baiyun Bulage on the Wulanchabu prairie in what is now

[9] Ding Daoheng was grandson of the foreward-thinking Qing dynasty governor of Sichuan Province (四川总督) and Self-Strengthening Movement (洋务运动) leader Ding Baozhen 丁宝桢 (1820-1886).

Inner Mongolia. From his perch on a camel, he noted the geological features of the nearby mountain. The following are his recollections as recorded in his journal:

> On the morning of July 3rd…as we had just reached the foot of the mountain, I saw a great amount of iron ore strewn along the gully. The closer we approached to the mountain, the richer the ore became. I raised my head to gaze at the mountain peak, towering lofty and firm, covered in black spots, and I knew that this was the site of the ore deposit. Half way up the mountain, there were layers upon layers of ore, and the quality of ore became purer and purer the higher we went. Once we looked down from a certain height, we could see that the entire south face of the mountain was a mining field.[10]

In 1935, He Zuolin 何作霖 (1900-1967), professor of geology at Shandong University, Beijing Normal University, and the Chinese Academy of Sciences (Ralph & Chau, 2014), identified two types of rare earths-containing minerals at the Bayan Obo site (Wang & Li, 2014), monazite and bastnäsite ("Guojia Yankuang Huashi Biaoben Ziyuan Gongxiang Pingtai"). Geologist Huang Chunjiang 黄春江 (1916-2008), working for the Japanese North China Development Corporation, the right arm of Japan's economic plundering of northern China's industrial and mining resources (Wang Shihua, 1993), followed in the exploratory footsteps of Ding Daoheng, making another visit to the Bayan Obo area in 1944, discovering two more mine areas, one to the east, and one to the west of Bayan Obo's main mine. Upon returning from his expedition, Huang Chunjiang published, in Japanese, a geological survey report entitled "List of rare-elements minerals" ("Huang Chunjiang Jiaoshou"). It is clear that Imperial Japan had its eyes set on the large steel and rare earths deposits of Bayan Obo, and most certainly would have exploited the resources were it not for Japan's defeat in 1945, and the end of WWII.

[10] Wang and Li, 2014. Unless otherwise noted, all Chinese-English translations of text are mine.

Bayan Obo is rich in three primary minerals: iron, rare earths, and niobium. The mine was the first and largest to be prospected, explored, and exploited by the Communist Chinese government. In October 1949, the People's Republic of China was established, with government headquarters in Beijing. On May 23, 1950, the newly established government sent out its first official exploration group—the Central People's Government Bayan Obo Geological Survey Team, under the leadership of head engineer Yan Kunyuan 严坤元 ("Zhongyang Renmin Zhengfu Dizhi Diaocha Dui Pucha Baiyun Ebo Zhukuang"). From 1950 to 1952, the geological team made a general survey of the entire extant mining area. In 1952, the team changed its name to the "241 Geological Team". The 241 Geological Team's research led to a report early in 1953 that pushed for the establishment of a large iron and steel company in Baotou for the purpose of iron refining. Two more official summary reports were completed in 1954 and 1955.[11] In February 1957, the Baotou Iron and Steel Bayan Obo Iron Mine Company was set up.

In 1957, Bayan Obo officially began operations as a mine, with a clear purpose: to provide raw materials to what would later become Baogang (包头钢铁集团) (Baotou Iron and Steel Group). Eventually, in 1959, electric locomotives took the place of human laborers, and the road was paved for the introduction of more technological and mechanical advances.

In 1959, the mine at Bayan Obo welcomed its first blast furnace, and completed a Sino-Soviet cooperative research project on iron, fluorine, rare earths, and rare elements

[11] The two reports were "Nei Menggu Baiyun Ebo Zhu Dong Kuang Dizhi Kantan Baogao" (《内蒙古白云鄂博主、东矿地质勘探报告》), "Geological Survey Report on the Main and East Mines at Bayan Obo of Inner Mongolia"; and "Nei Menggu Baiyun Ebo Tiekuang Xikuang Dizhi Kantan Baogao" (《内蒙古白云鄂博铁矿西矿地质勘探报告》), "Geological Survey Report on the West Iron Mine at Bayan Obo of Inner Mongolia" ("Guojia Yankuang Huashi Biaoben Ziyuan Gongxiang Pingtai").

(“Guojia Yankuang Huashi Biaoben Ziyuan Gongxiang Pingtai”). In the same year, China shot a movie depicting the fearless resistance of Bayan Obo natives to the advances of the pillaging Japanese who had set their mark on taking over the rich mineral resources of Bayan Obo. The film, entitled “Morning Song Over the Prairie” (《草原晨曲》), though filled with the communist propaganda of the time, is nevertheless an intriguing reflection of the struggle for control of mineral resources in China’s Inner Mongolia region (“Guochan Mengzu Heibai Lao Dianying ‘Caoyuan Chenqu’”) during the years of Japanese invasion.

Also in 1959, Baotou Iron and Steel Group made its first attempt at producing a rare earths ferrosilicon, which formed a key part of the birth of China’s rare earths industry (“Baogang Xitu Chanye Gaikuang”). The Baotou Research Institute of Rare Earths (包头稀土研究院), primarily dedicated to rare earths research and development, was established not long after, in 1963; to this date, it is one of the largest research and development facilities dedicated to rare earths (Mancheri, et al., 2013).

Government Support

Baotou Iron and Steel Group has taken the lead in China’s rare earths production, and has become an object of special attention by top Chinese leaders. Each time a major leader has visited, his statements can be used as a gauge of the mentality of the Chinese Central Government regarding rare earths at particular times. In 1964, Deng Xiaoping visited Baogang, leaving behind these words: “Keep iron first here, while making comprehensive use of [all the minable resources]” (“Baogang Xitu Hangye Gaikuang”).

Deng did not mention rare earths in particular, but rather lumped them together with the other minerals which should be comprehensively used.

During the early years of the Deng Xiaoping reforms in the late 1970s and early 1980s, the Chinese government, in order to increase productivity in low-profit industries like mining, gave greater fiscal freedom and responsibility to local governments (Fairbank, 1992). From 1978 to 1986, Vice Premier Fang Yi visited Baotou Iron and Steel Group seven times to assist in the implementation of the "comprehensive use" plan for Baotou's resources, in accordance with Deng Xiaoping's 1964 admonition, calling over two hundred government research units into play in the process.

In March 1986, in the face of increasing competition from technological advancements outside of China, the Chinese government endorsed the State High-Tech Development Plan, also known as the 863 Plan (863 计划, after the Chinese date format for March, 1986: 86/3). The plan, drawn up by Chinese engineers Wang Daheng 王大珩, Wang Ganchang 王淦昌, Yang Jiachi 杨嘉墀, and Chen Fangyun 陈芳允 in March, 1986, was originally titled "Suggestions regarding following and researching the development of foreign strategic high technology" ("Guojia Gao Jishu Yanjiu Fazhan Jihua")[12]. At the time, Deng Xiaoping gave this important comment (批示): "Speedy determination must be made with regard to this matter; it cannot be delayed"[13] ("Guojia Gaojishu Yanjiu Fazhan Jihua").

[12] In Chinese: 国家高技术研究发展计划.

[13] In Chinese: "此事宜速作决断，不可拖延".

The 863 Plan has placed special emphasis on rare earths research and the development of rare-earths-related end products. Over the years since the 863 Plan was put into motion, Baotou Iron and Steel Group has spearheaded much of rare-earths-related research in China. Between 1978 and 1989, China steadily increased its production output for rare earths, bringing increasingly larger amounts of rare earths raw materials to the world market at low prices. It was in 1992 that Deng Xiaoping reportedly compared China's rare earths with the oil of the Middle East (Krugman, 2010),[14] emphasizing China's rich endowment in these valuable resources. During the 1990s, China's "rare earth wings" matured (翅膀硬了). With arguably the most abundant rare earth resources of any country in the world, and the endorsement of the highest government leaders, the door of immense potential had opened, and China's unobstructed road to world dominance in both rare earth production and possibly related high-tech development was paved.

Under the large umbrella of the 863 Plan, the Chinese government put into place the 973 Program in 1997, also known as the National Basic Research Program (国家重点基础研究发展规划), with projects ranging across the fields of agriculture, health, information, energy, environment, resources, population and materials. Research on the nature and applications of rare earths has been a critical part of the 973 Program. China's Ministry of Science and Technology places extremely high importance on research projects related to finding solutions to the multitude of problems in producing and exploiting what it calls "non-renewable important strategic resources" ("973 Jihua

[14] The famous saying by Deng goes thus in Chinese: "中东有石油，中国有稀土". In English, it can be literally translated as: "The Middle East has oil, China has rare earths".

Qidong Xitu Gaoxiao Tichun Zhongda Yanjiu Xiangmu"), of which rare earths are a prime example.

It was through the momentum of state impetus, that China has become not merely a supplier of key upstream rare earths resources to the world market at low prices; it is also, through the 863 Plan and 973 Program, attempting to become a world leader in downstream fields that depend on rare earths, such as biotechnology, space technology, information technology, laser technology, automation, energy, and new materials (Mancheri, et al.).

In 1999, Jiang Zemin, during a visit to Baogang, left behind these words of wisdom: "Do well at the development and applications of rare earths, so as to turn resource advantages into economic advantages"[15] ("Baogang Xitu Hangye Gaikuang"). Over the years since the opening of mining operations in Bayan Obo, the Chinese government has gradually shifted its focus from the iron ore (which takes up the majority of deposits in the Bayan Obo mine area) to the rare earths found there.

But if it were not for the repeated emphasis of China's top leadership—over the years since the Reform and Opening Up under Deng Xiaoping—on indigenous creativity and innovation, it is possible that China would have remained a supplier of cheap rare earths oxides, and that alone.

World Rare Earths Production Data

As a matter of historical review, an overview of rare earths production amounts over the years is valuable as a way to gain perspective on the historical scale of rare

[15] Jiang's statement in the original Chinese reads: "搞好稀土开发应用，把资源优势转化为经济优势".

earths production. First, the world (excluding China) will be examined, followed by a summary of historical production figures for China in the following section. The information presented in the next two sections of this chapter provides an important background for understanding China's behavior as the near-monopolist of rare earths—the main subject of this thesis.

Unsurprisingly, the first commercial production of rare earths occurred in Sweden (where rare earths were originally discovered) and Norway during the 1880s. Production in Scandinavia was prompted by the invention of the Welsbach incandescent lamp mantle, which initially required the rare earth elements lanthanum and yttrium, but which after later refinements, only called for cerium. Although it was reported that a small tonnage of rare earths were mined in the United States as early as 1887, the first officially recorded production occurred in North Carolina in 1893, with South Carolina beginning monazite production in 1903. Also in the 1890s, commercial production of gas mantles made from lanthanide oxides and other metals occurred in Vienna (Massari & Ruberti, 2013). Monazite production in Brazil also began as early as 1887, and India commenced the extraction of the ore in 1911 (Hedrick, 1999). Unfortunately, production figures for the early years of rare earths exploitation are limited.

From the late 1940s through the early 1960s, rare earths production/exploration occurred around the world in Argentina, Australia, Brazil, Canada, Congo (region), Egypt, India, Indonesia, Ivory Coast, Japan, Madagascar, Malaysia, Nigeria, Republic of Korea, South Africa, Sri Lanka, and Uruguay. According to available production figures, production rates for monazite were highest for South Africa, with a yearly short tonnage in excess of 9,000 tons in the late 1950s (Parker, 1962).

In addition to continued efforts in the countries and regions listed above, production/exploration activities for rare earths continued through the end of the 1970s in places like Burundi, Finland, France, Kenya, Liberia, Malawi, Mauritania, Namibia, Norway, Senegal, Somalia, Spain, Thailand, West Germany, and the United Kingdom. By the end of the 1960s, Australia, India, Brazil, and Malaysia led foreign production, with tonnages in the 4,000s, 3,000s, 2,000s, and 1,000s, respectively (Parker, 1969). During the 1970s, the former U.S.S.R. and China added their names to the list of rare earth producers, and Australia nearly quadrupled its yearly monazite production by the end of the decade, with production totaling 17,000 tons in 1979 (Moore, 1979).

Over the 1980s, more players joined the game of rare earth production/exploration, including Denmark, Gabon, Greenland, Guyana, Mozambique, New Zealand, Taiwan, the Republic of Germany, Venezuela, and Zaire (Hedrick, 1985; Hedrick, 1987). Apart from China (which moved into first place in production during the late 1980s) and the United States, the four foremost productive countries in the world—Australia, Brazil, India, Malaysia—were overtaken in production by the former U.S.S.R., with the former U.S.S.R. out-producing Australia by the end of the decade. (Hedrick & Templeton, 1989; Hedrick, 1991).

The next two decades brought little change to the list of countries producing/exploring rare earths. As the China-US rare earths competition picked up steam, the following countries began production/exploration of rare earths: Austria (Hedrick, 1998), Turkey (Hedrick, 1992), Vietnam (Hedrick, 1996), Kyrgyzstan (Hedrick, 2002), the Gambia (Hedrick, 2004), and Zambia (Hedrick, 2007). Also, apart from China and the United States (through the late 1990s), the two countries to produce the most rare earths were India and Malaysia, though production in Australia and the United States had sputtered to a start again by 2014 (Gambogi, 2014).

Using data from the United States Geological Survey, during the first few years of the twentieth century, the United States produced a token amount of rare earths, with average production from 1900 to 1910 amounting to just over 178 metric tons per year. From 1911 to 1949, production figures are largely unavailable, with the exception of the years 1915-1917, 1925, and 1948. Overall, rare earths ores production within the United States during the years 1900-1949 was miniscule by later standards, and demand was relatively low ("U.S. Geological Survey").

When the United States Geological Survey began tracking the rare earths elements through its Bureau of Mines Minerals Yearbook in 1936, there was low domestic demand for rare-earths-related products; little if any production of rare earths materials from domestically mined sources; and very small imports. In that year, the only use of rare earths that was considered "even moderately well known" was for making sparking flints, called "misch metal", for pocket cigarette lighters. At the time, the majority of rare earths were considered "scientific curiosities", due to a lack of practical applications for rare earths. United States rare earths production data are not available for 1936[16], and its imports were a grand total of 22 pounds of ferrocerium and other cerium alloys, and less than one pound of cerium metal (Tyler, 1937).

From the mid-1930s through the end of World War II, applications for rare earths steadily expanded. It was during this period that rare earths were first used to create

[16] The United States Geological Survey concludes that production for 1936 is "N/A". U.S. Geological Survey. 2014.

photographic lenses with greater light-gathering capabilities. Misch metal, though continuing to serve its primary function of making sparking flints for handheld lighters, also helped facilitate the making of "malleablized iron". In 1939, one of the new uses discovered for rare earths compounds was the mothproofing and rot-proofing of fabrics. With regard to the sources of rare earths, Canada was a major import source during this period.

With the "accidental" discovery of the Mountain Pass mine in San Bernardino County, California, in 1949, the United States stumbled upon its "mother lode" of bastnäsite-locked rare earths. Production at Mountain Pass began in 1950, and with the exceptions of 1956 and 1962, production data are available for each year to the present. From 1950-1964, the United States, relying heavily on Mountain Pass, consistently produced several hundred metric tons of rare earths each year, with spikes over 1000 metric tons/year occurring in 1952, 1960, and 1961.

A turning point came in 1965, when rare earths production jumped from 265 metric tons (1964 figure) to 2900 metric tons (a more than 1000% increase year-on-year) following a rise in demand for the sought-after elements used to make color television sets. In 1966, US rare earths production leapt once again to 12,200 metric tons (a more than 4600% increase compared to 1964 figures). Production never dipped below 10,000 metric tons/year through the end of the 1960s.

During the 1970s, though production slipped below 10,000 metric tons/year in 1970 and 1971, the average for the decade was a robust 14,103 metric tons/year, with a peak of 19,900 metric tons in 1974. The 1980s recorded higher production yields, peaking at 25,300 metric tons in 1984. This production figure has not been matched since.

The average for the decade was 16,070 metric tons/year, and never once was production lower than 10,000 metric tons/year.

The 1990s was the best decade for US rare earths production in history, with a yearly average of 17,600 metric tons, and a peak production of 22,700 metric tons in 1990, in which year the United States once again produced more rare earths than any country (Hedrick, 1990). But US rare earths production ended down on the eve of 2000, with 1998 production freefalling from 20,000 metric tons/year in 1997 to 10,000 metric tons/year, and cutting that number in half once more in 1999 to 5000 metric tons/year. Omens of difficulty to come, the 1990s' statistics played out in harmony with an ancient Chinese saying, meaning "dragon head, snake tail" (龙头蛇尾), referring to anticlimactic behavior in which there is a spectacular start, and a poor finish.

The 2000s were bleak years for US rare earths production. The United States is the second-richest country worldwide in the natural endowment of rare earths ("Meiguo Yongyou Fengfu Xitu Ziyuan Chuliang Quanqiu Di Er Jin Ciyu Zhongguo", 2010), and for many years led the world in rare earths production. Due to environmental regulation constraints and the competition from low Chinese rare earths prices, Mountain Pass went offline from 2001 to 2011, leaving the grand production total for the decade at 5000 metric tons, all produced in the year 2000. In 2010 and 2011, concern over China's near-monopoly on rare earths production led to a push for reopening the embattled Mountain Pass mine in an effort to embark down a new path of rare earths independence. (See Figure 2).

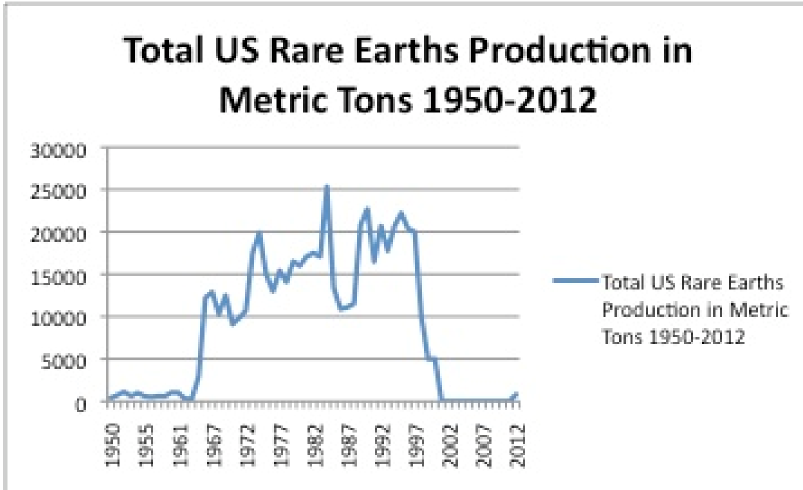

Figure 2. Total US Rare Earths Production in Metric Tons 1950-2012. Source: United States Geological Survey, 2014.

China's Rare Earths Production Data

According to the United States Geological Survey, there are few data for China's rare earth production before 1960 (Pui-Kwan Tse, Email Correspondence, 2014). In 1963, the Baotou Research Institute of Rare Earths (包头稀土研究院), China's largest rare earths technology research and development institution, was established. It was originally named "Baotou Metallurgical Research Institute" (包头冶金研究所); the name was changed to "The Rare Earths Research Institute of the Ministry of Metallurgical Industry" (冶金工业包头稀土研究院) on August 1, 1985. The research institute took its present name in 1992 when it became a part of Baotou Steel Group, and thus is also known as "The Baotou Steel Group Rare Earths Research Institute" (包钢集团稀土研究院).

Following is a chronological summary of the English-language data on China's rare earths production from the United States Geological Survey (USGS), which started to trickle in beginning in 1978-1979. It was reported by the USGS that the three Japanese corporations, Inoue Japax Research, Inc., Mitsui Metal Mining Company and Mitsui &

Company all sought to undertake joint research of rare earth development and technology with China. The USGS also reported for the first time that China was in the process of establishing two rare earth treatment facilities, one of which was located at Baotou, Inner Mongolia (Moore, 1979).

During the 1980s, with each passing year, new details continued to be added to the picture of China's burgeoning rare earth's industry. It was reported that the Bayan Obo mine had reserves of 1 billion tons of iron ore, of which rare earths comprised concentrations of 1%-6% and in certain parts 10%. Rare earth recovery at the time was "minimal", and for the first time, rare earths production was decentralized on a trial basis (Hedrick, 1980).

From the beginning of the 1980s, Japan and the United States imported rare earths from China. According to Hedrick (1981), the Chinese Rare Earth Company estimated total rare earth chlorides production in 1981 at 5,600 tons, more than a third of which (2,035 tons) was exported to Japan. During the same year, the United States reportedly signed a three-year contract that would guarantee Chinese rare earths exports to the tune of 2,000 tons per year. Also in 1981, production was reported in provinces of Inner Mongolia, Jiangxi, Henan, Guangdong, Hunan, and Fujian, with 20% of production occurring at the Bayan Obo site in Inner Mongolia.

In 1982, China opened its third rare earths plant near Baotou for the processing of rare earths compounds and metals. The first and second plants were engaged in production of rare earth alloys and rare earth ferroalloys, respectively (Hedrick, 1982). By 1983, USGS reports were already talking of the United States and China in the same breath in the opening paragraph of its mineral yearbook summary of world rare earths production: “Basnasite, the world’s principal source of rare earths, was mined as a primary product in the United States and as a byproduct of iron ore mining in China” (Hedrick, 1983). It was reported that Guangdong and Guangxi became important producers of monazite, although it is especially interesting to note (in light of China’s dismal rare earths environmental record) that China’s national standards for radioactive materials were so strict as to make the handling of monazite increasingly difficult, forcing China to extract the radioactive thorium from monazite, leaving rare earth chloride behind (Hedrick, 1983).

In 1984, China had 80% of world reserves of rare earths. In that year, rare earth ties between Japan and China tightened as Mitsui Mining & Smelting Company signed a five-year contract for the annual export of 200 tons of rare earths (Hedrick, 1984). In June 1985, a third rare earth separation plant was completed at Baotou, increasing production capacity for several rare earths, including neodymium, whose production capacity rose dramatically from 0.5 tons to 20 tons per year (Hedrick, 1985).

Rare earths production was reported at 12,200 tons[17] of REO in 1985, with deposits being noted in Bayan Obo as well as Jiangxi and Guangdong provinces. Jiangxi rare earths were highlighted due to their high concentrations of heavy rare earth elements, especially yttrium, samarium, europium, terbium, and ytterbium (Hedrick, 1986). In 1986, China reportedly produced a total of 11,860 tons of equivalent REO (Hedrick, 1987).

By 1987, China’s total rare earths reserves were reported to account for 76% of world reserves, and total production stood at 15,100 tons of REO, pushing China into

[17] The figure provided by the same USGS mineral yearbook report from 1987, changed this number to 11,860 tons, citing as the source the China Rare Earth Information Centre. See Hedrick, 1987.

close second behind the United States in world production of rare earths. In 1987, China's domestic consumption of rare earths increased, and a new rare earths plant opened in Jiangxi province. Also, Can-Pacific Rare Earths & Metals Corporation announced news of its joint venture 1000-ton-per-year separation plant scheduled to commence building in 1988 (Hedrick, 1987).

History was made in 1988 when the China Rare Earth Information Centre reported an annual production of 18,660 tons of equivalent REO, surpassing United States production of rare earths for the first time. According to the USGS report, this increase in production was primarily due to heightened production of iron-adsorption-type ore in Jiangxi province. In wake of higher REO production, China's largest rare earth processing plant (Shanghai Yue Long 上海跃龙化工厂) doubled its production capacity to 4,000 tons per year, and a new 100,000-ton-per-year mixed rare earth separation plant began operations in the Shenzhen Special Economic Zone (Hedrick and Templeton, 1988).

In 1989, China continued to hold top place for rare earths production, despite reduced output from southern mines. Total production was reported at 19,760 metric tons of REO, up 5.4% from 1988 (Hedrick and Templeton, 1989). 1990 marked a drop in production, and China lost its top-producer status for two years, with only 16,480 metric tons of rare earths produced in China compared to approximately 22,700 in the United States (Hedrick, 1990). In 1991, China continued to report a lower production rate of only 16,150 metric tons of equivalent REO (Hedrick, 1991). Though it is difficult to prove a definitive connection, it is of significance to note that these years, and their lower production figures, correspond to the years of post-Tiananmen "sanctions" by the United

States and other western powers. In 1992, China edged out the United States as the leading producer of rare earths at 21,340 metric tons of REO (Hedrick, 1992), and reported production of 22,100 metric tons of REO in 1993. 1994 marked another jump in rare earths production, with a reported total production of 30,650 metric tons of REO (Hedrick, 1994).

Increasingly higher rare earths production levels in China translated to lower and lower prices globally—prices pushed down by what the Chinese rare earths community calls "cabbage" and "turnip" prices ("Xitu Jiage Ru Guoshanche Cong Baicai Jia Shunjian Zhang Zhi Huangjin Jia", 2014; "Zhongguo Xitu Bei Jianmai Huangjin Maichu Luobo Jia", 2010). A well-accepted figure from the late 1990s-early 2000s claims that China's Southern Rare Earths Company produced a half-kilogram of either promethium or neodymium for approximately $30, while the United States produced the same amount of rare earths at the Mountain Pass mine for around $40 per half-kilogram. At the time, the United States decided to close the Mountain Pass mine for more than merely environmental reasons[18]: When the production cost of one half-kilogram of rare earths

[18] According to Ali (2014), the environmental issues faced by the Mountain Pass rare earths mine in the 1990s-2000s involved leakage from a piping system used to carry wastewater to an evaporation system. There were more than 60 known spills related to the faulty pipes uncovered by Federal investigation, and in the end the entire piping system was replaced. With regard to rare earths, for many years, the United States' environmental protection policies centered around such laws as the Clean Air Act (1970) and the Clean Water Act (1972) and other general environmental protection laws that regulated the general release of pollutants into the environment. Only recently (2012), has the Environmental Protection Agency undertaken the task of systematically researching the potential harmful effects on the environment by rare earths mining ("Rare Earth Elements: A Review of Production, Processing, Recycling, and Associated Environmental Issues"). Nevertheless, the temporary end of active mining operations at Mountain Pass in 2002 was due to the United States' satisfactory and gradually increasing implementation of existing environmental laws during the 1990s and early 2000s. Thus, even though there was a lack of industry-specific laws for rare earths in the United States, healthy implementation of other environmental laws had significant effects on the US rare earths industry; whereas in China, general environmental laws had less power on the ground during the same time period, and industry-specific environmental protection laws were non-existent.

rose to between \$35 and \$40, it was no longer economically viable to produce domestically ("Riben Zhan Jin Wo Xitu Pianyi Jia Gong Hou Jiage Kan Bi Zuanshi", 2010).

The year 1995 was another year of record rare earth production for China, with a total combined output of 48,002[19] tons of REO, translating to a 56.6% increase in production year-on-year. While the majority of rare earths production originated in Bayan Obo (26,905 tons REO), output from the rest of China was significant, as is reflected from the following figures: Sichuan Province (8,500 tons), Shandong Province (963 tons), Jiangxi, Guangdong, Hunan, and Fujian combined production of rare earths from ion-adsorption-type clays (9,770 tons) (Hedrick, 1995).

According to the United States Geological Survey, in 1996, China held 43%[20] of the world's rare earths reserves, the largest share of any country, and its production had increased to 55,000 tons of REO. New plants continued to open in various parts of China. Xingguang North Rare Earths Materials Company, Ltd. Established a rare earth refining plant in Chenyang, Liaoning Province with a production capacity of 2,000 metric tons per year of cerium oxide and cerium chloride. Panxi Rare Earth Company, Ltd. of Xichang, Sichuan Province began processing bastnäsite at its new plant; and Advanced Materials

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[19] Revised to 48,000 tons in 1996. See Hedrick, 1996.

[20] In 1984, according to an estimate by the Bureau of Mines, world rare earths reserves were 45 million tons of contained REO, and China's share of world rare earths reserves stood at 80% (approximately 36 million tons). By 1996, world reserves had increased to approximately 100 million tons of contained REO, with China's reserves accounting for 43%, approximately 43 million tons. Thus, the apparent drastic drop in reserves on the part of China between 1984 and 1996 was actually a net increase from 36 million tons to 43 million tons; but due to the dramatic increase in world reserves over the period, China's reserve percentage dropped relative to that of the rest of the world.

Resources, Ltd., of Toronto, Canada announced a 128% increase in cerium carbonate production at its Zibo, Shandong plant (Hedrick, 1996).

The year 1997 marked a significant point on China's breakneck production trajectory for rare earths. The State Planning Commission (国家计划委员会, now the National Development and Reform Commission 国家发展和改革委员会) announced that new rare earths projects would be placed on hold in an attempt to decrease production. At this early stage in China's rise to rare-earth near-monopoly, the government recognition of the seriousness of the over-exploitation of rare earths resources is significant, as it is an issue that has not been completely solved, even as of the writing of this thesis. As a result of direction from the State Planning Commission, China's production of rare earths for 1997 stood at 53,250 tons, a 3.8% decrease from the 1996 level (Hedrick, 1997).

Despite government efforts to curtail overproduction, including the implementation of the rare earths export quota system, China's overall mine production of rare earth oxides increased to 60,000 tons in 1998. During the year, two companies contributed to the growth of Chinese rare earths production capacity—Advanced Material Resources (Canada) and Rhodia (France) announced increases in production capacity due to new technology and equipment purchased from Japan's Nippon Yttrium Corporation, and the signing of an agreement for the construction of new production facilities in Baotou for rare earth alloys and metal hydride powder, respectively. Magnaquench, an American company, expanded its rare earth permanent magnet business by acquiring a neodymium alloy production facility and announcing plans for the construction of a neodymium-iron-boron powder magnet plant near Tianjin on China's northeastern seacoast (Hedrick, 1998).

China continued its efforts to control excess production. In 1999, the Chinese government announced that it would not be issuing any new rare earth production permits, in addition to the fact that it would be placing greater restrictions on foreign investment in rare earth processing plants and metallurgical operations within China. Notwithstanding, China's total rare earth oxide production for 1999 reached 70,000 metric tons, a 16% increase from 1998 levels (Hedrick, 1999). In November 1999, the Inner Mongolian Rare Earth Group, Inc. (IMREG) was established at Baotou, Inner Mongolia, to "address the status of the industry". Its primary goals included integrating rare earth research and development, production, and trade; to provide quality products; and to monitor the rare earths industry in the region. IMREG, a state-owned entity, focuses on the downstream aspects of the rare earth chain, and places emphasis on international cooperation. Overall, the Chinese rare earth market continued to expand and mature in 1999, despite bankruptcy filed on the part of Sichuan Panxi Rare Earth, Ltd., which previously had a 2000 ton/year capacity for bastnäsite concentrate (Hedrick, 2000).

In 2000, China's rare earth oxide production increased to 73,000 tons, and a joint-venture agreement was signed amongst Santoku Corporation, Baotou Rare Earth High and New Technology Industry Development Zone, Rhodia, and Westlake. The rechargeable batteries company formed as a result was named Baotou Santoku Battery Materials Company, Ltd. (BSBM) (Hedrick, 2001). By 2001, China's rare earth production had hit recorded highs of 80,600 metric tons of rare earth oxides. New developments in China's rare earths industry included the formation of a new joint venture, Jiangxi Rare Earth Group, with a total of ¥350 million (US$42.3 million) of capital invested by the city of Ganzhou (¥170 million), Jiangxi and Jiangxi Rare Earth Metal Tungsten group (¥180 million) (Hedrick, 2002).

"What goes up should come down" was the message from the Chinese government to the domestic rare earth industry in the late 1990s-early 2000s. In 2002, China's rare earth oxide production reached 88,000 tons, and then 92,000 tons in 2003. In an effort to control overproduction, China's Ministry of Land and Resources (中华人民共和国国土资源部; CMLR) announced that it would regulate the production of antimony, rare earths, and tin. Also, CMLR claimed it would close down illegal mining operations, and guarantee the compliance of all legitimate rare earth operations with health and safety standards. During the same year, Baotou Huamei Rare Earth Products Company, Ltd. of Baotou and eight other rare earths investment projects in the Baotou region were slated to begin production. Most of the new projects were battery-related. In addition, China reported the development of a new compound of ytterbium, gallium, and germanium that would not expand or contract under high heat levels, and that could withstand temperatures over 2,000° C. Expected use was to be in heat insulation for manned spacecraft (Hedrick, 2003).

In 2004, China's rare earth oxide production stood at 98,000 tons, with the majority (58,000 tons REO) coming from the Baotou, Inner Mongolia region. Jiangxi Province's iron-adsorption ores accounted for 25,000 tons, and other mines throughout China recorded 15,000 tons of rare earths production. China's REO production hit new record highs in 2005, with a grand total of approximately 119,000 tons—a nearly 18% increase compared to 2004 (Hedrick, 2005). In 2006, it appeared at first that China's rare earth concentrate production stayed at essentially the same level as in 2005, approximately 119,000 tons. Later reports claimed 133,000 tons (Hedrick, 2007). In addition, Chinese domestic demand for rare earths continued to increase (62,800 tons of equivalent REO), accounting for nearly half of total production (Hedrick, 2006).

By 2007, China's rare earths production had become increasingly diversified, with the following characteristics: (1) High production; (2) high domestic demand; (3) increased exports; and (4) tightened tariffs. Total rare earths production for 2007 was approximately 120,000 tons (Cordier & Hedrick, 2008). Domestic demand increased to 72,550 tons of equivalent REO, up from 62,800 tons in 2006. Exports increased to 54,393 tons of rare earth compounds and metals, up from 52,230 tons in 2006. Of particular note, in 2007, China enacted export tariffs on various rare earth products in order to increase prices and reduce exports (Hedrick, 2007). The rare earth export tariffs were 10% in 2007. Restricting exports would become a trend in later years.

In 2008, it was reported that rare earth materials were in tight supply in China. Simultaneously, partially due to the general world financial downturn in 2008, demand for certain rare earths fell and there existed an overall sluggish mood in the rare earths market throughout the year. Nevertheless, total production for rare earth oxides in China amounted to 125,000 metric tons, 5,000 metric tons higher than 2007 (Cordier & Hedrick, 2008). In 2009, though China's total production increased to 129,000 metric tons, production and export quotas tightened, and Chinese rare earth metals exports to Japan dropped steeply (Cordier, 2009).

According to the United States Geological Survey, China's rare earth mine production accounted for 97% of world mine production in 2010. Citing domestic environmental concerns, China controlled exports of REOs through taxes and quotas. While the Chinese government set the production quota for the year at 89,200 tons of contained REO, actual production was approximately 130,000 metric tons (Gambogi & Cordier, 2010). In 2011, although China accounted for 95% of world rare earth mine production, a drop in production was measured (105,000 metric tons equivalent REO), with greater restrictions imposed by the Chinese government. In 2011, it appeared that environmental restrictions were beginning to take effect, as it is claimed that the Chinese government began withholding export quotas for companies that did not meet environmental protection guidelines (Gambogi, 2011).

According to the latest data from the United States Geological Survey, China's production of rare earth oxides for 2012 and 2013 was 100,000 metric tons and 100,000 metric tons, respectively (Gambogi, 2014). In 2012, China continued to clamp down on rare earths production and exports, citing domestic environmental concerns as the underlying reason. Producers of rare earths were required to undergo government inspections, and their feed material was to come from licensed rare earth mines. Also, rare earths traders were required to have registered capital of ¥50 million ($8 million).

In 2012, according to China's estimate, it had a 23% share in world rare earths reserves ("Situation and Policies of China's Rare Earth Industry"), although USGS estimates placed China's rare earths reserves at approximately 50% of the world total. In 2012, following requests from the European Union, Japan, and the United States, the World Trade Organization launched an investigation into China's restrictive rare earths trade policies. In addition, India expected the year-end opening of a 10,000-ton-per-year monazite processing plant. In Malaysia, plans for a rare earth oxide processing plant in

Malaysia were stalled by outcries from environmental activists, though production was expected by year-end from the Lynas facility—purported to be the largest rare earths processing facility in the world (Gambogi, 2013; Tan, 2012). While China still maintained its stranglehold on the rare earths market as a whole, increasing efforts worldwide to find alternatives to China's rare earths were signs that could not be ignored.[21]

In 2013, according to United States Geological Survey data, China's production and export quotas for rare earths were 93,800 tons and 31,000 tons, respectively. According to recent USGS reports, China's rare earths production for 2013 was 95,000 metric tons—close to its production goals. It could be argued that China made strides toward its goal of controlling rare earths production and putting the lid on illegal production (Gambogi, 2014; Gambogi, 2015).

As of 2013, China had over 170 rare earths production plants, with the majority of plants producing between 1000 and 2000 metric tons of rare earths per year. There are only five locations with production capacities of over 5000 metric tons per year. China's rare earths industry can be divided into three major areas, based on geography: (1) The North, represented by more than 80 companies concentrated in Baotou (Inner Mongolia) and Gansu with a production capacity of 75,000 metric tons of rare earths material per year; (2) the South, which produces approximately 20,000 metric tons of rare earths materials per year, most of which are heavy rare earths elements (HREEs); and (3) the

[21] According to a recent Jamestown Foundation report, Japan is currently in discussions with high-ranking mining officials in Mongolia regarding cooperating in exploiting Mongolia's rare earths resources. This comes as both governments seek to strengthen ties in hopes of blunting Sino-Russian influence in the region (Campi, 2015).

Sichuan region, which produces between 15,000 and 20,000 metric tons per year. ("Zhongguo Xitu Lishi Huigu", 2013).

According to the latest available information from the USGS, China's rare earths production for 2014 was 95,000 metric tons, the same as production figures for 2013. From this figure, it would seem that China is gaining greater overall control of its rare earths production. In 2014, China's export quota for rare earths was 31,000 tons. This rare earths export quota was perhaps China's last, as the WTO ruled against China in a case brought against China by the United States, the European Union, and Japan accusing China of unfair export quotas for rare earths. As of January 1, 2015, China has cancelled rare earths export quotas. It is important to also note that according to the USGS, in 2014, China's rare earths reserves maintained the level of 55,000,000 tons, a number China has claimed since 2010 (Gambogi, 2015; Gambogi, 2011; Gambogi, 2012; Gambogi, 2013; Gambogi, 2014); but since world reserves have increased to 130,000,000, China's relative share has dropped to approximately 42%.

The current chapter has examined the topic of rare earths from a historical perspective, primarily tracing the history of the discovery and exploitation of rare earths, concluding with a snapshot of China as the near-monopolist of rare earths (the result). In Chapter 2, based on the current literature, I will examine the specific reasons behind China's rise to rare earths supremacy (the means). Combined with the historical review provided in Chapter 1, such an analysis will provide a helpful context within which to understand China's behavior as a near-monopolist of rare earths.

CHAPTER 2: CHINA'S PATH TO NEAR-MONOPOLY OF RARE EARTHS

Introduction

In order to understand China's behavior as a near-monopolist of rare earths, one must first examine the roots of the near monopoly. In other words, it is imperative that my study first take up the question of exactly through which means China arrived at its position of rare earths supremacy, before undertaking an analysis of how it has behaved in that position of dominance. The current chapter will attempt to examine the means wherewith China came to a near-monopoly of rare earths, using the extant literature in English and Chinese.

As shown through the previous short history of rare earths production, China is strategically positioned as the near-monopolist of rare earths production worldwide.[22] Some Chinese researchers have used the word "monopoly" (垄断) to describe China's rare earths production (Wu & Yu, 2012), though for the purposes of this thesis I suggest the use of "near-monopoly", because China, while dominating the world rare earths market, does not enjoy complete monopoly on world rare earths production.

In my analysis, I argue that China has achieved a near-monopoly on rare earths production on the basis of the following factors: (1) Strong support for the development of the rare earths industry by the Chinese government; (2) lack of or disregard for environmental regulations regarding the production of rare earths; (3) illegal and/or

[22] In fact, China is first in at least four rare earths related areas: (1) reserves, (2) production, (3) sales, and (4) consumption (Cheng & Che, 2010).

unregulated production; (4) relatively low cost of rare earths production in China compared with the rest of the world.

(1) Government Support

During the Mao era (1949-1976), China's centrally planned (or command) economy, apart from stagnating because of near-nonexistent market competition, government price setting, and excessive central control of the majority of industries through the seemingly omnipresent state-owned enterprises (SOEs), it was also plagued by a seemingly never-ending stream of "campaigns" or "movements" which, for the most part, proved disastrous for the growth of the economy and the well-being and quality of life of China's citizenry[23] (Wang, Liu & Li, 2003). One example of such campaigns was the so-called "Great Leap Forward", through which chairman Mao planned to surpass Britain in steel production, but which resulted in a vast tonnage of very bad steel and a "Mao-made" famine that killed 20-40 million Chinese (McNeill & McNeill, 2003; Fairbank, 1992).

[23] A Taiwanese history of the Communist Party of China comments on China's economy during the Mao years and shortly afterward: "After the establishment of the communist state, Mao Zedong fantasized that he could use the methods of 'class struggle' and 'excessive poverty' to create a communist society in China ahead of schedule. Thus, during the 1950s, after a complete transplant of the Soviet Union's centralized planned economic system, and after initiating the 'Three Red Banners' movement in 1958, in which he attempted to expedite economic development through the method of mass movement, the end result was three years of great famine. In 1966, the 'Great Cultural Revolution' caused the Mainland's economy to fall into recession once again. Once Mao Zedong died in 1976 and the 'Gang of Four' crumbled, the 3rd Plenary Session of the 11th Central Committee of the Communist Party of China admitted that the entire domestic economy was on the brink of collapse. It was then that the Communist Party was forced to make revisions and reforms to its economic policy and system" (Wang, Liu & Li, 2003). The original Chinese reads thus: "中共建立政權後，毛澤東幻想用‘階級鬥爭’和‘窮過度’的方式，提早進入共產主義社會。於是五十年代在全盤移植蘇聯中央極權計劃經濟制度之後，1958 年又在大陸發動‘三面紅旗’運動，企圖以群眾運動之方式加速經濟建設，結果是帶來三年的大飢荒。1966 年發動‘文化大革命’運動，復使大陸經濟呈現衰退；直到 1976 年毛澤東死亡、‘四人幫’垮臺，中共在十一屆三中全會上承認大陸整個國民經濟已經面臨崩潰邊緣，迫使中共在經濟政策路線及體制上進行修正與改革".

As a result of Deng Xiaoping's "Reform and Opening Up" (改革开放) policy initiated in the late 1970s and carried out in full force especially from the 1980s to the early 2000s, China's government placed paramount emphasis on economic growth, creating the economic miracle of a thirty-year annual average GDP growth rate of 9.8% ("Zhongguo Shishi Qiannian Fazhan Mubiao Jinzhan Qingkuang Baogao: Gaige Kaifang 30 Nian Yu Zhongguo Fazhan")—a feat unequaled in human history. This steep economic take-off, fueled by Deng's market reforms and opening up to the world, put the Chinese government on a trajectory of success beyond imagination. When Chinese leaders set the goal of quadrupling the economy by 2002—which sounded "ludicrously overambitious" at the time, not many outside of China would have guessed that the goal would be met two years ahead of schedule. China's economic explosion, though slowing, still continues today.[24]

Economic growth rate was one of the key criteria against which Chinese communist cadres of positions high and low were evaluated for many years. A well-known Chinese saying seems to sum up this "forward-looking" principle of action: "一切向钱看"[25]. Money-madness has consumed not only the worldviews of many Chinese

[24] The state-designed Chinese economic miracle is expected to continue for at least another ten to fifteen years (Shirk, 2008). China's economic growth has shown its resilience through three major tests, one political and two financial: (1) The Tiananmen Square incident; (2) the Asian financial crisis; and the (3) worldwide financial downturn of 2008. Though annual GDP growth rates are down from pre-2008, and there is no lack of pessimistic outlooks on China's economic future (Davis, 2014), China is still the fastest growing major economy in the world, and many analysts do not predict a change in that status for the near future (Rapoza, 2014).

[25] The phrase originally read as "一切向前看" ("yí qiè xiàng qián kàn"), meaning "looking forward in everything". A homophonic play on words switched out the "前" (qián), meaning "front" or "forward" for "钱" (qián), meaning "money", to render the phrase "putting money above everything else" (literally, "looking to money in everything").

consumers, the mindset has also deeply influenced the modus operandi of many cadres, especially on the lower end of the hierarchical spectrum, where career future has been, until recently,[26] tied almost exclusively to economic productivity. As noted by Chen (2009), since the "early 1990s, China's officialdom has formed a culture whereby GDP growth is a major indicator to measure administrative chiefs' performances and even determines their future job promotions."

Within the context of the Chinese government's seemingly one-sided focus on economic development, one of the most important goals of development was technological advancement. Interestingly, the development of China's rare earths industry matched both of these needs: During the early years of rare earths development, China followed the guidance of leadership[27] by turning abundant resources into (1) economic returns; later, China began to establish her own complete "mine-to-magnets-style" industry chain, including an ever-maturing research and development component, which could go far toward enabling China to reach its goal of (2) technological advancement.

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[26] Under Xi Jinping, the performance metrics of cadres' success or failure have been further diversified to include environmental and social criteria, although it seems too early to tell just how effective these new measures will be in curbing China's looming ecological problems (Sanderson, 2014).

[27] Deng Xiaoping is claimed to have made the following statement in 1992: "The Middle East has oil, China has rare earths" (Krugman, 2010). In the Chinese: "中东有石油，中国有稀土". Jiang Zemin once said, "Do well at the development and applications of rare earths, so as to turn resource advantages into economic advantages" ("Baogang Xitu Hangye Gaikuang"). In the Chinese: "搞好稀土开发应用，把资源优势转化为经济优势".

In China, industries[28] thrive or die depending on the level of governmental support. If this is true for industries like textiles, papermaking, and catering, it is even more so for "strategic" industries like coal, oil ("The long arm of the state", 2011), and rare earths. If it were not for the guiding, supporting hand of the Chinese central government, in establishing the 863 Plan and 973 Program, which placed priority on high-tech development, including rare earths, it is certain that China would have had neither the drive nor stamina to become the near-monopolist of rare earths.

Shirk (2008) notes: "As the country that gave the world gunpowder, paper, and the compass, China is reclaiming its heritage of technological inventiveness. Its capabilities still lag behind the United States and Japan, but it is trying to catch up fast". In 1986, when Deng Xiaoping approved the request of four highly respected scientists to launch a research and development impetus by which China could "catch up" with the rest of the world in high-tech development, China was the underdog of the rare earths world, but possessed a great potential in raw rare earths resources. In 1986, China produced 12,200 tons of REO. By the end of the 1990s, China's resolute decision to develop rare earths had paid off, with production figures of approximately 65,000 metric tons of equivalent REO in 1999, compared with 5000 metric tons produced in the United States during the same year (Hedrick, 2000).

From the current literature, it is abundantly clear that China's success in gaining a near-monopoly on the world rare earths market is inseparable from the strong support and

[28] I refer to legitimate industry, although it could be argued that illegal, underground, or black-market industry could not survive and thrive if it were not for some form of tacit approval from government.

preferential treatment of the Chinese government. Morrison & Tang (2012), in a Congressional Research Service report, make this insightful summary:

> To many observers, China's rare earth policies are part of a complex web of Chinese government industrial policies that seek to promote the development of domestic industries deemed essential to economic modernization. In the late 1980s, the United States was the global leader in rare earth production. However, *preferential policies by the Chinese government* and lax environmental standards there quickly enabled China to become a dominant, low-cost producer of rare earths by the late 1990s.

While it is true that the "preferential policies" mentioned above include subsidization, etc., the fact must not be overlooked that such preferential policies came about and existed for only one reason: the Chinese government placed high priority on the development of rare earths production, application, and trade. In other words, without the deliberate, calculated, over-arching support of the Chinese government for the rare earths sector, there would have been no significant protection of the industry.

In addition, since the ultimate goal of the economic development of the 1980s and 1990s can be summarized by "economic development" itself, perhaps one of the greatest "preferential policies" of China's government for the rare earths industry was its near-tunnel-vision approach to economic development, and the lax environmental protection that occurred by default. "Pragmatic" "economic madness" (Jacques, 2012) had consumed China, and each booming industry, including rare earths, fought its way to the holy grail of success with the smiling approval of Deng's "black-cat-white-cat"[29] ("Deng

[29] Deng Xiaoping, throughout his political career, referred more than once to what would be later called "猫论" ("Cat theory"). The saying upon which the theory is based can be summed up in one sentence: "It does not matter whether the cat is white or black, as long as it catches mice, then it is a good cat" (不管白猫黑猫，捉到老鼠就是好猫。). The saying originated long before Deng's time, and is recorded in Pu Songling's Qing dynasty work, *Strange Tales of Liaozhai* (《聊斋志异》): "Yellow foxes or black foxes,

Xiaoping Tongzhi 'Heimao Baimao Lun' Beihou De Gushi", 2006) development policy. By allowing China's rare earths industry to develop at the cost of environmental degradation—by not including the environmental cost of rare earths development in the overall accounting of rare earth production cost for so many years—thereby, China gained its greatest advantage, and simultaneously buried for a time the monstrous problem that only now China's government is facing head-on: serious environmental degradation (to be discussed in more detail below, and in Chapter 4).

(2) Environmental Factors

As a matter of historical review, it is abundantly clear that the United States, the country that enjoyed the title of the world's top rare earths producer from the 1950s through the late 1980s, was almost completely edged out of the rare earths market by China (Hurst, 2010; Morrison & Tang, 2012; Wübbeke, 2013). It is also evident that a significant part of the reason for the downturn in US rare earths production at Mountain Pass, CA (the major US rare earths producer) during the 1990s was environmental compliance cost challenges (Ali, 2014) surrounding groundwater pollution (Massari & Ruberti, 2013). In China, however, until recently, few such constraints have existed,

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it matters not which kind it is—the kind that catches mice is the greatest" (“黄狸黑狸，得鼠者雄”). A similar saying is also prevalent in the Sichuan dialect of Chinese, and most likely Deng borrowed the phrase from his native dialect, as he hailed from Sichuan. Eventually, the saying became attributed to him, and the interpretation that sums up "Cat theory" is: Command economy or market economy—this is not the question, for these are only means to the end of resource allocation, and have nothing to do with political systems.

though in theory the idea of "sustainable development", including environmental protection, has been part of the Chinese rhetoric since the early 1990s.[30]

A common Western perspective on the relationship between China's rare earths development and the environment is that it was the closure of the Mountain Pass Rare Earths Mine in the 1990s that caused China's rare earths production to "flourish" (Ali, 2014). It could be argued that China's rare earths industry was already flourishing before the Mountain Pass mine closure, which only strengthened China's grasp on the market by default. Cheng and Che (2010) concur that there is a price tag for the development of many of China's rare earths enterprises: the over-exhaustion of resources and the destruction of the ecological environment.[31] The fact that China's rare earths industry has caused environmental degradation is openly admitted by the Chinese government. In an official government document from 2011 ("Guowuyuan Guanyu Cujin Xitu Hangye Chixu Jiankang Fazhan De Ruogan Yijian"), China's State Council makes the following frank statement:

> After many years of development, China's rare earths mining, metallurgy/separation, and applied technology research and development have

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[30] The United Nations World Commission on Environment and Development's 1987 report, *Our Common Future* (a.k.a. the "Brundtland Report"), defined "sustainable development" thus: "Humanity has the ability to make development sustainable to ensure that it *meets the needs of the present without compromising the ability of future generations to meet their own needs*" ("Report of the World Commission on Environment and Development: Our Common Future", 1987, emphasis mine). This is commonly accepted as the first major reference to "sustainable development" in an international context. The Communist Party of China interprets the United Nations' goals of sustainable development (including those the Millennium Declaration) to include economic development, social development, and environmental protection. According the Communist Party of China, the goals of sustainable development have been a part of the country's top priorities since the early 1990s ("Dang He Zhengfu Tichu De 'Ke Chixu Fazhan' Zhanlue Juti Neirong Shi Shenme?", 2006).

[31] In Chinese: "大量稀土企业的发展，在一定程度上仍是以资源的过量消耗和生态环境的破坏为代价的". Also, Sun (2011) points to a lack of an environmental protection mindset as the ultimate source of failure in environmental practice ("环保意识薄弱").

> achieved fairly large improvements, and the scale of the industry is continually expanding. Yet problems continue to exist within the rare earths industry, e.g. illegal mining in the face of numerous prohibitions; increasing overcapacity in metallurgical and separation industrial potential; *destruction of the ecological environment and serious waste of resources*; lagging in the development of high-end applied technologies; and relative chaotic disorder of rare earths exports, all affecting the healthy development of the industry (emphasis mine).[32]

The following are examples of rare-earths-related environmental degradation in China[33]: (1) Bayan Obo (白云鄂博). The pit is located in an arid, dusty, desert environment, and the tailing dam associated with the mine continues to grow higher and larger with passing time. Thorium, a radioactive element commonly associated with the extraction of rare earths, is found in the Bayan Obo tailing dam at a concentration of 0.056%. Radioactive contamination has spread to the ground outside of the dam. Blowing dust is already a problem in the region, and thus airborne radioactive contamination is a real and dangerous hazard to the inhabitants of the surrounding region (Sun, 2011).

(2) Liangshan, Sichuan (四川凉山). Here the environmental destruction has taken the form of massive soil erosion, which has led to the clogging of riverbeds; as well as major safety hazards induced by haphazard, irresponsible mining methods. (3) Southern China. The majority of rare earths mined in the southern Chinese provinces can be classified as weathered crust elution-deposited rare earths ores (风化壳淋积型稀土矿), formerly (and more commonly) known as ion-adsorbed rare earth ores (离子吸附型稀土

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[32] The original Chinese reads: "经过多年发展，我国稀土开采、冶炼分离和应用技术研发取得较大进步，产业规模不断扩大。但稀土行业发展中仍存在非法开采屡禁不止，冶炼分离产能扩张过快，生态环境破坏和资源浪费严重，高端应用研发滞后，出口秩序较为混乱等问题，严重影响行业健康发展。"

[33] Cheng & Che (2010).

矿). The actual rate of exploitation of these mines is rather low; yet large swaths of vegetation in the vicinity have been damaged and destroyed; and soil runoff and general destruction of the ecological environment are particularly serious (Cheng & Che, 2010).

It is estimated that for the production of one metric ton of heap-leached raw ore with a thickness of 4-8 meters, 180 square meters of mine surface must be destroyed, and an area covered in various mining side-products such as rocks, stone fragments, etc., expands over an average area of 220 square meters. Adding to this the various damages caused by the destruction of the upper layers of soil and the piling of various mining-related waste products at mining sites, the production of one metric ton of rare earths raw ore destroys approximately 450 square meters. According to 2010 estimates (Cheng & Che, 2010), China loses 25 square kilometers of land to rare-earth-related man-made desertification every year; and these figures do not represent the uncalculated loss sustained from general environmental damage caused by rare earths mining.

Southern China's ion-adsorbed rare earths industry has significantly contributed to environmental degradation in the following areas: downstream gullies and valleys have been seriously clogged;[34] riverbeds have been elevated; fields have been destroyed; water has been polluted; thereby creating a "man-made desert". Mining techniques used in southern China—heap leaching and pond leaching—have caused "extreme degradation" ("破坏极大") to the natural environment. Also, because of changes caused to the geological structure of mining areas, in the event of heavy rains, the risk of landslides is greatly heightened (Song & Yang, 2013).

[34] A case study on a Jiangxi mine supports this conclusion. See Yang & Chen, 2013.

In Jiangxi, one of southern China's rare-earths-rich provinces, locals near ion-adsorbed rare earth mines call the process of rare earths leaching the "Mountain-Moving Movement" ("搬山运动"). The process leaves hills hole-ridden and virtually stripped of vegetation. Effusion and acid precipitation produce waste-water run-off high in ammonia nitrogen and heavy metals, which in turn pollutes the local supply of drinking water and irrigation water. Also, land polluted by rare earth tailings automatically becomes a non-arable wasteland. According to estimates by the Ministry of Industry and Information Technology of the People's Republic of China, the environmental pollution/damage caused by rare earths mining in southern Jiangxi amounts to ¥38 billion (approximately $6 billion), but the entire 2011 profit for rare earths production province-wide in Jiangxi was a drop-in-the-bucket ¥6.4 billion (approximately $1 billion) (Liu & Wang, 2013).

A case-control study on the relationship between rare earths pollution and leukemia offers a valuable perspective on the relationship between environmental pollution caused by rare earths mining and human health. In the study, a strong connection was established between the occurrence of leukemia and the drinking of rare-earth contaminated river water (Wu, Zhou, and Zhong, 2003). On an interesting side-note, Wu et al. also claimed that drinking tap water in the vicinity of the mining area did not lead to an increased risk for leukemia.[35] Though leukemia cases caused by China's rare earths pollution may truly be a issue, it is uncertain how significant rare earths pollution is as a cause for leukemia in China as whole. The study, nevertheless, does coincide with

[35] The authors also claimed that cigarette smoking and consumption of alcohol were not risk factors for leukemia. Though smoking and drinking have not been absolutely proven as risk factors for leukemia, it is known that smoking and drinking are associated with higher risks of cancers in general. See "Alcohol Use and Cancer", 2014.

purported findings in at least one other place, Malaysia, where it is reported that leukemia cases were linked to pollution from a rare earths plant developed by Japan's Mitsubishi Corporation. The rare earths plant was shut down more than twenty years ago. These reported "facts" have been part of the rallying cry of anti-rare-earths protesters in Malaysia in recent years (Tan, 2012).

Recent research also examines the toxicology of rare earths in the soil, and their effects on plants, animals, and microorganisms. Findings show that exposure to rare earths in plants can cause inhibition of growth, chromosomal aberration, DNA damage, structure changes of cells, and destruction of chloroplast structure. In animals, exposure resulted in the decrease of lymphocyte proliferation and immunity in mice; chromosome damage; oxidative damage of the nervous system; also, sperm malformation rate increased, and sperm motility rate decreased. In microorganisms, observations included inhibition of bacteria, actinomyces and fungi activity; as well as significant inhibition of the microbial respiration rate. High concentrations of rare earths in soils, resulting from rare earths mining and production, could possibly pose human health hazards (Jin & Huang, 2014)

Fang, Zhang, Li, Du, and Ma (2013), in a study on rare earth resources management policies, make the following three conclusions regarding rare earths environmental pollution: (1) Every link in the rare earth chain, including mining, metallurgy, separation, processing, and materials production, is still characterized by serious pollution problems; (2) environmental degradation has not been included in production costs as of yet; (3) there is a lack of effective constraining measures for environmental protection in China, and the compliance rate for such regulations among rare earths enterprises is low.

Along a similar vein, "During the rare earths production process, including mining and separation, the environmental cost generated is extremely high. Nevertheless, China's rare earth pricing does not completely include this environmental cost. Therefore, the returns gained from rare earths exports are far from making up for the environmental cost" (Wu & Liao, 2012).

The English-language literature on the topic of the environmental effects of the rare earths industry in China leaves the reader with a somewhat different perspective than that available in the Chinese-language literature. McLellan, Corder, Golev, and Ali (2014), in a paper on the sustainability of the rare earths industry, came to the conclusion that information on the environmental impact of China's rare earths industry is limited and not necessarily trustworthy, because, according to McLellan et al., only "broad estimates", mostly from government sources, are available.

While lack of broad, detailed, and accurate information may plague research on the environmental impact of the rare earths industry in China, it is a widely accepted view in the English-language literature that China's lax rare earths environmental record and regulations are a major contributor to the low costs of China's rare earths (Hayes-Labruto, Schillebeeckx, Workman, & Shah, 2013); and it is China's low cost "bottom line" that has given it ultimate advantage over the United States and other countries in the world rare earths market.

Hayes-Labruto et al. (2013) point out that China's rare-earths-related environmental degradation mainly takes the form of downstream water pollution, as in the case of Baotou Steel's production, which pollutes the near Yellow River, thus contaminating the irrigation and fishing for 150 million users downstream. Also, one must not forget that toxicity from chemicals has caused measurable amounts of disease, occupational poisoning, and farmland destruction in and nearby Baotou, Inner Mongolia.

China's rare-earths environmental record is dark. For every ton of rare earth produced, the resulting pollutants include 8.5 kilograms of fluorine and 13.5 kilograms of dust; and if concentrated sulfuric acid high temperature calcination techniques are used to produce approximately one ton of rare earths, the process generates 9,600 to 12,000 cubic meters of waste gas containing dust concentrate, hydrofluoric acid, sulfur dioxide, and sulfuric acid, approximately 75 cubic meters of acidic wastewater, and about one ton of radioactive waste residue (Hurst, 2010).

The situation outlined in the paragraph above is merely the tip of the iceberg, as the entire Baotou region produces over 10 million tons of various kinds of improperly treated waste water each year. The pollution contaminates potable and irrigation water in the region. Apart from the water pollution issues associated with rare earths mining and production near Baotou, the improper disposal of rare earths tailings and the black-lung-causing radioactive pollutants that rare earth workers come into contact with during the course of occupational activities are also major concerns. The most common illness in Baotou at the time of Hurst's study (2010) was pneumoconiosis ("black lung"), and cases in Baotou accounted for 50% of all cases in the Inner Mongolia autonomous region. Though slightly out-dated[36], Hurst's portrayal of the environmental hazards posed by

[36] Hurst's research (2010) came before the implementation of China's 2011 "Emission Standard of Pollutants for the Rare Earths Industry (GB 26541—2001)". One of Hurst's key points was the fact that at

China's rare earths industry and the lack of effective regulation still hold much truth, as China has many miles to cover on its path to environmental responsibility.

According to the extant literature, China's rare earths industry has caused/does cause great ecological and environmental damage, and that the environmental damage is one result of China's corner-cutting approach to rare earths mining and production, which in turn has contributed to China's rise to the position of near-monopolist of rare earths production—in the light of these facts, what kind of environmental regulations does China have in regard to rare earths? How did cutting corners environmentally give China the advantage in regard to rare earths, eventually leading it to become the near-monopolist?

China first passed its Environmental Protection Law (《中华人民共和国环境保护法》) on December 26, 1989, and has amended it several times since then. The most recent amendment occurred on April 24, 2014. The law, as it reads, gives great importance to environmental protection, proclaiming that the it was formulated for the protection and betterment of the human and ecological environment, to prevent pollution and other hazards, to ensure health, and to promote the development of a socialist modernity ("Zhonghua Renmin Gongheguo Huanjing Baohu Fa"). Though the Environmental Protection Law and other rare-earths-restrictive laws and regulations have strict stipulations for the mining industry, according to the extant literature, there exists a dichotomy between the laws passed in Beijing and the actual mining situation on the ground. Laws, when not enforced, are worthless; China's rare earths environmental

the time, China had only "general pollution control standards", and that "the country" had "never actually worked out pollutant discharge standards for the rare earth industry", a fact which changed in 2011.

record stands as evidence to this truth. Thus, when I refer to China's "lax environmental regulations", I specifically refer to the lack of implementation of regulations, not necessarily a lack of laws on the books. In other words, we can call China's environmental restrictions "lax" because the positive results of such restrictions and regulations, in reality, have been much less than the intentions.

The rare earths industry is restricted by that part of the environmental protection law concerned with minerals. Mining is referenced twice in the document. The first mention occurs in Chapter 1 (Overview 总则), Article 7: "The responsible administrative departments for land, mining, forestry, and water resources of the local People's Governments at the County level and above should regulate and manage resource protection according to the legal regulations" (Ibid). Again, mining appears in Chapter 5 (Legal Responsibility 法律责任), Article 44: "[Anyone] engaged in the destruction of land, forest, grassland, water, mineral, fishing, or wild animal resources, shall be legally responsible according to the regulations of related laws" (Ibid). Chapter 5, Article 41, is more forceful, but equally as unspecific and broad-principle-oriented as Articles 7 and 44: "Anyone causing environmental pollution hazards has the responsibility to remove the hazard, and compensate the entity or individual for the loss". According to Chapter 5, Article 38, entities responsible for causing environmental pollution "accidents" may be fined, and the individual personally responsible may be dealt administrative discipline.

Other environmental protection laws that have bearing on the rare earths industry include the "Law of the People's Republic of China on Prevention and Control of Water Pollution" (《中华人民共和国水污染防治法》), and the "Law of the People's

Republic of China on the Prevention and Control of Atmospheric Pollution" (《中华人民共和国大气污染防治法》). The former was adopted on May 11, 1984, and the latter on August 29, 1995. It is the stated purpose of both laws to protect and improve the environment and safeguard human health, and both laws have indirect bearing on the rare earths industry, which both present serious hazards to the atmosphere and water.[37]

On January 24, 2011, the Ministry of Environmental Protection of the People's Republic of China (中华人民共和国环境保护部) and the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (国家质量监督检验检疫总局) co-issued the "Emission Standard of Pollutants for the Rare Earths Industry (GB 26541—2001)" (《稀土工业污染物排放标准》（GB 26451—2011）), effective October 1 of the same year. The standard detailed new regulations for the rare earths industry mainly in the areas of water pollution and atmospheric pollution.

Later in 2011, the Chinese government published "Several Opinions of the State Council on Promoting the Sustainable and Healthy Development of the Rare Earths Industry" (《国务院关于促进稀土行业持续健康 发展的若干意见》), acknowledging the serious damage to the environment that the rare earths industry has caused, and calling for greater adherence to existing environmental policies. China's environmental policies with regard to the rare earths industry will be discussed in more detail in later chapters.

[37] Other laws and regulations that restrict pollution from the rare earths industry are the "Marine Environment Protection Law of the People's Republic of China" (《中华人民共和国海洋环境保护法》), adopted August 23, 1982, and effective as of March 1, 1983; and the "Decision of the State Council on Implementing Scientific Outlook on Development and Strengthening Environmental Protection" (《国务院关于落实科学发展观 加强环境保护的决定》), published in December, 2005.

(3) Illegal Mining of Rare Earths

China's overproduction of rare earths in relation to world demand and the resulting upheaval of world rare earth supply/demand during the 1990s eventually led to the significant lowering of rare earth prices worldwide. As a result, China emerged as the near-monopolist in the rare earths market by the late 1990s-early 2000s. Even though China has made it a stated priority for many years to control overproduction, only recently (1998-99) did it implement production quotas for rare earths, and even then, it seemed difficult to keep production within quota limits, although as of the writing of this thesis, China has officially cancelled its export quotas for rare earths in an apparent compromise with the World Trade Organization after losing a recent WTO case brought against China by the United States, Japan, and the European Union.

One of the main factors leading to China's rare earth overproduction and the upset in the worldwide rare earths market was unregulated and illegal mining. Though regulations exist in theory that would hamper the illegal mining, implementation was less than desirable, as has been noted above. As a consequence of the lucrative nature of rare earths mining, unregistered, permit-less rare earths producers popped up in rare-earth-rich areas just like "bamboo after spring rain" (雨后春笋).[38]

Rare-earths leaching methods in developed countries such as the United States are considerably different from those that have been used in China, where illegal mining is still rampant. In situ leaching—the most common approach in places like the United States and Canada—though less destructive of the environment, is also more expensive

[38] The saying "雨后春笋" ("yǔ hòu chūn sǔn") is used similarly to "spring up like mushrooms" or the verb "to mushroom" in English. See http://www.iciba.com/雨后春笋.

than other leaching practices, and requires more high-tech instruments. Pool leaching is more commonly used in China, because of its lower cost, even though its environmental toll is much higher than in situ leaching. It is reported that a country farmer in Jiangxi with a limited understanding of science can easily become a “rare earths elements producer”. All he/she needs to do is shovel a truckload full of rare-earth-rich soil, mix in high quality fertilizer, and submerge the mixture evenly in a backyard leaching pool. The result of this “home-style pool leaching” process is lucrative rare earth elements. There is no need for permits or inspections, as the entire operation takes place “off the grid” (Liu & Wang, 2013).

Attracted by the monetary gain promised by rare earths mining, some individuals and groups have been operating without permits, infringing on the mining rights of others, and engaging in random and unrestrained excavation. The situation became increasingly worse over time, and caused havoc in the order of mining. The main factor driving the disorderly state of affairs in the rare earths mining community[39] is the pursuit of economic gain, which lures opportunist types to strike out for “easy money”. The results of permit-less rare earths production are (1) overproduction of rare earths; (2) destructive domestic competition; (3) the overall low efficiency of rare earths mining; (4) increases in the wasting of rare earths; (5) soil erosion, and (6) destruction of the ecological environment (Cheng & Che, 2010). The connection between permit-less producers of rare earths and higher rates of environmental damage is worthy of note.

[39] The situation is the most severe in the mining of southern China’s weathered crust elution-deposited rare earth ore (风化淋积型稀土矿).

An ironic state of affairs exists in the Chinese rare earths industry today in exact opposition to that which ushered the glory days of China's rare earths mining in the 1990s and 2000s. While China currently owns the largest share of the world rare earths market, it is fast losing its position because of several factors, two of which are illegal mining and the inordinately speedy expansion of rare earths industrial capacity (Wu & Liao, 2012; see also Fang et al., 2013), a fact which is in turn tied closely to the mushroom-like growth of illegal mines. Because of these and other factors, China's share of total world rare earths reserves is quickly dwindling. Thus, illegal mining, which worked in China's favor during the days of rare earths market flooding ("dumping") in the 1990s, is now a serious liability. Also, Wu & Liao (2012) agree with Cheng & Che (2010) on the connection between lack of regulation and environmental degradation:

> "The small size, large numbers, low-tech nature, and difficulty of regulation of enterprises, are considered the main reasons for environmental degradation and waste of resources in the rare earths industry".[40]

China's unrestrained mining/production/export spree during the rare-earth heyday years (1990-2005) led to growth of China's rare earths by 800.65%. While production and exports were booming, prices remained low, and China, for the time being, enjoyed its "top of the pile" status. Supply and demand dictates that when supply exceeds demand, prices drop. The partially uncontrollable (China did seek to control it early on) excess in

[40] The original Chinese reads: "稀土行业的企业规模小、数量多、技术水平低、难以监控被认为是造成环境破坏和资源浪费的主要原因".

China’s supply due to illegal mining and overproduction was a double-edged sword, bringing a crisis (危机)[41] of opportunity and danger.

As noted above in the review of China’s environment-related laws, the rare earths industry in China is restricted to different degrees by several laws. One which comes to bear on the illegal mining issue is the Mineral Resources Law of the People’s Republic of China (《中华人民共和国矿产资源法》), adopted by China’s government on March 19, 1986, and amended on August 29, 1996. In Chapter 6, “Legal Liability”, Article 39, the law states that:

> If a person, in violation of the provisions of this Law, mines without a mining license, enters and mines without authorization in a mining area that is embraced in State plan or a mining area that is of great value to the development of the national economy or mines without authorization specified minerals of which protective mining is prescribed by the State, he shall be ordered to stop mining, compensate for the losses caused, and his mineral products and unlawful proceeds shall be confiscated, and he may also be fined. If he refuses to stop mining and thus causes damage to the mineral resources, the persons who are directly responsible shall be investigated for criminal responsibility in accordance with the provisions of Article 156 of the Criminal Law. Any units or individuals who enter and mine in the mining areas of State-owned mining enterprises and other mining enterprises established by others in accordance with law shall be punished in accordance with the provisions of the preceding paragraph.[42]

From the wording above, unlicensed rare earths production clearly falls into the category of criminal activity, and is punishable by under the provisions of the law. Alas, China’s rare earths industry is not corruption-free, and many times, regulatory clout loses force in the face of economic gain, and the rare earths black market continues to survive regardless of written laws and regulations (Torrisi, 2014).

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[41] The Chinese characters “危” (danger) and “机” (opportunity), when put together form the word “危机” (wēijī), meaning “crisis”. Thus, a “crisis”, in the Chinese understanding, contains both danger and opportunity.

[42] This is the official English translation provided by the Chinese government at http://www.china.org.cn/english/environment/34342.htm.

Guanxi (关系), or social connections, are an important protective canopy under which high-polluting enterprises operate within the existing regulatory environment. As Chen (2009) notes: If enterprises

> keep good relations (*guanxi*) with local officials through bribery in forms of cash, valuable gifts, invitation to banquets, and all-expense-paid trips abroad, it is not difficult for them to avoid compliance of strict environmental standards and thus lower the manufacturing cost. The key figures for polluting companies to maintain good *guanxi* with are those cadres in the local party committee, the administrative departments, and the courts. For the environmental administrative fines or pollutant discharge fees collected by the local environmental protection bureaus, if is possible for the related entrepreneurs to bargain with the administrative staff due to lack of supervision.

(4) Low Costs of Rare Earths Production

According to Chinese-language scholarly sources, the strategic nature of rare earths forms a glaring contrast with the low prices of rare earths exported from China. In 1990, the average price of a ton of rare earths for export was $13,600; in 2005, the same ton of rare earths was exported for an average of $7322, representing a more than 46% drop over a 15-year period. If the devaluation of the US dollar were to be factored in, the price drop would be even greater (Liu, 2013). Regardless of how these figures are interpreted, one fact is certain—Chinese rare earths dropped in price significantly during the 1990s and early 2000s.

China's position of near-monopoly on the production of rare earths was ultimately solidified due to one "bottom line" factor: cost. Disregard for the environment; mining and producing without permits; or a combination of the two ultimately worked in favor of lower prices for China's rare earths. Though many Chinese academics today lament that presently, China, while endowed with the most abundant rare earths resources and the greatest rare earths production capacity on the planet, does not have the ability to control world market prices for rare earths, one thing is certain about the past: China's rise to near-monopolist status was directly tied to its low costs and ample supply of rare earths. Lower costs do not just happen—they are the result of cutting costs all along the rare earths industry chain—from mining to smelting/separation to production of rare earths ores, rare earths metals, etc. Until recently, it seems that this corner-cutting approach was met with an "open-one-eye-close-one-eye" (睁一只眼闭一只眼)[43] stance by many local Chinese government officials.[44]

According to a historical overview of rare earths pricing, Hayes-Labruto et al. (2013) point out that world rare earths prices were noticeably affected when China's rare earths mines "came into full force in the 1990s". As a result, "supply quickly outstripped demand, driving prices down significantly". Add to this the fact that due to growing demand for neodymium magnets in the 2000s, China produced higher amounts of all rare earth elements, because rare earths cannot be mined separately. The result was overproduction of rare earths in general, and low rare earths prices worldwide.

In the 1950s and 1960s, China's rare earths production was an expensive and technically challenging undertaking. After Xu Guangxian 徐光宪, "China's Father of Rare Earths" (稀土之父), created an invention for the cheaper separation of rare earths elements, China's production capacity increased to 10,000 tons/year in the early 1980s. There are two reasons for China eventually overtaking the United States to become the

[43] In English, the saying could be translated "look the other way".

[44] China's Central Government has put forth considerable effort to regulate the rare earths industry and other high-polluting industries through laws and standards since the 1980s. Nevertheless, as the fact of wave after wave of campaigns against sub-standard rare earths mining and production so aptly demonstrates, the discontinuity between legislation and implementation is a chasm not easily bridged. See "Zhongguo De Xitu Zhuangkuang Yu Zhengce" (2012).

top producer of rare earths: the Mountain Pass Mine's own environmental issues and cheap Chinese rare earths (Wübbeke, 2013). For the purposes of this chapter, I take special note of the latter of the two reasons.

Morrison & Tang (2012) make the following statement regarding China's rise to rare earth production dominance: "In the late 1980s, the United States was the global leader in rare earth production. However, preferential policies including significant subsizidation by the Chinese government and lax environmental standards quickly enabled China to become the dominant, low-cost producer of rare earths by the late 1990s." Note that Morrison & Tang's emphasis is on China's low-cost production of rare earths. The connection between lax environmental standards/lack of enforcement and the low-cost production of rare earths is evident; and according to Morrison & Tang's analysis, the result of the combination of these factors is market domination.

Also, "through the 1990s, China's exports of rare earth elements grew, causing prices worldwide to plunge. This undercut business for Molycorp (Mountain Pass Mine) and other producers, and eventually either drove them out of business or significantly reduced production efforts" (Hurst, 2010). It is understood here that China's exports continued to grow in quantity, and prices remained low. If it were not for the low cost and high volume of Chinese rare earths during the 1990s, it would have been difficult to drive rare earths giants like Molycorp temporarily out of the market.

There are at least three more factors that have contributed to the low cost of Chinese rare earths production. The first is connected with the rampant phenomenon of illegal rare earths mining. Although China adopted laws as early as 1986 (see "Mineral Resources Law" above) requiring mining corporations to obtain the necessary permits (and pay the necessary fees) before engaging in mining or any form of rare earths processing or production, the reality of the situation up until recent times, and especially during the rare earths "boom" period during the 1990s, was that regulation was lax, and illegal mining common. Illegal mining not only destroyed environments, but led to an unnatural lowering of rare earths costs (成本). Because illegal rare earths producers did not pay regulatory fees (either because the related requirements were lax to begin with or such requirements were evaded by the rare earths producers), this drop in production cost gave Chinese rare earths an overall price advantage over countries such as its largest competitor at the time, the United States, where environmental regulatory overhead added considerable cost.

Second, China is known as the world's factory (世界工厂). The three largest reasons for this are (1) China's Reform and Opening policy during the late 1970s and early 1980s opened China up for foreign investment, and ultimately led to the building of virtually innumerable factories, manufacturing centers, etc. (2) China is fairly rich in raw materials, which makes manufacturing there all the more convenient. (3) Most important of all, China's was, up until recently, one of the cheapest labor forces on the planet. Blakely, Cooter, Khaitan, Sincer & Williams (2011) conclude that China's cheap labor factored in significantly to China's rise to rare earth near-monopolist status.

Third, the rare earths industry of China was highly government-subsidized during the boom years of the last decade of the 20th century. Jeffrey A. Green states that during the 1990s, China:

> Flooded the market by more than tripling the previous world supply of the materials. During this time, Chinese rare earth-producing firms were largely unprofitable but were allowed to survive through direct and indirect support by the Chinese

> government. This backing enabled China's rare earth industry to continue to mine and export these materials at prices far below the actual costs of production. With the additional industrial advantage of a low labor cost, questionable environmental standards, and export taxes, the impact of these efforts were swift and dramatic: within 20 years China went from producing roughly one-third to nearly all of the world's supply of rare earths. Mines in the United States and elsewhere, unable to remain profitable against cheap Chinese exports, went out of business. The United States was completely dependent on imports. With the mines shuttered, companies in the United States that refined the rare earths metals and alloys and manufactured rare earth magnets moved overseas or simply closed" ("China's Global Quest for Resources and Implications for the United States", 2012).

With low labor costs, along with rampant illegal mining, lack of investment in environmental protection, and the powerful backing of the Chinese government through subsidization and science-and-technology-driven initiatives such as Programs 863 and 973,[45] the Chinese rare earths industry lunged forward at high speeds during the 1990s and early 2000s. By that time, China had established itself as the near-monopolist in the world rare earths market. Therefore, according to some, China began reformulating its game, suddenly becoming more serious about issues like the environment, illegal mining, labor costs, etc., because of its fear that such reckless exploitation of strategic resources could one day lead China to become entirely dependent on foreign rare earths imports.

In summary, the current literature supports the conclusion that China has gained its current position of near-monopolist of rare earths based on (1) strong government support for the development of the rare earths industry, (2) disregard for the environment, (3) illegal and/or unregulated mining, and (4) the low cost of rare earths production. At this juncture, the thesis turns to the review of the international and domestic factors that have affected China's behavior as a near-monopolist of rare earths.

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[45] The 863 Plan and 973 Program are ongoing initiatives spearheaded by the China's Central Government for the express purpose of sharpening China's high-tech competitive edge. Rare earths research and development projects have traditionally enjoyed high-priority status under these government initiatives.

CHAPTER 3: INTERNATIONAL FACTORS INFLUENCING CHINA'S BEHAVIOR AS NEAR-MONOPOLIST OF RARE EARTHS

Introduction

China's behavior as the major producer and exporter of rare earths has gained the attention of the world in recent years. In September of 2010, after the collision of the Chinese fishing trawler "Minjinyu 5179" (闽晋渔 5179) with two Japanese coastguard vessels (Blakely et al.) in the vicinity of the disputed Senkaku/Diaoyu Islands, and the subsequent Japanese detainment of the Chinese trawler's skipper, it was reported that China placed an administrative hold on exports of rare earths to Japan, sparking immediate reactions of alarm in Japan and the West (Bradsher, 2010). Much western media portrayed the incident as an example of China flexing its geopolitical muscles through a stranglehold on rare earths resources. Whether or not this was actually the case has yet to be proven beyond question, though western media such as the *New York Times* have implied China's use of rare earths as an economic weapon on numerous occasions (Ibid).

The trawler collision incident has amply spotlighted China's near-monopoly on rare earths in an international context. But what exactly are the international factors that influence China's behavior as a near-monopolist of rare earths? In this chapter, I identify the following factors: (1) international demand for rare earths in the context of lower rare earths production outside of China; (2) international pressure on China to conform to certain trade regulations; (3) international "price-setting authority" issues on the part of China; (4) geopolitical factors such as the condition of relations with Japan, etc.

(1) International Demand

In the opinion of Mao & Wu (2012), "due to the over-pollution associated with the production of rare earths raw materials, the resulting environmental cost, and the fact that some developed countries have strict environmental regulations, these developed countries are unwilling to produce rare earths raw materials. This is one of the main reasons that China's production of rare earths raw materials takes such a high percentage of world rare earths raw materials production." Mao & Wu also point to three types of rare earths costs that are higher outside of China, thus forcing international rare earths producers to shut down or decrease production thereby increasing demand for China's rare earths: (1) production costs, (2) tax costs, and (3) social costs (environmental, etc.). All of these costs are considerably higher internationally compared with China. It seems that the rare earths industries of many countries, after a calculation of the costs associated with rare earths production, have either stopped or significantly reduced rare earths production, and opted in favor of purchasing cheap rare earths from China.[46]

From the international perspective, China has rare earths trade relations with numerous countries due to international demand for rare earths for use in high-tech manufacturing and industry/government stockpiling. This international demand has

[46] Taking the metals of praseodymium and neodymium as an example, production costs for China Southern Rare Earths Company (中国南方稀土公司) hovered around $30 per kilogram, whereas pre-closure costs at the Mountain Pass mine in California, US had been as high as $40 per kilogram. According to Yang (2011), when production costs of these two rare earths metals are between $35 and $40 per kilogram, it becomes uneconomical for the United States to produce the rare earths, let alone the fact that Chinese production prices were well below $35 per kilogram.

directly influenced China's behavior as the rare-earths near-monopolist, leading it to increase production of rare earths, which in turn has contributed to China's status as a rare earths near-monopolist. Add to this the reality of increasing environmental regulations imposed on rare earths mining and production internationally, and the demand only increases. Also worthy of note is that China originally emerged as the near-monopolist of rare earths production in a large degree due to its disregard for environmental concerns. As noted in Chapter 2, China's rare earths industry has been and continues to be a significant cause of environmental degradation and human health hazards. Yet the very fact that rare earths mining and production is environmentally detrimental has increased international demand for rare earths from China. As Blakely et al. (2011) comment:

> The environmental detriment caused by the production of rare earths is a notable side effect of mining and processing. Within the production process, radioactive thorium, uranium and, later in separation, acid baths consisting of toxic chemicals are used. Due to the severe risk of using such hazardous materials and strict environmental legislation giving rise to high production costs, *developed countries*, such as the United States and Canada, *have in recent years preferred to import rare earths from China instead of mining their own reserves* (emphasis mine).

In other words, developed countries desire to reduce pollution caused by rare earths mining on their own soil, and at the same time seek to find the most cost-effective method to produce the rare earths worldwide. At present, China is the answer to the dilemma of the rest of the world. Through arrangements with China, other countries are able to produce (either in China or domestically) the rare-earth-dependent end-products that their high-tech markets need, while mitigating a large degree of pollution on their own soil—a winning combination for Western corporations that deal in rare earths and rare-earths-related products and materials.

The demand for China's rare earths is sometimes couched in language of desperation, as if there is no alternative. At the time of the 2010 China-Japan rare-earths spat over the fishing trawler, for countries like the United States, there were no easy alternatives, as the record from a Senate committee hearing in September 2010 reveals:

> Fifteen years ago, the United States was the world's largest producer of rare earth elements. *Since then our country has become almost entirely dependent on imports from China*. Unfortunately, the Chinese industry is on track to absorb all Chinese rare earth production as soon as 2012. In July, China's Ministry of Commerce announced that China would cut its export quota for rare earth minerals by 72 percent, raising concerns around the world about supply disruptions ("Rare Earths", 2010).

Of primary concern is the United States' near-complete dependence on China for rare earths as of 2010[47]. In the year 1990, the United States produced over 22,000 tons of equivalent REOs, and most of its rare earths imports came from France (Hedrick, 1990). In 2000, France had taken a far second to China, which had not even been on the import horizon for the United States ten years earlier, and the United States' rare earths productivity had significantly decreased to approximately 5,000 tons per year (Hedrick, 2000). Also, from 2002 to 2011, "the quantity of U.S. rare earth imports from China as a percent of total U.S. rare earth imports averaged 78.3%" (Morrison & Tang, 2012). The trend during the 2000s, especially during the non-productive years for the United States rare earths mining industry, was toward ever-increasing dependence on China's rare earths exports. U.S. reliance on China for its supply of rare earths, though alarming for reporters, industry experts, and politicians in the United States, was just one example of China's rare earths near-monopoly. During this same time period, resource-poor Japan

[47] Since 2010, American dependence has been slightly assuaged by the reopening of the Mountain Pass, CA rare earths mine, yet the United States lacks a complete rare earths production chain, and many rare earths oxides, once mined at Mountain Pass, must be sent to China for processing.

was even more dependent on China for rare earths, absorbing approximately one third of China's rare earths exports (King & Armstrong, 2013).

Simply put, China's near-monopoly on rare earths production has been fueled and in part caused by the gap in production in the West. Of course, there are many factors, such as environmental degradation, low costs, government subsidization, etc., that also factor in to the equation (see Chapter 2). But from a purely international perspective, as the competition (the United States) has been effectively marginalized (at least for the time being),[48] and the United States and other countries continue to have high volume requirements for rare earths; the natural beneficiary of the situation is China, simply because it produces such a large percentage of the world's rare earths (approximately 90%).

(2) Trade Conformity Pressure

Now that it has been established that the international factor of demand for China's rare earths has contributed significantly to China's status as rare earths near-monopolist, we turn to an inquiry into the nature of China's behavior as a rare earths near-monopolist. From an international perspective, the main behaviors that nearly all rare-earths-dependent countries are concerned about are China's recent increased restrictions (since 2005-2006) on rare earths exports[49].

[48] According to US government-published industry estimates ("Rare Earth Materials in the Defense Supply Chain", 2010) in 2010, at the time of the statement, it would take approximately 15 more years (until 2025) to rebuild the United States' rare earths industry supply chain.

[49] Some of these restrictions have been/will be removed as of 2015, e.g. the rare earths export quota system was cancelled on Jan. 1, 2015, and rare earth export duties are due to be abolished in May 2015.

China is undeniably the leader in the rare earths market, and many developed nations, including the United States, Japan, and the countries of the European Union (EU) depend on China's exports of rare earth oxides, metals, etc. to fuel their high-tech and defense industries. Nevertheless, though China holds supremacy in rare earths mining and production, China does not hold a controlling influence in the decision-making process of worldwide trade. Thus, while in reality, China holds the key to the world's largest rare earths powerhouse, organizations like the World Trade Organization (WTO) still believe themselves to have the final say in trade issues relating to rare earths. Therefore, China's behavior as a rare earths near-monopolist, though begrudgingly, is indeed influenced, and indeed controlled, to a certain extent, by international factors such as WTO decisions.

China has restricted rare earths exports since 1999[50] ("Zhongguo De Xitu Zhuangkuang Yu Zhengce"), yet recent limits went further than the international market expected. China's increased restrictions on rare earths exports, which led to a subsequent hike in rare earths prices from 2010 to 2011, was opposed formally by the WTO in 2012. When the United States, Japan, and the EU decided to simultaneously file three cases (DS 431, DS 432 and DS 433) through the WTO against China for its restrictive rare earths trade policies, China reacted by emphasizing that rare earths cannot be traded limitlessly, due to their exhaustible nature, and that China's restrictive trade policies are in the best interest of the natural environment. But the interesting fact is, though China is the near-monopolist of rare earths, it is not the hegemon of the world trade system, and thus, China must seriously consider injunctions originating with the WTO.

[50] Other figures cited earlier state 1998.

The three WTO cases against China were essentially one, though filed separately by three different countries. The official record states that Japan, the United States, and the EU requested “consultations with China with respect to China’s restrictions on the export of various forms of rare earths, tungsten and molybdenum” (Dispute DS433, 2014). The three complainants were later joined by the following third parties: Brazil, Canada, Colombia, India, the Republic of Korea, Norway, Oman, the Kingdom of Saudi Arabia, Chinese Taipei, Viet Nam, Argentina, Australia, Indonesia, Turkey, Peru, and the Russian Federation.

In the “summary of key findings” released by the WTO, the issues were encapsulated thus:

> This dispute concerns Chinese export restrictions on rare earths, tungsten, and molybdenum. These are raw materials used in the production of various kinds of electronic goods. China argued that the restrictions are related to the conservation of its exhaustible natural resources, and necessary to reduce pollution caused by mining. The complainants disagreed, arguing that the restrictions are designed to provide Chinese industries that produce downstream goods with protected access to the subject materials. China imposes three distinct types of restrictions on the export of rare earths, tungsten, and molybdenum: first, it imposes duties (taxes) on the export of various forms of those materials; second, it imposes an export quota on the amount of those materials that can be exported in a given period; third, it imposes certain limitations on the enterprises permitted to export the materials (Ibid).

The WTO panel assigned to the case took over two years of deliberation and discussion before issuing a 257-page report in English, which outlined the three-pronged argument referenced above. In short, in regard to duties on rare earths, tungsten and molybdenum, the complainants claimed that China had overstepped the boundaries set in its 2001 accession to the WTO. Annex 6 of the accession protocol (“Protocol on the Accession of the People’s Republic of China”) lists “Products subject to export duty”.

With the exception of tungsten ore and concentrates, for which export duty rates are not to exceed 20%, neither rare earths nor molybdenum were listed within Annex 6. Therefore, the United States, Japan, and the EU held that China should not be allowed to assign export taxes for these items.

China, in its own defense, called on the General Agreement on Tariffs and Trade 1994 (GATT 1994), claiming that the "General Exceptions" provision in Article XX gave precedent for such duties for the protection of "human, animal or plant life or health" (Dispute DS433, 2014). The complainants countered that the provision in Article XX was not available as a grounds for disregarding the accession protocol, and that in addition, the duties themselves are not necessary for the protection of human, animal or plant life or health. In other words, it is specifically the mining process of rare earths, tungsten and molybdenum that creates environmental hazards, and these hazards cannot be mitigated through export taxes.

The second issue at hand was the export quotas for rare earths, tungsten, and molybdenum. While China acknowledged that such quotas were not in harmony with WTO member obligations as outlined in the GATT 1994, it did reference the exceptions allowed in Article XX of the GATT 1994, namely that a member country had the right to restrict exports of certain items for the sake of conservation. This argument was eventually rejected by the WTO panel on the basis that China was not using export quotas for the protection or conservation of natural resources, but for (1) the control of an international market and (2) the benefit of domestic industries that used the elements in question.

By way of side-note, it is noteworthy that China's rare earths export quota system was in place by 1999, long before China's accession to the WTO in late 2001. This begs the question: Why did the WTO not address the issue of rare earths export quotas in 2001? Why did the WTO not make the cancelling of such quotas a precursory condition to China's accession to the organization? Would the quota system have been allowed to continue indefinitely without contest if it were not for the drastic cuts in export quotas in 2010-2011 and the adverse reaction in the world market? These are questions that, unfortunately, cannot be answered with certainty, but nevertheless, are worthy of consideration.

Finally, China imposes certain restrictions on the right of enterprises to export certain resources. In this case, China also appealed to Article XX of the GATT 1994 and its provision for the conservation of exhaustible resources. However, the panel found that China had not explained itself satisfactorily, and that it was not clear how Article XX justified China's trading rights restrictions. All in all, as of the writing of this thesis, the case has amounted to a loss for China.

Recent Chinese research has spotlighted China's current position as the losing party in the WTO decision to oppose China's rare earths export restrictions, primarily seeking for the most beneficial future path for rare earths management. Li & Xu (2014) approach the subject from the perspective of the protection of rare earths resources and environmental protection, which they claim are the two major rare-earth policy goals of the Chinese government. According to the article, China's over-mining of rare earths since 1985 has caused a rapid depletion in China's rare earths resources. Taking the Bayan Obo mine as an example, the most recent estimates put total mine reserves at 1/3 of the original amount. The situation for ion-adsorption rare earths in southern China is also not promising. In light of the seriousness of the depletion of China's rare earths resources, and to protect the remaining resources and the environment, the Chinese government prioritized the implementation of two types of policies: (1) rare earths export restrictions and (2) rare earths production control.

According to Li & Xu, rare earths export restrictions take two forms: (1) export quotas and (2) export taxes. As early as 1999, China began using export quotas, although the simultaneous export encouragement given through export rebates kept exports high. In October 2003, China began slowly fazing out export rebates for rare earths, a process that was complete by May 2005. In October 2006, China began levying taxes on certain rare earths products, and eventually increased the number of taxable rare earths products and the tax rate. Originally, the Chinese government sought to accomplish two goals through rare-earths export quotas and export taxes: (1) decrease foreign demand for China's rare earths, thereby decreasing mining and production, and as a result causing less environmental damage and resource depletion; (2) balance the lopsided supply-demand relationship in the world rare earths market by decreasing supply, which had been in excess.

According to the authors, neither of these goals have been met, because foreign rare earths consumers have moved production to China, greatly increasing China's percentage share of world rare earths consumption. In 2000, China's consumption of rare earths stood at 19,000 tons REO, accounting for 24% of worldwide rare earths consumption. By 2013, however, China's rare earths consumption had jumped to 85,000 tons REO, or nearly 70% of world consumption of rare earths. During this time period, China's production of rare earths hit record highs above 130,000 tons REO.

In addition, overall, China's rare earth export quotas have not reflected the actual export volume for rare earths in recent years. Between 2004 and 2013, only in one year—2010—did China exceed export quotas; every other year, exports (not including smuggled rare earths) did not meet quotas. Also, China's high export taxes have created a two-tiered pricing system, whereby rare earths for domestic use are significantly less costly than those for export. This has created lucrative margins for smugglers, who have taken great advantage of the domestic-export price gap.

Apart from rare earth export restrictions, China's protective policies include a second part: production control. In the opinion of Li & Xu, China should take full advantage of production control as a way to mitigate environmental degradation and protect rare earths resources. The authors also insightfully point out that this method of protecting China's rare earths resources would be more palatable for the international community, especially the WTO, because in the recent case brought against China by the United States, the EU, and Japan, issue was taken with China's export quotas, export taxes, and regulatory measures, not with production quotas, which would provide a way to conserve resources in a non-discriminatory way.

(3) Rare earths pricing

Many Chinese researchers believe that China's rare earths pricing is abnormally low, and that based on objective factors, China should be able to set higher international prices for rare earths. Mao & Wu (2012), in an analysis of the relationship between rare earths pricing and rare earths reserves, make the following claim: China's rare earths should sell for higher than current prices, due to application values (high-tech and military), relative scarcity, environmental costs, and supply monopoly.[51] According to the authors, not only are export prices of rare earths too low, domestic prices are also below desirable levels.

The article begins by addressing an issue that is a matter of “discussion for every part of society” in China: the question of why China does not have the true ability to set prices for rare earths in the international market. The authors state that China’s rare earths exports have been characterized by a long history of cheap export prices, and that even though recently rare earths prices jumped significantly by 300 to 500 percent, the fact that China has the ability to create price hikes is not equivalent with the ability of China to set market prices for rare earths. For, as Mao & Wu argue, the sharp increase in rare earth prices followed by a steep price fall is ample evidence that China does not have a true say in the matter, but that what the world witnessed was simply the natural and temporary result of China restricting rare earth supply, which, according to the authors, is not a long-term solution to stopping the outward flow of cheap rare earths.

Mao & Wu cite and summarize the work of several Chinese researchers (including Xu Guangxian, the “father Chinese rare earths”), who have all, over recent years, called for China to create strategic rare earths reserves. In the opinion of these well-known Chinese scholars, the creation and maintenance of rare earths reserves is the only dependable way to truly gain international say in rare earth pricing. Xu Guangxian once said, “I strongly urge our country to establish a reserve system of strategic rare earth elements. Our country should invest approximately $1 billion in the procurement of rare

[51] It is interesting to note that Chinese sources often use the word “monopoly” to refer to China’s rare earth supremacy, whereas Western researchers tend to shy away from such absolute terminology in favor of “near-monopoly” or “quasi-monopoly”, etc.

earths at a time when market prices are low, and add to that the protection of our own rare earths resources, thereby reclaiming international price-setting authority". Nevertheless, the authors acknowledge that the use of strategic reserves of certain materials as a means of setting/controlling market prices is usually a tactic of buyer countries, and not seller countries; and China is the seller country in this scenario. Thus, more research is necessary into how China, in its role as seller, could control rare earths prices through maintaining strategic reserves.

In the 2010 article, "From Large to Strong in Rare Earths: How Can China Change?" published in *Rare Earth Information*, the issue of "price-setting authority" (定价权) is set against a broader background. "China controls over 90% of the rare earths metals market, yet it lacks the ability that countries like Australia and Brazil have to control world prices.[52] A strange phenomenon exists in the worldwide commodity market: taking oil, coal, and iron ore as examples, whenever China is in the exporting stage, prices are extremely low; but as soon as China becomes an importer, prices soar". The article refers to America's import/stockpile strategy, in which the United States chooses against mining its own resources in favor of importing and stockpiling against a future "rainy day", when America could introduce rare earths into the world market as a price-lowering tactic, in the event that prices were to rise inordinately high.

Zhang & Mao (2012) consider China's lack of "price-setting authority" as a grave international factor influencing China's rare earths industry. The authors identify two major problem areas, and make several suggestions for China's rare earths industry, in hopes of rectifying the situation. First, from a macro-scale, China's rare earths industry is

[52] Literally, it lacks the "world price-setting authority" (世界定价权).

systemically monolithic and cumbersome. The industry takes directives from the Ministry of Land and Resources, the Ministry of Commerce, the National Development and Reform Commission, Ministry of Industry and Information Technology, large Central Government-owned enterprises, and local government departments, etc. Second, from the perspective of individual enterprises, it is difficult to arrive at a unified price system (统一的价格机制) due to the “numerous and spread-out” (散而多) nature of China’s rare earths enterprises.

The authors point to the crux of the matter: China’s rare earths market relies too heavily on its low-cost price advantage, focusing on the immediate benefits of the current international pricing system by which China can “steal the market with low prices” (低价抢市); whereas what China’s rare earths enterprises should be doing is thinking about long-term profitability and price-setting authority. Zhang & Mao believe that the key to realizing this international goal is cooperation of domestic enterprises for the good of China’s entire rare earths industry. In other words, individual enterprises should stop malicious competition, and begin cooperative competition, with the goal of bringing the greatest benefit to individual enterprises as well as the entire industry. The authors use the term “prisoner’s dilemma” to describe the impasse that exists between China’s rare earths enterprises and the industry at large in China, and analyse the related pricing issue by using static and dynamic Nash equilibriums from game theory. In their analysis, the authors illustrate in simple terms the negative effect on the entire market caused by malicious, uncooperative competition by individual enterprises within a market characterized by a static Nash equilibrium and lack of complete information. In a dynamic Nash equilibrium situation, in which information is shared freely, the outcome for both the individual enterprises and the market as a whole are maximized through cooperation and sustained prices, as opposed to continual price dropping.

In summary, Zhang & Mao see only one way for China's rare earths industry to recover the "price-setting authority" for rare earths exports: greater cooperation and greater self-control in the domestic rare earths market. As a result, not only will the industry as a whole and China's international rare earths status be greatly benefited—China's individual rare earths enterprises will also be protected and strengthened.

(4) Geopolitical factors such as relations with Japan

Though China has never officially admitted to using administrative measures to halt rare earths exports to Japan, it is commonly accepted in the international community that during the Sino-Japanese trawler crisis of September 2010, China suspended shipments of rare earths to Japan in protest of Japan's detention of a Chinese fishing trawler's skipper, Zhan Qixiong (詹其雄).

In September 2010, during the Chinese administrative embargo on rare earths exports to Japan, the United States Senate, Subcommittee on Energy, Committee on Energy and Natural Resources held a hearing on rare earths in which China was referred to as a "one-nation OPEC for rare earths". During the hearing, Lisa Murkowski, U.S. senator from Alaska, in a prepared statement, called out China's use of certain minerals (rare earths) as a "weapon to strike back against vulnerable countries who have failed or who are unable to meet their own needs with domestic production", referring to Japan and in extension the United States. David Sandalow, Assistant Secretary, Policy and

International Affairs, Department of Energy, put it this way in his statement during the hearing: "The recent maritime dispute between China and Japan in which there were unconfirmed[53] reports that China threatened or adopted a de facto ban on such exports to Japan underscore the geopolitical risks associated with these issues" ("Rare Earths", 2010).

In a 2011 House Foreign Affairs Committee hearing, the United States government officially described China's actions in September 2010 thus:

> In September 2010, the People's Republic of China shocked the world by halting critical rare earth mineral exports in retaliation to a territorial dispute with Japan in the East China Sea. The Chinese action sent a clear and unmistakable message to Japan and the rest of the world: China is willing to use economic tools to achieve diplomatic goals.
>
> Two months later, when the export ban was lifted, the price of cerium soared from approximately $5 per kilogram before the ban to $67 per kilogram after the ban. The price of neodymium went from $42 per kilogram in April 2010 to $142 per kilogram 3 months after the ban. Then, the price of dysprosium nearly doubled from $250 per kilogram to $400 per kilogram in January 2011.
>
> China's actions against Japan fundamentally transformed the rare earths market for the worse. As a result, manufacturers can no longer expect a steady supply of these elements, and the pricing uncertainty created by this action threatens tens of thousands of American jobs ("China's Monopoly on Rare Earths: Implications for US foreign and security policy").

The outcry in the United States did not only stem from the rare earths price hikes brought about by China's suspension of rare earths exports. The United States, up until September 2010, had been dependent on Japan[54] for the production of rare-earth rich magnets for defense purposes. It was the consideration that in the future, the United

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[53] Reports were unconfirmed at the time.

[54] Also, Japan was heavily dependent on China's supply of rare earths. From 2002 to 2009, China supplied 86.75% of Japan's total rare earths imports. In 2010, even after China's tightening of rare earths exports, Japan imported 82% of its rare earths from China (Sun, 2011).

States would be forced into complete dependence on China—a seemingly less-than-dependable rare earths provider—for these products, that created a degree of alarm in Washington (Bradsher, 2010).

The root cause of China's decision to halt rare earths shipments to Japan has been the object of discussion and debate. Though China's then-Prime Minister Wen Jiabao made a strong statement claiming otherwise[55] [56], many scholars agree with the conclusion of the Congressional hearing report referenced above that China used rare earths as a bargaining chip in a geopolitical-related conflict. It is a well-known fact that China and Japan have been at odds for years over the sovereignty of certain portions of the East China Sea, especially the Diaoyu/Senkaku islands. It was precisely in this disputed location that Mr. Zhan's trawler rammed two Japanese coast guard vessels, eventually resulting in Mr. Zhan being taken into Japanese custody. The holding of the Chinese trawler skipper resulted in major anti-Japan sentiment in China, and even produced anti-Japan protests in cities across the country that could be seen as part of a strengthening sequence of nationalistic anti-Japan protest waves in China over recent years (Reilly, 2013). In this context, the actions of China in placing a temporary halt on exports of rare earths to Japan seem clearly in the realm of the geopolitical, and more than mere coincidence.

Ting & Seaman (2013) call rare earths "the new elements of geopolitical power". In the new age of green high technology, rare earths have become essential to the normal

[55] Wong, Edward; Bradsher, Keith. 2010. "Chinese Leader Denies Using Mineral Exports for Political Ends." *The New York Times*. October 8, 2010. Accessed at http://www.nytimes.com/2010/10/09/world/asia/09china.html?_r=0.

[56] "No discrimination in rare earth supply". 2012. *The People's Daily Online*. Accessed at http://english.peopledaily.com.cn/90778/7719811.html.

functioning of high tech industry as we known it. According to the authors, China's near-monopoly on rare earths has left countries like Japan and South Korea dependent on Chinese rare earths elements and vulnerable to changes in supply from their giant neighbor to the west. In the case of the trawler incident of 2010, Japan and South Korea felt acutely threatened by China's actions, and have since been actively looking for alternative sources of rare earths. From a geopolitical perspective, Ting & Seaman conclude that China's actions as a rare earths near-monopolist have left the region of East Asia less stable, as countries like South Korea and Japan seek to exploit alternative sources[57] to China's rare earths, such as sea-bed mining in the region, which has ignited new potential for conflict over sovereignty.

Thus, the international factor of geopolitical conflict seems to have a significant effect on China's behavior as a rare earths near-monopolist. At the same time, China's actions as a rare earths near-monopolist have also fueled geopolitical conflict, as the limiting of rare earths exports creates volatility in the world rare earths market, thus contributing to a vicious cycle that gives little hope of ending soon.

Similarly, Wübbeke (2013) and Blakely et al. (2011) see China's rare earths-related behavior both being influenced by and influencing the geopolitical scene. On one hand, disputes in the East China Sea have influenced China's behavior, providing opportunity

[57] The Japan Oil, Gas, and Metals National Corporation (JOGMEC), responsible for the security of Japan's rare earths, is constantly searching for new mines across Asia, Africa, and the Americas (Blakely et al., 2011). In addition, on the tail of geopolitical tensions relating to the Diaoyu/Senkaku-fishing trawler-rare earths export administrative embargo issue, in October of 2010, Japan began actively seeking out countries like Vietnam as potential non-Chinese sources of rare earths elements. In a "political and strategic decision", Japan's then-Prime Minister Naoto Kan and his counterpart, Vietnam's Nguyen Tan Dung, arrived at an agreement by which Japan would be allowed to mine for rare earths in Vietnam in exchange for assisting Vietnam develop its nuclear power industry ("Rare Earths Supply Deal Between Japan and Vietnam", 2010).

to use rare earths as a playing card in the geopolitics of the region. While China denies any "politicization" of the rare earths issue, and has cooperated thus far in the WTO deliberations regarding rare earths export restrictions (see chapter 2), simultaneously, China's behavior as a rare earths near-monopolist in applying an unofficial embargo on rare earths exports to Japan during escalation of the Diaoyu/Senkaku conflict indicates a "strategic use of REE in order to achieve political concessions", thus exerting a considerable influence on the geopolitics of the region. Though geopolitical considerations do not seem to be foremost for China's rare earths industry—after all, restrictions on rare earths exports began without any obvious geopolitical motivations—nevertheless, it is one of the international aspects that should be factored in to discussions of China's behavior as a rare earths near-monopolist.

In summary, international rare-earth demand, international rare-earth trade pressure, international rare-earth pricing issues, and international rare-earth-related geopolitical factors each influence and/or are influenced by China's behavior as a near-monopolist of rare earths. Anyone desiring to understand the factors bearing on China's actions as the supreme rare earths producer and exporter, must take into consideration these international factors. In addition, and perhaps more importantly, domestic factors also have a serious affect on China's behavior as a near-monopolist of rare earths. After all, it was domestic influences that, to a large degree, facilitated China's rise to near-monopolist status during the late 1980s and 1990s, at a time when heavenly, earthly, and human factors (天时地利人和) worked in harmony to catapult China into position as the world's foremost rare earths producer and exporter. It is these domestic factors, touched on in Chapter 2, to which we turn to in more detail in the next chapter.

CHAPTER 4: DOMESTIC FACTORS INFLUENCING CHINA'S BEHAVIOR AS NEAR-MONOPOLIST OF RARE EARTHS

Introduction

In Chapter 3, we examined international factors affecting and motivating China's behavior as a near-monopolist of rare earths. In the current chapter, I will seek to review, based on the current literature, the domestic factors influencing China's behavior as rare earths near-monopolist.

It is worthy of note that the factors to be discussed in this chapter are similar to those in Chapter 2. In Chapter 2, we discussed factors that contributed to China becoming the supreme rare earths producer. Ironically, many of these same factors have now become reasons behind China's restrictions on rare earths production and export, and the overall framework of state leadership of the rare earths industry is emphasized again. The domestic factors leading to and influencing China's behavior as a near-monopolist of rare earths include: (1) Environmental protection; (2) rare earth resource protection; (3) strengthening rare earths industry regulation; and (4) protecting and aiding China's domestic rare earths industry.

Each of the four domestic factors listed above can be seen as policies implemented by the Chinese Central Government. Just as China strongly supported the development of its rare earths industry as part of a nation-wide economic renaissance known to the rest of the world as the "Reform and Opening Up", in recent years the Central Government has placed priority on cleaning up the environmental mess caused by its domestic rare earths industry, and regulating the disorderly operations of the industry.

Each of the factors discussed in the current chapter exist only under the guiding and watchful eye of Beijing's top party officials and legislators: each factor a tool in the chest of a master, tools by which an industry is re-invented.

(1) Environmental Protection

China has climbed its way to the top of the rare earths pyramid, partly based on its objective inherent advantages, e.g. considerable exploitable rare earths resources; and partly based on a wide range of human factors. The first human factor to consider is lax environmental protection. It is a well-known fact in the mining industry that rare earths extraction takes a serious toll on the wellbeing of earth's natural environment (see Chapter 2). It was China's lack of environmental protection that allowed an inordinate amount of cheap, destructive mining practices to flourish during the 1990s and into the 2000s, giving China a production advantage over countries like the United States, whose environmental policies made rare earths production a more expensive pursuit.

During the writing of this thesis, a pollution documentary entitled "Under the Dome" (《穹顶之下》), by Chai Jing 柴静, a famous Chinese journalist, took China by storm, with hundreds of millions of views by an audience for the most part locked in the grip of a smog nightmare from which China is only now seeming to be slowly awakening (Kuhn, 2015). Air quality is just one aspect of the environment that is affected by China's pell-mell sprint toward "modernity". Water and ground pollution are also major concerns, and rare earths contribute to the pollution of them all. In China, serious environmental protection seems to be a fairly new idea having emerged within the last few years, and gaining greater ground as "the country's basic policy" only recently in 2014. Chinese

Premier Li Keqiang, in an annual parliamentary meeting in March 2014, said that China would "resolutely declare war on pollution as [it] declared war on poverty" (Kaiman, 2014). But new as it may be, the greater push for environmental protection is indeed a domestic factor directly influencing China's behavior as a near-monopolist of rare earths. While the degree to which environmental protection in China is being implemented is questionable (Ibid), the fact that China has made a conscious and specific effort to clean up its rare earths industry for environmental protection purposes, cannot be ignored.

According to the "basic principles" (基本原则) section of a 2011 State Council directive regarding the healthy development of the rare earths industry, environmental protection was a top priority for China's Central Government: "Basic principles. To persevere in *environmental protection* and resource conservation, implementing stricter policies in regard to protective exploitation of rare earths resources and putting into place more stringent ecological *environmental protection* standards"[58] (emphasis mine). The idea of environmental protection is mentioned 11 times in the State Council directive, emphasizing the importance the Chinese Central Government has attached to rare-earths-related environmental issues ("Guowuyuan Guanyu Cujin Xitu Hangye Chixu Jiankang Fazhan De Ruogan Yijian").

The State Council directive was based on another legal document previously published in January 2011 by the Ministry of Environmental Protection and the General Administration of Quality Supervision, Inspection and Quarantine (中华人民共和国国家质量监督检验检疫总局). The document, entitled "Emission Standard of Pollutants

[58] In the original Chinese: "基本原则。坚持保护环境和节约资源，对稀土资源实施更为严格的保护性开采政策和生态环境保护标准".

for Rare Earths Industry" (《稀土工业污染物排放标准》), outlined more stringent emissions standards for pollutants than had been previously been set under general environmental protection laws.

Of course, it could be argued that by 2011, China had the luxury to make environmental protection a priority; after all, China had already climbed to the position of near-monopolist of rare earths. Just in the previous year, 2010, China had already flexed its rare earths muscles in the midst of a diplomatic spat with Japan, administratively denying rare earths exports to Japan until Japan had released the Chinese fishing trawler skipper who had been held in Japanese custody after his trawler had rammed two Japanese coast guard boats in September of that year (see Chapter 3). Thus, for China to make official statements in 2011 about mitigating environmental damage caused by rare earths mining through protective measures prescribed by law which had a direct effect on rare earths exports to rare-earth-dependent countries, the environmental protection rhetoric could have seemed less than believable to observers outside of China. Why did such official direction not come twenty years earlier, when China was destroying the environment on its way to rare earths dominance?

Environmental protection is closely connected with the consolidation of China's rare earths industry. Small scale, large number, low technological capacity, and regulation difficulty are the main reasons behind rare-earths-related environmental degradation and resource waste. From this perspective, larger corporations are usually more environmentally responsible and easier for the government to regulate. Therefore, some authors (Wu & Miao, 2012) suggest a greater consolidation of the rare earths industry, a process that has so far created six large conglomerates and is continuing as of the writing of this thesis (Shen, 2014).

Chinese government policies regarding rare earths have become directly connected to environmental protection. This fact reflects the Chinese government's official position that seeks to realize the sustainable development of the rare earths industry through control of China's rare-earths production excess. Zhu Hongren (朱宏任), the Chief Engineer at the Ministry of Industry and Information Technology of the People's Republic of China (中华人民共和国工业和信息化部), cites the following problems in China's production of rare earths: (1) unconstrained development, (2) resource waste, and (3) serious environmental pollution. A comprehensive consideration of a host of factors including China's economic development and environmental protection lead Mr. Zhu to the following conclusion: China must restrict rare earths exports. Chen Deming (陈德铭), Minister of the Ministry of Commerce of the People's Republic of China (中华人民共和国商务部) from 2007 to 2013, made the following statement: "China's restrictions on the rare earths industry are necessary measures based on the needs posed by environmental protection"[59] (Yang, 2011).

China constantly points to environmental protection to justify its behavior relating to rare earths. Cheng & Che (2010) hold that environmental protection should top the list of China's rare earths priorities, if sustainable development is to be realized.[60] In the

[59] In Chinese: "中国限制稀土产业不得已而为之，主要是出于环境保护的需要".

[60] In Chinese: "要合理规范资源利用总量和开发力度，加强科研与管理，提高资源得综合利用率；加强三废治理，保护环境，实现人与自然的协调发展。稀土产业必须贯彻环保第一的原则，才能够实现可持续发展".

recent WTO case, as China was accused of breaking WTO rules with regard to rare earths export taxes, export quotas, and qualifications for rare earths exporters, China's response to the accusations included a critical reason behind rare earths export restrictions: environmental protection. After US president Barack Obama announced the filing of a complaint with the WTO in March, 2012, China was quick to respond as to the reasons behind its restrictions of rare earths exports. On March 13, 2012, Liu Weimin, spokesperson for the Ministry of Foreign Affairs of the People's Republic of China made China's position clear in his regular press conference. The question was posed: "It is reported that China's restriction on the export of rare earth and other high-tech raw materials impairs the interests of US enterprises. The US side will file a complaint with the WTO on that. How does China respond?" Liu Weimin replied:

> Rare earth is scarce and nonrenewable. The exploitation of rare earth will exert impact on the *environment*. *In order to protect* the resources and *environment* and realize sustainable development, the Chinese Government adopts management measures not only on rare earth export, but also on its mining and production. Relevant measures meet WTO rules. China's reserves of rare earth take up 36.4% of the world's total. However, China has been supplying over 90% of the world's demand of rare earth. Over the years, China has been striving to maintain a considerable amount of rare earth export, *despite enormous environmental pressure*.
>
> China will continue to provide rare earth to the international market and carry out effective management of rare earth export in accordance with WTO rules. China hopes that other countries endowed with rare earth resources will engage actively in rare earth development and jointly shoulder the responsibility of global rare earth supply. China would also like to enhance cooperation with other countries on searching substitute resources and improving the utilization of rare earth ("Foreign Ministry Spokesperson Liu Weimin's Regular Press Conference on March 13, 2012", 2012, emphasis mine; grammatical mistakes in official translation).

From an examination of Liu's statement, according to the Chinese government, the connection between China's actions as a near-monopolist of rare earths and environmental protection is solid. The connection is drawn between environmental protection and three phases of management: rare earths mining, production, and export. According to the Chinese government, it is with the two-fold goal of environmental protection and resource protection, that China has been restricting mining, production, and exports. The United States, Japan, and the EU did not accept China's explanation, further accusing China of using environmental protection as a smokescreen for increasing the international market price of rare earths while preserving low rare earths prices domestically. China's appeal to environmental protection was eventually dismissed, and the WTO case ended in defeat for China. In a scholarly paper reviewing the legal matters associated with the 2012 WTO rare earths case, Zhang (2012) makes the following suggestion to China's lawmakers:

> Begin taxing rare earths resources as quickly as possible. With regard to the export of natural resources, China has implemented the following policies, all of which have had noticeable results in controlling the trade direction of these exhaustible resources: export taxes, export quotas, export qualifications, and low price limits, etc. All such policies are both easy to implement and low in cost. *In fact, regardless of whether these exhaustible resources are exported or consumed domestically, their mining and production cause the same amount of environmental pollution*. Therefore, it is imperative that China learns from the environmental protection and resource conservation practices of developed countries, and under the condition of complying with WTO regulations, regulate the export of rare earths (emphasis mine).

Though some may consider Zhang's suggestions outdated after the August 2014 WTO decision against China's rare earths export restrictions, nevertheless, it underlines the fact that environmental concerns are high on the list of reasons behind controlling China's rare earths exports.

Li & Xu (2014) make a direct connection between environmental protection and restrictions on rare earths exports: First, China has two major policy goals with regard to rare earths management: resource protection and environmental protection. A *desire* to protect the environment is one of the main motivators, and *actually* protecting the environment is one of the main goals of China's rare earths policies. According to Li & Xu, management of rare earths includes two very important aspects, which were discussed briefly in Chapter 3: (1) rare earths export restrictions and (2) rare earths production controls. The authors are of the opinion that the former will most likely be cancelled, in light of the WTO decision against China's rare earths exports restrictions, but that the latter is a possibility for protecting the environment and pleasing the WTO simultaneously. By December, 2014, China had not made any significant changes to its rare earth export taxes and export quotas in the "Tariff Execution Plan 2015" (《2015 年关税实施方案》), released by the Customs Tariff Commission of the State Council (国务院关税税则委员会) on December 16, 2014 ("Xitu Chukou Guanshui Quxiao Yuqi Luokong", 2014), although changes are expected by mid-2015 ("Yenei: Xitu Chukou Guanshui Mingnian Quxiao Duoxiang Xinzheng Tiaokong Ziyuan", 2014). Then, on January 1, 2015, the Chinese government announced to the world that export quotas for rare earths had been cancelled as of that date, and that export taxes on rare earths would see changes in May 2015 (Yap, 2015; Shen, 2015).

(2) Rare Earth Resource Protection

According to the 2012 statement by Foreign Ministry Spokesperson Liu Weimin above, rare earths management measures including restrictions on mining, production, and exports have been implemented for one of two goals: environmental protection and resource protection. Resource protection as a motivating factor for China's behavior as a near-monopolist of rare earths is well-supported in the extant literature.

Cheng & Che (2010) present a sweeping overview of the current (at the time) mining situation and future potential of China's rare earths industry. While identifying several serious industry problems, including resource wastefulness, illegal mining, and environmental problems, the second most important suggestion for the future of China's rare earths industry was resource protection: "[China should] standardize the mining order, strengthen *resource protection*, mine in a reasonable manner, and increase the utilization efficiency of resources…Our country should implement national *protective* policies with regard to the mining of rare earths, and put an end to production or cancel mining rights for offenders" (emphasis mine).

In her discussion of the 2012 WTO case, Zhang (2012) gives two specific suggestions to the Chinese government. First, the Foreign Trade Law of the People's Republic of China (《中华人民共和国对外贸易法》), revised last in 2004, should be updated to take into account for WTO regulations and changes in the world rare earths market. The crux of the issue lies in rare earths resource protection. China's Foreign Trade Law allows for completely halting foreign trade of exhaustible resources for the purpose of resource protection, whereas the WTO at most allows for restrictions on exports for exhaustible resources, and that under one condition, namely that domestic measures also be taken to restrict the production and consumption of the said exhaustible resources. Putting aside the issue of China's domestic laws being at odds with WTO regulations, Zhang's obvious point is that all restrictions—whether domestic or international—on the production or export of rare earths, exist for the purpose of rare earths resource protection.

Second, Zhang suggests that the Chinese government issue a "Law for the Protection of Rare Mineral Resources" (《稀有矿产资源保障法》). Her argument is straightforward: there are several laws which indirectly protect rare earths resources,[61] but no law that exists solely for their protection. According to the article, China has about 30% of the world's rare earths resources, and is a "great power of rare earth resources in the world" (全球稀土资源大国) when compared to other countries with rare earths reserves, such as the United States, Russia, Canada, India, etc. Nevertheless, as the demand for rare earths continues to rise, the world's reserves are being steadily depleted, with some places nearing complete resource exhaustion. Thus, according to Zhang, the time has come for China to pass legislation for the protection of rare earths, if China hopes to realize the sustainable development of these exhaustible resources.

In an August, 2010 *Rare Earth Information* article, the author gives one of the strongest stances possible on rare earths resource protection and exports. "[China] must gradually decrease or terminate rare earths exports. Along with the speedy development of China's national economy, and the continual increase in research and development of new materials and new energy resources, the demand for rare earths will increase tremendously, and it will be very difficult to satisfy the needs of China's development [merely] from China's [own] rare earths reserves. Therefore, we must resolutely protect

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[61] These laws include the *Criminal Law of the People's Republic of China* (《中华人民共和国刑法》); *Mineral Resources Law of the People's Republic of China* (《中华人民共和国矿产资源法》); and *Provisional Measures on Administration of Survey and Extraction of Specific Types of Minerals for Protected Mining* (《保护性开采的特定矿种勘查开采管理暂行办法》).

our national interests and hold up under the pressure of Western developed countries by strictly controlling rare earths export quotas, and reducing them year on year" ("Zenmeyang Bian 'Xitu Daguo' Wei 'Xitu Qiangguo' ", 2010).

The suggestions of the previous article came at a time when China's new-found restrictive power over rare earths exports was at a strong point, just before the Diaoyu/Senkaku fishing trawler incident of September 2010. In contrast, the tone of policy suggestions in recent scholarly publications such as Li & Xu (2014) is much less aggressive with regard to export restrictions, in light of the recent WTO rare earths case. Regardless of these differences in tone and aggressiveness, the overall conclusion remains the same: the solution for the conservation and protection of China's rare earths resources is through restrictions on exports or on production: "if restrictions are not imposed on the development and usage [of rare earths], [these] resources will be prematurely exhausted" (Yang, 2011).

In his 2011 article, Yang gives a series of suggestions for China's rare earths industry, the first of which being resource protection, along with consolidation of the domestic rare earths industry and the strengthening of the creativity and technological expertise of the same. Resource protection could be seen as part of China's defensive strategy, while industry consolidation and technological advancement could be seen as part of China's offensive strategy.

In Wübbeke's 2013 overview of China's rare earth policies and narratives for reinventing the rare earths industry, a similar picture to that outlined in the Chinese-language literature is presented in English. Wübbeke examines China's current situation and future plans regarding the rare earths industry, and calls the environmental-resource-protection plan the “green narrative”. He highlights how the Chinese government named rare earths “special resource[s] for protected extraction” in 1991, but did not actually start to emphasize the need for resource protection until the end of that decade, after ever-increasing production and exports of rare earths during the 1990s.

A 2005 report by 15 scientists from the Chinese Academy of Sciences rang the warning bell for China’s rare earths industry, gaining the attention of top leaders like Wen Jiabao. In the report, attention was called to the low return rate of REE mined at the Bayan Obo mine in Inner Mongolia, the waste of resources, and the possibility that the east pit at Bayan Obo could be exhausted within 35 years, if the current rate of extraction continued. Xu Guangxian, “China’s Father of Rare Earths” estimated that the southern rare earths deposits could be exhausted within ten years. Though some alarmists called for the complete closure of the Bayan Obo mine, China’s leaders have opted for a middle-of-the-road approach to rare earths resources protection that includes restrictions, but not complete closure (Wübbeke, 2013).

Hurst (2010) makes the following summary of China’s recent actions as a rare-earths near-monopolist as related to resource protection: “In an effort to try to protect its resources, the Chinese government has been clamping down on its domestic industry in several ways, including: restricting export quotas on rare earth elements…Of most concern to the international community, China has been restricting export quotas in order to have enough resources for its own industries and to regain control over its domestic operations.”

Finally, Blakely et al. (2011) analyze China’s rationale behind its export restrictions. Though the authors mention “Save REM for future generations” as one of

China’s rationales, they are not convinced by China’s argument and so they claim that the idea of resource protection, while it could apply to other natural resources, should not apply to rare earths. The reasoning is as follows: “Despite their name, rare earth metals are relatively abundant, especially in China. The primary difficulty with REMs is extracting them, which is technically complex and environmentally degrading, but not in finding deposits”. In other words, the logic here is that if China plans to protect its rare earths resources based on scarcity, the argument does not hold water, because China’s rare earths are fairly abundant, though they may not be economically viable to mine. This opinion seems out of harmony with the general view presented regarding China’s rare earths resources protection, but nevertheless represents the view of a small minority.

(3) Strengthening Rare Earths Industry Regulation

A central problem faced by China’s rare earths industry is irresponsible and illegal mining, as well as export-restriction evasion and smuggling, etc. Recent restrictions on the trade of rare earths and China’s over-all behavior with regard to its rare earths industry cannot be disconnected from China’s push to increase regulatory measures on the industry.

Regulatory measures are usually referred to under the broad umbrella term of “industry management” (产业管理). Sun (2011) described the disorderly situation in the rare earths industry. The disarray included (1) long-term above-quota production (超指标生产) by Chinese rare earths enterprises; (2) inappropriate arrangements for export quotas and weighting, leading to competition for the lowest selling price and serious reselling of quotas for higher prices; (3) export quota evasion (playing the system) by foreign enterprises; and (4) rampant smuggling by a complete underground network by which 20,000 to 30,000 tons of rare earths per year were smuggled out of China from 2006 to 2009 using names like “iron ore”, “marble”, “cleanser”, and “lime powder”, etc.

Sun (2011) reminds readers that beginning in 2006, China increased its efforts at re-ordering the poorly-regulated rare earths industry. The first item on the agenda in 2006 was the change of government directives from “guidance-oriented” (指导性) to “command-oriented” (指令性). The new command-oriented directives included the implementation of production restrictions and export taxes. The Chinese government also released several new rare-earths-related policies and directives, including industry entrance qualification requirements and pollution requirements.

In 2006, the Ministry of Land and Resources of the People’s Republic of China, along with other government bodies, declared the decision to cease from offering new rare earths mining licenses, and the rare earths mining quota was decreased by 20%. Also in the same year, export taxes on rare earths products and chemical compounds increased by 10%, and 41 types of rare earths metal, alloy, ore, and salt products were added to a list of items prohibited for export; and the number of government-approved rare earths exporters fell from 47 to 39.

In 2007, taxes on exports of rare earths concentrates increased from 10% to 15%, whereas rare earths metals were taxed at 10%. During the same year, the Chinese government restricted foreign enterprises’ ability to invest in rare earths smelting and separation (restricted to joint ventures and cooperation), while banning foreign enterprises from rare earths exploration, mining, and mineral processing. During 2008, the overall quota for rare earths exports fell by 21%, while export taxes for yttrium, europium, dysprosium, and terbium increased to 25%, with export taxes for other types of rare earths products growing to 15%. In 2009, twelve government ministries and departments including the Ministry of Industry and Information Technology, the Ministry of Public Security, and the Ministry of Finance formed the Rare Metals Inter-ministerial Coordination Mechanism (稀有金属部际协调机制). During 2010 and early 2011 (Sun's analysis runs through February 2011), directives and regulations from China's Central Government seemed to come with greater frequency than between 2006 and 2009. In May, 2010, the Ministry of Industry and Information Technology issued its "Requirements for Entrance into the Rare Earths Industry" (《稀土行业准入条件》), detailing rules and regulations for layout conditions, production scale, techniques and equipment, energy consumption, comprehensive resource utilization, environmental protection, product quality, production safety, etc.

Sun concludes that while China has put in place a large amount of rare earth legislation since 2006 in hopes of regulating the disorderly industry, it is far from bringing the rare earths industry under control. In 2010, after nearly four years of new legislation, implementation continued to be the greatest challenge facing China's rare earths industry. For example, China's rare earths export quota for 2010 was 30,258 tons, but in actuality, 39,813 tons of rare earths were exported, outshooting the quota by 31.58%. Sun finishes his argument with several policy suggestions, one of which is similar to Zhang above: China should create new legislation entitled "Protection Law for Rare Earths Resources" (《稀土资源保障法》).

Yan, An & Hao (2011) analyze the existing regulation problems in China's rare earths industry from the perspective of sustainable development. The authors point to the disorderly production practices of some rare earths enterprises that have led to an imbalance between production and selling. Also, the authors see larger problems on a national scale in the regulation and management of the entire rare earths industry: (1) The rare earths industry is lacking an effective market economy management system. This refers to problems such as multi-headed management and turf wars; as well as overlapping, decentralized, and inefficient administrative functions. (2) Rare earths production enterprises engage in disorderly competition, without effective market management. Price wars between rare earths producers have given the government a significant challenge, and there has been resistance within the rare earths industry. (3) Export practices are in disarray and disorder, and regulation is in need of being strengthened. This is the crux of the matter, as, according to Yan et al., if it were not for the lack of proper export tax and quota control, China would not be losing such a great amount of valuable rare earths resources.

In conclusion, Yan et al. claim that the main reason behind the lack of motivation seen in China's rare earths enterprises is lack of industry management, regulation, and integration. In simple terms, if China can put its rare earths house in order domestically (including mining, production, and export regulations), it will be able to "stand united" in its competition against international rare earths players. If higher levels of regulation and enforcement can be realized in China's rare earths industry, perhaps it can accomplish the protection and sustainable use of China's rare earths. From this argument, it is evident that China's domestic obsession with whipping its rare earths industry into shape comes from the ultimate motivation to strengthen its place as the rare earths near-monopolist in the world market. Also, China's behavior in restricting production and/or exports of rare earths is seen by the industry as an integral part of the overall push by the Chinese government to rectify industry problems and improve management effectiveness and efficiency for the industry.

(4) Protecting and Aiding China's Domestic Rare Earths Industry

Another domestic factor leading to and influencing China's behavior as a near-monopolist of rare earths is the protection and aiding of China's own rare earths industry. This factor, though not as noticeable in China's rhetoric, nevertheless is an important motivator, especially in the export realm. China's restrictions on exports, including export taxes, export quotas, and qualification restrictions for enterprises engaging in the export of rare earths, all contribute to a two-tiered pricing system, with domestic prices lower than export prices (Hayes-Labruto et al., 2013). This is precisely what the United States, Japan, and the European Union protested in the recently decided WTO case. In the eyes of the US, Japan, and the EU, China's simultaneous use of the three-pronged restrictive policies mentioned above increased costs, decreased supply, and made it more difficult in general to export rare earths out of China, all at a time when the world demand for rare earths continued to increase. Chinese-language literature rarely acknowledges the desire of the Chinese government to give pricing advantage to domestic rare earths producers, whereas this point is a major complaint found in the English-language literature.

In fact, when it comes to protecting domestic industry either in China or the rest of the world, both Chinese scholarship and scholarship outside of China tend to play the victim. On the Chinese side, researchers tend to paint the picture that China's rare earths production and exports continue to expand, while prices continue to drop, and China is stuck in a position where the "price-setting authority" is held by "developed countries", and thereby China is left with increasingly depleted resources and a lack of say in international pricing for rare earths (Yan et al., 2011).

From the English-language literature, research seems to support a different story, in which China's taxes on exports have created difficulties for foreign companies who have been accustomed to consistently importing, and in some cases almost 100% dependent on China's cheap rare earths. In addition, export quotas have also frustrated international buyers, especially when it has seemed that while quotas have been enforced on China's foreign exports of rare earths, domestic rare earth consumption in China has not suffered. In other words, China's rare earths market has played favorites in its export policies. Of course, this was one of the main complaints of the US, Japan, and the EU in the recent WTO case. Also, with regard to China's export taxes and export quotas on rare earths, another concern brought up in the English-language literature is the Chinese tactic of using export taxes and export quotas to attract foreign rare earths enterprises to move operations to China, especially research and development operations. Western researchers have noted that manufacturers which move operations to China can easily side-step China's export quota restrictions, as export restrictions only apply to raw materials, not finished products (Hayes-Labruto et al., 2013). The obvious fear is that China will, through various means, obtain trade secrets and key technologies from foreign companies which are lured into the “dragon’s lair” by lower rare earths prices and less-severe export restrictions.

In Hayes-Labruto et al. (2013), the rare earths issue is discussed from a China vs. the Rest of the World (ROW) perspective. From the viewpoint of the ROW, the authors bring several “accusations” against China, including the use of rare earths as a geopolitical weapon, as discussed briefly in Chapter 3. The authors also highlight China’s protection of its own domestic rare earths industry by which an “unfair competitive advantage” is created on the side of China. Through export taxes, China raised the prices for certain rare earths by as much as 850%. However, it is informative to note that the increase in prices for certain rare earths elements (neodymium, praseodymium, europium, dysprosium, and terbium oxides) were the same within and without China, while for others, prices for export were considerably higher (samarium, cerium, and lanthanum).

Along the same vein, Hayes-Labruto et al. make the following statement regarding the result of the protection of China’s domestic rare earths industry, namely the aiding of that same industry by attracting foreign investment[62]: “China’s de facto monopoly position and the creation of price differences is often interpreted as ‘an attempt to capture more rents along the value chain’ because companies that require REE inputs are forced to move their operations to China ‘to benefit from a steady and affordable supply of rare earths’ ”.

The obvious rift in interpretations of China’s behavior as a near-monopolist of rare earths underlines the general phenomenon of mistrust between China and the rest of

[62] As of 2012, $960 million had been invested by the United States, Germany, France, Japan, and Canada into China’s rare earths industry, indicating China’s strategy to attract foreign investment had been successful (Hayes-Labruto et al., 2013).

the world. As recent US Congressional research put it, China's behavior is for the sole purpose of benefiting its downstream rare earths industry at the expense of the defense and commercial industries of other countries (Morrison & Tang, 2012). On the Chinese side, issues are seen differently, and the rift of mistrust is called by its name (Hayes-Labruto et al. 2013).

In summary, China's behavior as a near-monopolist of rare earths has many domestic motivating factors, the most prominent among them being environmental protection, resources protection, industry regulation, and the protection of domestic industry. These factors, taken in conjunction with the international factors discussed in Chapter 3, and in the overall context of the guidance and support of the "omnipresent" state, paint a two-fold picture of the factors influencing China's behavior as a rare earths near-monopolist, especially in the realm of production and export restriction. In the following chapter, discussion will focus on a synthetic understanding of the state of China's behavior as a near-monopolist of rare earths, ultimately in the context of the direction and protection of the policies of China's Central Government.

CHAPTER 5: TOWARD A SYNTHETIC UNDERSTANDING OF INTERNATIONAL AND DOMESTIC FACTORS INFLUENCING CHINA'S BEHAVIOR AS A NEAR-MONOPOLIST OF RARE EARTHS

Introduction

Thus far, I have shown how China became a near-monopolist of rare earths, primarily through (1) Government support and guidance of the domestic rare earths industry; (2) lack of or disregard for environmental regulations regarding the production of rare earths; (3) illegal and/or unregulated production; and (4) relatively low cost of rare earths production in China compared to the rest of the world.

I have also examined the preeminent international and domestic factors influencing China's behavior as a near-monopolist of rare earths. International factors include (1) international demand for rare earths in the context of lower rare earths production outside of China; (2) international pressure on China to conform to certain trade regulations; (3) international "price-setting authority" issues on the part of China; (4) geopolitical factors such as the condition of relations with Japan, etc.

Domestic factors that exert influence over China's rare earths-related behavior are: (1) Environmental protection; (2) rare earth resource protection; (3) strengthening rare earths industry regulation; and (4) protecting and aiding China's domestic rare earths industry. Domestic motivations behind China's behavior as a near-monopolist of rare earths have, in many cases, been overlooked by Western researchers, who tend to emphasize the threat posed by China's international motivators, such as controlling prices and utilizing the "geopolitical weapon" side of rare earths for its own advantage.

In the current chapter, I will attempt to arrive at a synthetic understanding of the two-sided coin of China's rare earths behavior motivation in the overarching context of state guidance. In the current literature—both in Chinese and English—there has been a significant lack of scholarship analyzing China's rare earths behavior from an international-domestic integrated perspective. In my opinion, to understand China's world-affecting behavior with regard to rare earths, sufficient and symmetrical weight must be given to all possible influential factors. Focusing attention on one side of the coin will yield, at best, only half an explanation.

Hayes-Labruto et al. (2013) analyze China's rare earths policy from two perspectives—China's own perspective and that of the rest of the world (ROW). The authors "investigate whether China's rare earth policy could be understood as a socially responsible strategy that balances environmental, social and economic needs catalyzed by stakeholders or whether it is a strictly economic, resource-nationalist strategy driven by China's current dominance in rare earth elements". The paper employs the "China Inc." metaphor, designating the ROW as the dependent stakeholder, and offers suggestions as to how to increase salience, thus strategically adapting to and partially overcoming China Inc.'s dominant position.

The reasoning behind an "us vs. them" comparison is not without its validity, and it is common to see such issues through a "polarized" lens. Even though Hayes-Labruto et al. attempt to see both sides of the China vs. ROW argument, the conclusion of the paper points to ways by which the ROW may overcome (if only partially) China's domination of the rare earths market. It could be deduced that if the goal of research is to give greater advantage to a certain "side" of an economic struggle, lack of research objectivity is a possibility. Whereas, if one aims to take an unbiased perspective on the issues, and identifies the factors influencing China's actions as a rare earths near-monopolist, with the research goal of arriving at an integrative synthetic understanding of which factors play decisive roles in China's behavior, perhaps a more balanced perspective could be reached, which could be beneficial to a multiplicity of global rare earths actors.

The purpose of the following synthetic treatment of the international and domestic factors influencing China's behavior as a near-monopolist of rare earths is to present a more well-rounded, integrated understanding of the foresaid factors. The current literature on the topic tends to see China's near-monopoly on rare earths either as a threat to the world at large, or as an objective fact that calls for better resource management in China and the rest of the world. The proposed purpose of this thesis is an integration of the two views from the international-domestic factor perspective. In other words, instead of taking an "us vs. them" approach, I propose an objective synthesis of all possible factors, both international and domestic, that influence China's rare earths supremacy.

International Factors

A. Demand. From the late 1990s, the demand on China's rare earths industry increased as rare earths operations around the world cut or halted production. Of course, it could be argued that it was the flooding of the world market with cheap Chinese rare earths elements in the first place during the 1990s that caused considerable price drops, which in turn drove many extra-Sino producers out of the market. Regardless, the objective fact that rare earths production around the world slumped in the late 1990s to early 2000s, in conjunction with growing production figures in China (see Chapter 1) created significant opportunities for China to establish itself in its position as the near-monopolist of rare earths.

While world demand for rare earths was high, China's production was even higher during the 1990s-2000s. As China's overproduction in relation to world demand continued, rare earths prices stayed relatively low, further exacerbating the situation for rare earths producers outside of China, and increasing China's hold on the market. It was the fact that China could provide the world with the cheapest rare earths elements and products, in conjunction with increased demand from the rest of the world, that constituted to the fundamental nature of China's near-monopoly.

In this example, it is evident that a combination of one major international factor (demand) with the context of China's domestic situation (cheap supply), directly influenced the near-monopoly situation. This scenario is not new, as China has gained a reputation as the "World's Factory" over the last thirty years as a result of it Reform and Opening-up Policy (改革开放政策), strategically placing itself in the position of the world's largest, most economical producer of consumer goods, based on its strategic advantages of lower wages, a well-rounded business ecosystem, lesser compliance with various labor and environmental restrictions, less taxes on exports, and an artificially depressed currency (Bajpai, 2014). The bottom line is, China is a master of supply and demand, and in the case of rare earths, it adds one more key strategic advantage to the list: resource abundance.

With regard to rare earths, China views its status as the largest producer with both self-congratulation and trepidation—self-congratulatory in that China is sure of its advantages, and desires to make full use of China's status with regard to rare earths; and fearful that the demand—both domestic, and from other nations—will lead to a real depletion of its rare earths resources.[63] All in all, China has largely been on the benefiting end of the rare-earths supply-demand relationship.

B. Trade Pressure. China's entrance into the WTO was welcomed by many domestically and around the world. Closer ties and promises of fair trade with the world were applauded (Shirk, 2008). By the time China had acceded to the WTO, it was already

[63] This is not the first time in history that China has been wary of its being taken advantage of. Historically, trade relations with foreign nations have been a source of conflict. China has been intertwined in trade relations with greater Asia and other parts of the World since at least the Han dynasty (Adshead, 2000). During the Tang dynasty, Sino-foreign trade flourished during the first two hundred years of the rule of the house of Li; but near the end of that fabled era, foreigners and foreign trade were ousted from one of China's greatest trading cities, Guangzhou (Ibid). By the end of the last Chinese imperial dynasty, the Qing (1644-1912) China had become a self-absorbed, self-centered power with little desire to communicate with the outside world. During the late 1700s and early 1800s, however, as opium smoking became increasingly popular among China's vast population, the opportunity to open up the door of trade with China presented itself to certain opportunist individuals from the British empire (Brook & Wakabayashi, 2000), who began importing opium into mainland China, primarily through the southern port city of Canton (Guangzhou). The Chinese government had issued a ban on opium smoking many years earlier, to little avail. Finally, the Qing government sent Lin Zexu (林则徐), a powerful official, to deal with the opium issue. His treatment of the matter, though valiant, ended in failure, as the British subdued Chinese forces with superior fire-power. As a result of the First Opium War (and the Second Opium war that followed), the door to trade with China was officially "cannon-blasted" open, and ports in the cities of Guangzhou, Xiamen, Fuzhou, Ningbo, Shanghai, etc. were opened to foreign trade. What followed the First Opium War was known as the "Hundred Years of Humiliation" (百年耻辱), ending with the establishment of the People's Republic of China (PRC) under the leadership of Mao Zedong in October 1949. In the years following the birth of the PRC, China's foreign trade was less than blossoming, until the Reform and Opening era began in the late 1970s-early 1980s. What has happened in the more than thirty years since the adoption of a more open foreign trade policy has changed China and the world. After gaining traction for more than two decades of manufacturing and trade, China entered the World Trade Organization in late 2001. With greater opportunity, comes greater responsibility, and more than once, trade disputes through the WTO have blamed China for breaking rules of fair trade within the framework of WTO guidelines. Though China has a long history of foreign trade, as with anything, current trade issues are more easily influenced by recent events and viewpoints, as opposed to older ones. Yet in the case of China, the Hundred Years of Humiliation has deeply influenced the Chinese national psyche, even to this day. In the 5,000-year river that is Chinese history, the era of humiliation is fresh in memory. The result is, at the least severe, a distrust of foreigners and foreign companies or governments; and at the most severe, rabid nationalism and xenophobia (Wang, 2012).

the near-monopolist of rare earths. World demand for and booming production of cheap rare earths in China continued to guarantee China's position at the "top of the pile". But as China increased restrictions on exports, and especially after the 2010 unofficial embargo on rare earths exports to Japan, China had reason once again to be leery of greedy foreign interests, just as the rest of the world became increasingly less trustful of the motivations behind China's actions. The WTO case battled out between the US, Japan, and the EU against China ended in a defeat for China, effectively silencing some hot-headed voices of trade restriction within China, but by no means ending the ongoing debate about how to protect China's rare earths resources and natural environment.

A reading of the Chinese language media and scholarly publications reveals the tremendous pressure that China felt internationally with regard to rare earths trade around the time of the WTO case. A group of articles published in the *People's Daily* entitled "The United States, Japan, and the European Union Unite in Putting Pressure on China's Rare Earths Exports", includes an article by the title "Rare Earths Case Reveals the Insatiable Face of the West Scrambling For Resources".[64] The article summarizes the Chinese perspective on the pressure on rare earths exports restrictions:

> When protecting their own economic interests, the United States and Europe are accustomed to using double standards. The protective trade measures of some countries are dual in nature: in regard to items that the country does not lack, it closes its market to China, robbing China of a place to sell its goods; and those things which they lack, they force China to sell. There was nothing wrong with China managing and controlling the rare earths market, but since this increased the import costs for Western countries, the West said, "This is not going to work". They have the voice of influence on the matter, and are able to turn bad into good with mere words. The bottom line is, the result must be in harmony with their interests ("Mei Ri Ou Lianshou Shiya Zhongguo Xitu Chukou", 2012).

[64] In Chinese: 稀土官司暴露了西方欲壑难平哄抢资源的嘴脸.

An article from Hong Kong's Wenwei Po (《文匯報》) titled "China Levels Strict Controls on Rare Earths: Going In for the Long-haul in the Lawsuit with the European Union, America, and Japan" records part of an interview with an anonymous industry expert, who, at the time (July 23, 2012) expressed that China was under a great amount of pressure over the issue of whether or not China's rare earths export restrictions were designed to protect resources and the environment or to gain the greatest benefit from a monopoly on the market ("Zhongguo Yanguan Xitu Yingzhan Ou Mei Ri Chansong", 2012).

These articles express strong opinions regarding China's behavior as a rare earths near-monopolist, and should be considered carefully. While both articles are characteristically nationalistic in their treatment of the WTO case, nevertheless, it is clear that China had no choice but to be affected by the pressure originating from the WTO and the United States, Japan, and the EU.[65]

In summary, if it were not for this international factor, it is very possible that China would continue restricting its exports of rare earths through export quotas indefinitely, or perhaps, as some scholars have suggested, even end its rare earths production at some time in the foreseeable future.

[65] Recent industry analysis suggests that though China has cancelled export quotas for rare earths, China is nevertheless tightening its hold on rare earths, especially HREEs, through other methods such as export tax systems, making the export of rare earths even more prohibitive than before the export quotas were cancelled (Lifton, 2015). It should be noted that such analysis is only preliminary, based on less than one month of observation. In addition, China's Ministry of Industry and Information Technology (MIIT) held a key national rare earth conference on Wednesday, January 28, 2015. The two items on the agenda were (1) the continued consolidation of the rare earths industry into six major conglomerates and (2) gaining greater control over rare earths products for export. Some fear that the regulations in the making will result in even less rare earth material being exported from China (Shen, 2015).

C. “Price-setting Authority”. China’s “father of rare earths”, Xu Guangxian and others have referred frequently and with great emphasis to China’s need for a strategic rare earths reserve system for the purpose of claiming world rare earths “price-setting authority” for China (Chapter 3). In the eyes of the scholarly community in China, rare-earth “price-setting authority” is yet another power that has been unfairly stripped from China by the West. As the *Rare Earth Information* article entitled “From Large to Strong in Rare Earths: How Can China Change?” states:

> China controls over 90% of the rare earths metals market, yet it lacks the ability that countries like Australia and Brazil have to control world prices.[66] A strange phenomenon exists in the large commodity market: taking oil, coal, and iron ore as examples, whenever China is in the exporting stage, prices are extremely low; but as soon as China becomes an importer, prices soar.

From the Western perspective, China has controlled the prices of rare earths since becoming the near-monopolist, and has continued to do so through rare earths export restrictions that caused price hikes which were detrimental to the world rare earths industry. In reality, the issue is simple. When supply exceeds demand, the buyer(s) has/have much more deciding power regarding the price of the product. In 2010-2011, when prices for rare earths increased by several hundred percent, the rest of the world found that the export restriction problem they had been carefully observing for nearly four years had indeed become a viable threat to the health of rare earths-dependent industries in the high-tech and defense sectors.

Eventually, the soaring prices did come down to relatively earthly levels, yet the rest of the world was intent on fixing the root problem. That solution included at least two aspects: (1) finding alternative sources for rare earths, and (2) bringing China’s

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[66] Literally, it lacks the “world price-setting authority” (世界定价权).

export restrictions into check. The former being much more difficult to achieve in the short term than the latter, the rest of the world, under the leadership of the United States, Japan, and the European Union, took up the case regarding export restrictions with China through the intermediary channel of the World Trade Organization.

China, on the other hand, knowing that extreme tightening of export restrictions like those in 2010-2011 are not long-term solutions to gaining true “price-setting authority”, has gone about searching for alternative methods for gaining this sought-after power. In other words, China is able to directly influence—in the short term, through export restrictions/embargos, etc.—the pricing of rare earths, but does not have the ability to set prices over the long-term, because as long as China is a member of the WTO, any pinch in the flow of rare earths exports on the part of China is sure to be met immediately with concerted defiance by the other WTO members. This is perhaps one of the “lessons” China has gleaned from its recently lost WTO case. Therefore, if China is to gain the rare earths “price-setting authority”, it must do so through means other than export restrictions. The current push in the Chinese academic community is toward establishing a vast reserve system by which the price of rare earths could be tweaked at will.

The lack of world rare earths price-setting authority should be labeled passive-negative, although China is fast working to turn the tables and make price-setting an active-positive factor for its rare earths industry. In August 2014, China was reported to have purchased 10,000 metric tons of rare earths oxides, adding this amount to its steadily-growing stockpiles—tools for pushing the prices of rare earths up (McLeod, 2014). According to Bloomberg News:

> China's move may be an effort to reverse a decline that's seen the price of at least one rare earth tumble 76 percent from its 2011 high, according to Peng Bo, an analyst at China Merchants Securities Co. In March, the World Trade Organization sided with the U.S., Japan and Europe in ruling that China hadn't adequately justified imposing export duties and quotas on rare earths and other resources. "China is facing imminent pressure to abolish the export quota, so stockpiling is part of the policy reaction to help *prop up prices* and keep more of the resources at home for future use," Peng said by phone from Shenzhen today ("China Said to Add 10,000 Tons to Rare Earths Stockpiles", 2014, emphasis mine).

Price-setting authority is indeed a crucial factor directly influencing the actions of China as a near-monopolist of rare earths. If and when the Chinese government gains the power to set rare earths prices worldwide, this international factor will become a top consideration for countries like the United States and Australia, although this is highly unlikely in the near future, as China's reserve stockpiles have not reached the "critical mass" necessary to wield such authority.

D. Geopolitical Factors. During the China-Japan fishing trawler spat in 2010, media outside of China made very specific accusations confirming China's use of rare earths as an economic-geopolitical weapon in the midst of a diplomatic crisis. As noted previously (Chapter 3), China never officially admitted to the charges, and blamed any disruptions in rare earths shipments on coordination issues between companies and customs, etc. Putting aside official rhetoric, for the purpose of this thesis, let us assume that the administrative halt on the export of rare earths from China to Japan in the final quarter of 2010 was indeed related to the trawler incident in the East China Sea, and that China did, as reported in western media, use rare earths as a weapon against Japan, the obvious underdog with regard to rare earths in this situation. How do these assumptions play out?

From China's perspective, the geopolitical use of rare earths makes perfect sense. Deng Xiaoping is reported to have said in 1992, "The Middle East has oil, and China has rare earths"[67] (See Chapter 1). Oil has been used to serve geopolitical ends on a multitude of occasions throughout recent history, e.g. the oil embargo placed on Japan by the United States and China during the Sino-Japanese war, preceding World War II; the 1967 Oil Embargo; and the Oil Crisis of 1973 ("First Oil Shock"). It would only be fitting, in this context, to understand Deng's statement to include the geopolitical tool/weapon aspect, or at least to include the possibility of such a use for rare earths.

A thorough study of the background to the 2010 halt in rare earths shipments to Japan shows that China had been decreasing export quotas for years, beginning in 2006. In 2010, the export quota was 30,258 tons[68], down from 48,155 tons in 2009, 49,990 tons in 2008, 59,643 tons in 2007, and 61,070 tons in 2006. Therefore, China's alleged use of an administrative halt on rare earths export to Japan as a geopolitical tool was only adding frost to snow (雪上加霜), as opposed to a bolt of lightning from a blue sky.

Taken from another perspective, regardless of China's true motives in the alleged rare earths embargo, the fact that the halt in shipments of rare earths to Japan was perceived in the West to constitute an embargo, is enough reason to consider it a de facto embargo. From the Chinese perspective, perhaps the behavior exhibited in this case is merely a logical progression from the restrictive tendencies of the years preceding 2010. In fact, earlier in 2010, scholars were calling for a complete halt to all rare earths exports (Chapter 3). It could be that China had long been waiting for an opportunity to experience

[67] In Chinese: "中东有石油，中国有稀土".

[68] Figures include export quotas for domestic producers and traders, and Sino-foreign joint ventures.

the power of monopoly, when the perfect moment presented itself in September 2010. But to conclude that China is a capricious power that one day is doing business as usual with the world market, and the next completely shuts off exports, is an extreme view. China's actions should be seen in the context of the gradual tightening of its restrictive policies on rare earths exports beginning in 2006, in light of environmental and resource protection concerns (China's perspective); but at the same time, China's actions in halting rare earths exports should also be understood to include the geopolitical factor (the Western perspective). To use a metaphor, China's rare earths behavior since 2006 could be considered a multi-faceted, multi-front war on those both inside and outside of China who would deplete China's rare earths resources and degrade the natural environment; whereas the use of geopolitical force in the halt of rare earths exports in 2010 was like a short-term, high-impact strike on a specific high-value target. China's government knows that such actions are only feasible and effective in the short-term, and its long-term goal is to protect its resources through steady, gradual, legislative, and regulatory means—while always having the "big stick" of a possible "rare earths embargo" at hand.

Though the long-term future points to a multi-polarized world of rare earths production, for the short-term, China is still the near-monopolist, controlling approximately 90% of world production. In this context, the geopolitical use of China's near-monopoly is not out of the question for the foreseeable future. As the world's dependence on China's rare earths wanes (as the rest of the world seeks rare earths resources outside of China), and China's domestic demand grows, the advantages to such a course of action as seen in 2010 will considerably decrease.

China’s use of rare earths for geopolitical ends is clearly positive, from the Chinese perspective. Conversely, it is a negative factor for the rest of the world. China, through active market manipulation, was able to achieve at least three goals, two geopolitical, and one economic: (1) punish Japan for its detention of the Chinese fishing trawler captain, Zhan Qixiong; (2) prove to the world that China is willing to use means such as embargo to fight back against what it considers incursion on its rights of sovereignty over the Diaoyu/Senkaku islands; and (3) considerably increase the world price of rare earths (if only in the short-term), thereby increasing China’s rare earths rents.

Domestic Factors

A. Environmental protection. It is a well-known fact that China has enacted many laws and measures for the protection of the environment in the context of rare earths mining and production, the entire process of which is extremely degrading to the natural environment. From the perspective of China as the near-monopolist of rare earths, however, the implementation of rare-earths-related environmental codes brings negative impacts to China’s monopoly on rare earths.

As discussed in Chapters 2 and 4, China (1) gained status as the supreme rare earths producer and exporter partly because of lax environmental regulations, or lax enforcement of existing regulations, which in turn cut costs. As has been noted by several researchers (see Chapter 4), China has not truly included the environmental cost of rare earths production in its rare earths business. It has consistently passed off environmental costs to society.

Second, (2) China has also justified its rare earths exports restrictions on the basis of environmental factors, as Mr. Liu Weimin, spokesperson for the Ministry of Foreign Affairs of the People's Republic of China emphasized in 2012 during the early days of the recently concluded WTO case revolving around China's rare earths export policy. China has taken an active role in beefing up environmental legislation, and claims that restricting production and exports are a way to mitigate environmental damage. While cutting down on overall production would be sure to improve environmental pollution by simply cutting down on the pollutants being released into the atmosphere, water, and soil, merely restricting exports only causes friction with rare-earths-dependent countries like the US, Japan, and the EU.

Regardless of the manner in which China does so (production cuts or export restrictions), if China prioritizes rare earths environmental protection, it will certainly cause a decrease in China's competitive market advantage, due to increased environmental protection costs. Thus, while the Central Government continues to hand down new rare earths industry regulations relating to environmental protection, the industry, especially the smaller players, do not always comply, and when compliance is achieved, it may not be ideal in the government's eyes. The combination of two phenomenon have kept implementation less than ideal for China's rare earths environmental protection: (1) 上有政策下有对策 ("Policies come from above, countermeasures come from beneath"; or "Where there is a policy coming from above, there is a countermeasure coming from beneath") and (2) 睁一只眼闭一只眼 ("Open one eye, and close one eye"). The two Chinese sayings encapsulate it well: there is always a loophole or two to be exploited in existing laws; and there seems always to be an official or two (or more) willing to look the other way on issues like environmental protection. These problems, while not unique to China, nevertheless strike many observers as being more rampant when compared with the world at large.

China's environmental protection is positive for the environment, but it brings negative effects to China's near-monopoly status in the world rare earths market. However, in the face of domestic social pressures to clean up its rare earths industry, China has no choice but to legislate. However, as we have seen in Chapter 4, the gap between legislation and regulation is frequently chasmal. As greater strides are made in implementation of environmental regulations at the local level, China will be forced to recalculate portions of its rare earths strategy in light of rising mining and production costs.

B. Rare earth resource protection. As discussed in Chapter 4, China has placed resource protection at the top of its list of rare-earths priorities, along with environmental protection. This has been reflected in recent legislation, research, and popular discourse. But contrary to the factor of environmental protection, China's active pursuit of rare earths resource protection can bring positive impacts to China's position as the near-monopolist of rare earths.

From the national perspective, China's rare earths behavior, including production and trade quotas, as well as the establishment of strategic stockpile reserves, is easily understood in terms of resource protection. In the context of the rapid rare earths resource depletion that has occurred over the past half century, it is no surprise that China is concerned about the future of its rare earths resources. The most alarming of forecasts calls for the exhaustion of some rare earths resources within ten years (see Chapter 4).

The general consensus of the rare earths community in China supports the idea that China, if it does not do something quickly to protect its dwindling rare earths resources, will soon become a net importer of the strategic elements, at which point the rest of the world could flip the tables on China, and charge exorbitant prices to a rare-earths-poor China. This is by no means a pleasant scenario for the Chinese government. Thus, efforts to protect rare earths resources have strengthened in recent years.

China has cancelled its export quotas for rare earths as of January 2015. This cancellation of the export quota system will have significant effects on the quantity of rare earths Chinese producers and traders can sell on the international market. This development has been in the making since China lost the WTO case earlier in 2014. Perhaps China's next move will come in the form of strengthening mining and production restrictions, thereby effectively reducing production at the source, thus protecting China's strategic rare earths reserves. The factor of China's resource protection can be seen as one of the most effective in preserving and protecting China's position as the world's rare earths leader.

C. Industry regulation. As China's rare earths industry continues its path to greater consolidation, government control on the industry is expedited. Though illegal mining, reckless mining, environmental pollution, resource waste, and smuggling continue to plague the industry, China seeks to achieve greater cost efficiency and thus a stronger hold on the rare earths market through better management and regulation. If China's efforts continue to prove successful, a better-regulated rare earths industry will benefit China's position as the near-monopolist of the rare earths world through streamlining an overgrown and wasteful industry.

D. Protecting and Aiding Domestic Rare Earths Industry. During the recent WTO case, accusations were frequently hurled at China for playing favorites to its own rare earths industry by exacting export taxes and export quotas on rare earths. At the same time, voices of alarm in the rest of world attracted attention to another aspect of China's export quotas and taxes: foreign rare earths producers were being lured into China to dodge taxes and quotas, and thereby increasing the risk for intellectual property and technology to be stolen.

This factor could be seen as the second most important domestic factor following rare earths resource protection. The fact that China places great priority on developing its own rare earths industry is no surprise. China currently has the most advanced, most complete rare earths industry chain in the world. The United States, in contrast, will need approximately ten years[69] to rebuild its broken industry chain, according to government estimates in 2010 ("Rare Earth Materials in the Defense Supply Chain", 2010). China's active competition in this aspect has, for the time being, played a great role in solidifying China's position and influencing China's behavior as a near-monopolist of rare earths.

In summary, it is an interrelated web of factors both international and domestic that influence China's behavior as a near-monopolist of rare earths. In the distant future, these factors will change, as is possible for China's position as the near-monopolist of rare earths. But for the near future, an understanding of these specific factors is critical if one aims to understand China's current rare earths situation.

[69] The estimate was 15 years from 2010. This thesis was completed in 2015.

The Overarching Role of the Chinese Government

In order to place all of the influential factors, both international and domestic, in their proper context, one must return to the theme of the ever-present role of the Chinese state. As noted in Chapters 1, 2, and 4, since 1986, with the advent of the 863 Plan, the Chinese government has placed a high priority on rare earths development, both production and application, as a part of its push for high-tech development, which in turn is a key part of China's overall thirty-plus-year thrust for economic development, which has awakened the "sleeping giant" of the East.

As China's path to economic development has encountered challenges and obstacles since the Reform and Opening Up of the late 1970s until the present, China's rare earths industry has also felt effects in turn. Perhaps the greatest negative event to occur early on in the period of China's rare earths development was the temporary isolation from certain parts of the Western world after the Tiananmen Square incident. Shortly after the June 4, 1989 incident, the United States issued what would later be known as the "Tiananmen Sanctions"—a combination of actual and threatened actions against China, especially with regard to most-favored-nation (MFN) status,[70] as "punishment" for what the West viewed as a severe violation of human rights.

Due to isolation by the West, the three-year period following the 1989 Tiananmen crackdown was one of relative economic stagnation for China. During the early years of Reform and Opening Up, China had experienced the best years of domestic development

[70] China's most-favored-nation (MFN) status, which had been revoked after the Tiananmen incident, was eventually renewed by President Bill Clinton in 1994. In the eyes of some Americans, the president's decision showed that in the end, it was not political values and human rights that mattered most to America, but profits and political gain (Perry, 1995).

since the establishment of the PRC in 1949. This was due in large part to the fact that China was on positive terms with all world blocs at the time, and enjoyed the privileges of memberships in international organizations. The three years between 1989 and 1992 also marked the downfall of the former Soviet Union. Though China did not miss a beat diplomatically in recognizing the new nations formed as the former USSR dissolved, nevertheless it was especially wary of repeating the mistakes—especially economic mistakes—that had led to the ultimate failure of the once-strong communist state. One of the critical lessons learned was the importance of economic growth, which was the focus of Deng Xiaoping's "Southern Tour" (南巡) of 1992 (Shambaugh, 2013).

It was precisely during the critical juncture of 1989-1992 that China's rare earths industry took off. 1988 had marked the first time in history that China had overtaken the United States as the world's foremost producer of rare earths; thus, the potential of China's rare earths production was already evident before the Tiananmen incident. I posit that the sanctions and isolation from the West in the aftermath of Tiananmen, which, according to analysts, came as a surprise to the Beijing leadership, served to highlight China's vulnerability in the rare earths field (as well as a host of other high-tech fields). As noted in Chapter 1, China's rare earths development during the 1980s had been helped along to a large degree by investment from abroad, and though China had large reserves of raw rare earths, it was quite vulnerable to cut-offs in technological assistance during this period. Though the "Tiananmen Sanctions" did not seem to phase the industry significantly, the threat of being cut off from the Western world seemed to have factored in to China's rare earths development plan.

At this juncture, it is important to recall that China's top leadership placed great importance on the development of China's rare earths industry as part of the overall government thrust of high-tech development represented by the 863 and 973 Programs. It is within the context of rare earths being elevated to a strategic height by the Chinese government during the late 1980s-1990s, that China's rare earths industry blossomed. It was at this crucial moment in history that Deng Xiaoping (1992) called on the rare earths industry to understand its strategic importance to China—on the level of Middle East oil; it was also in the 1990s that Jiang Zemin directed rare earths producers at Baotou to take greater advantage of China's rich endowment of rare earths resources, and turn resource advantages into economic advantages (see Chapter 1).

The 1990s ignited China's rare earths boom. Production skyrocketed, increasing quickly year-on-year. Eventually, production was so voluminous that prices dropped. The vicious cycle of price wars between rare earths producers further exacerbated the downward spiral. As we have noted, China laments the fact that it cannot "set the price" of rare earths. In my interpretation, this statement simply means, China does not have the ability to set the price higher. If the international price of rare earths were higher, it would be more profitable for China's rare earths industry. And, China would be able to funnel funds from higher prices into environmental projects.

As the 2000s neared an end, voices of environmental protection were beginning to have an impact on the rare earths industry. Not long after, in the early 2010s, a host of government laws and regulations emerged regarding pollution and environmental protection targeted specifically to the rare earths industry. The dilemma faced by the

Chinese government is actually simplistic in its nature (cost-benefit relationship) yet nevertheless extremely difficult to amend:

In the early days of China's rare earths mining and production (1950s-1970s), there were few applications for the minerals. The industry was hampered by both technological and political handicaps, such as the Cultural Revolution. Once Deng Xiaoping initiated the Reform and Opening Up during the late 1970s-early 1980s, the industry was blessed with inflows of foreign investment and technology; as a result, the industry flourished, to the point that due to illegal, unlicensed production and rampant smuggling during the 1990s and 2000s, China rapidly depleted its rare earths resources, degraded natural environments and ecosystems, and pushed world rare earths prices through the floor. As noted earlier, for many years, China did not include environmental costs in its accounting of rare earths mining and production costs. In recent years, these environmental costs have gained the attention of lawmakers in Beijing, and have slowly begun trickling down to cadres in the provinces, who are beginning to become accustomed to being performance-critiqued on metrics that include environmental protection as well as the old metric—economic growth.

The crux of the matter revolves around the relationship between returns from rare earths and environmental costs associated with the mining and production of rare earths. The ideal situation is to strike a balance between the two factors. For many years, China all but ignored the environmental costs brought on by rare earths mining and production, which continued to accumulate, without even a government agency to keep tabs on the damage. At present, due to years of excess production of rare earths, prices are very low, and the returns on rare earths come nowhere close to balancing the loss created by environmental degradation.

To sum it up another way, China's behavior in regard to rare earths production and exports has gone through two major stages since the 1980s: (1) rapid and semi-uncontrolled expansion, and (2) slower, regulated expansion. During the 1980s, and especially after the early 1990s, China's rare earth production was, much like every other sector of the economy, focused on the sole goal of growth. Expansion increased by leaps and bounds, with a 425% increase in production between 1990 and 1999 (Hedrick, 1990; Hedrick, 1999), and rebates for companies that exported rare earths pushed exports higher and higher (Li & Xu, 2014).

As the 1990s drew to a close, the Chinese government began to place emphasis on the strategic nature of rare earths ("973 Jihua Qidong Xitu Gaoxiao Tichun Zhongda Yanjiu Xiangmu"), and the need to protect these resources from premature "extinction". Thus, beginning in 1998/1999, export control measures were gradually introduced (Hedrick, 1998). By 2005/2006, export quotas were significantly controlling the amount of rare earths that left the country, if only on paper (smuggling was and still is a major obstacle). Since 2011, the Chinese government has made significant strides in rare-earths-related legislation, in theory making a 180-degree turn from its policies of "development or bust" during the 1980s and most of the 1990s.

At present, China seems committed to fixing its environmental woes caused by rare-earths mining. What China has attempted to do through export restrictions is to raise prices, thereby increasing its near-monopoly rents, seeking thereby to mitigate a portion of environmental damage, an endeavor at which it has not been successful to date. Now that China has lost the recent WTO case, it is imperative that it finds another way to maximize the resource protection, domestic use, and export pricing of rare earths. The present possibilities tend to point to a restructuring of China's tax system, including resource tax, which could help to balance the economic return-to-environmental rehabilitation relationship.

Regardless of how China accomplishes its many goals, and no matter which of the international or domestic factors influence China's rare earths industry the most at any given moment, one thing is certain: China's rare earths industry, like all other industries in China, exists and functions within the pre-determined context designated for it by China's central government. That context is the context of sustainable development and overall economic growth.

To conclude, in the future, China will undoubtedly continue to do all within its power to remain the near-monopolist of rare earths. That having been said, China's ultimate goal seems to be one of comprehensive monopoly over the entire industry—from "mine to magnet". China is working untiringly to become a leader, not only in rare earths oxides and mining, but in a whole host of high-quality high-tech downstream products that will rival those produced in the West, all the while cleaning up its domestic rare earths industry, and protecting its own rare earths resources and environment.

BIBLIOGRAPHY

Adachi, Gin-ya; Imanaka, Nobuhito; Tamura, Shinji. 2010. "Research trends in rare earths: A preliminary analysis". *Journal of Rare Earths*. Vol. 28, No. 6. Dec. 2010, p. 843

Adshead, S. A. M. 2000. *China in World History*. New York: St. Martin's Press.

"Alcohol Use and Cancer". 2014. *American Cancer Society*. Accessed at http://www.cancer.org/cancer/cancercauses/dietandphysicalactivity/alcohol-use-and-cancer.

Ali, Saleem H. 2014. "Social and Environmental Impact of the Rare Earth Industries". *Resources*. 2014 (3), pp. 123-134. Doi:10.3390/resources3010123.

Bajpai, Prableen. 2014. "Why China is 'The World's Factory'". *Investopedia*. October 22, 2014. Accessed at http://www.investopedia.com/articles/investing/102214/why-china-worlds-factory.asp.

"Baogang Xitu Chanye Gaikuang". (包钢稀土产业概况) "A Survey of the Baotou Steel Rare Earths Industry". Baotou Gangtie Jituan Youxian Zeren Gongsi (Guanfang Wangzhan). 包头钢铁（集团）有限责任公司（官方网站）. Baogang Group (Official Website). Accessed at http://www.btsteel.com/xtcy.asp?ID=105&BigClass=%CF%A1%CD%C1%B2%FA%D2%B5.

Blakely, Christopher; Cooter, Joseph; Khaitan, Ashu; Sincer, Iclal; Williams, Ross. 2011. *Rare Earth Metals and China*. Ann Arbor, Michigan: Gerald R. Ford School of Public Policy.

Bradsher, Keith. 2010. "Amid Tension, China Blocks Vital Exports to Japan". *The New York Times*. September 22, 2010.

Brook, Timothy; Bob Tadashi Wakabayashi (Eds.). 2000. *Opium Regimes: China, Britain, and Japan, 1839-1952*. Berkeley and Los Angeles: University of California Press.

Brumme, Anja. 2014. "Wind Energy Deployment and the Relevance of Rare Earths: An Economic Analysis". Wiesbaden: Springer Gabler, . Accessed at http://download.springer.com.ezproxy.fiu.edu/static/pdf/466/bok%253A978-3-658-04913-3.pdf?auth66=1415291877_57bc3ea41d38c441c482674f08365ecd&ext=.pdf.

Campi, Alicia. 2015. "Mongolia Signs Economic Deal With Japan to Offset Chinese and Russian Trade Domination". *Eurasia Daily Monitor*. The Jamestown Foundation. February 20, 2015. Accessed at http://app.bronto.com/public/?q=preview_message&fn=Link&t=1&ssid=500&id=1d47qw252owixgrazfzd3pu4wfw6c&id2=jz2mskoerpza0o5ow8qn8niubd43o&subscriber_id=arspzotczprozhdeltjwgazndndybei&delivery_id=bfdlscrtdydbnzmnkmwajdkjsafsboc&messageversion_id=bnxlurkhzctwggkpmmdneqbiktucbjn&tid=3.AfQ.T3Oh.C1Ez.AZ82JA..AwvRPw.b..l.AxTh.b.VOfQ8w.VOfRWA.YBRrYQ.

Chen, Weiwei; Chen, Hanzhe. 2014. "Shimao Zuzhi Shangsu Jigou Caiding Zhongguo Xitu Chukou Zhengce Weigui: Wo Shangwubu Tiaoyue Falu Si Fuzeren Jiuci Fabiao Tanhua" (世贸组织上诉机构裁定中国稀土出口政策违规 我商务部条约法律司负责人就此发表谈话). ("World Trade Organization Appellate Body Rules China's Rare Earth Export Policies In Violation of Regulations: Head of China's Ministry of Commerce Department of Treaty and Law Gives Speech on the Issue") *Xinhua Wang* (新华网). *Xinhua Net*. August 8, 2014. Accessed at http://news.xinhuanet.com/fortune/2014-08/08/c_1111985363.htm.

Chen, Zhiyu. 2014. "Xianzhi Xitu Chukou: Lu Shangsu Shibai" (限制稀土出口 陸上訴失敗). "Restricting Rare Earths Exports: Mainland Appeal Fails". *Lianhe Bao* (聯合報) *United Daily News*. August 9, 2014. Accessed at http://udn.com/NEWS/MAINLAND/MAI1/8859673.shtml.

Cheng, Jianzhong & Che Liping. 2010. "Zhongguo Xitu Ziyuan Kaicai Xianzhuang Ji Fazhan Qushi" (中国稀土资源开采现状及发展趋势). "Current Exploitation Situation and Development Trends in China's Rare Earths Resources". *Xitu* (《稀土》). *Chinese Rare Earths*. Di 31 Juan Di 2 Qi 2010 Nian 4 Yue (第 31 卷第 2 期 2010 年 4 月). Vol. 31, No. 2, April 2010.

"China & Global Rare Earth Market Forecasts (2016, 2018 & 2019) in New Research Reports". 2014. *PR Newswire*. September 16, 2014. Accessed at http://www.prnewswire.com/news-releases/china--global-rare-earth-market-forecasts-2016-2018--2019-in-new-research-reports-275263311.html

"China must tackle rare earth industry chaos". 2014. *Renmin Ribao* (*The People's Daily)*. August 11, 2014. Accessed at http://english.people.com.cn/business/n/2014/0811/c90778-8767565.html.

"China Rare Earth Quarterly." 2013. *Shanghai Metals Market*, 4Q Edition, No. 8. January 24, 2013.

"China Said to Add 10,000 Tons to Rare Earths Stockpiles". 2014. *Bloomberg News*. August 5, 2014. Accessed at http://www.bloomberg.com/news/2014-08-05/china-said-to-add-10-000-tons-to-rare-earths-stockpiles-1-.html.

"China's Global Quest for Resources and Implications for the United States". 2012. *Hearing Before the US-China Economic and Security Review Commission*. One Hundred

Twelfth Congress, Second Session, January 26, 2012. Washington: 2012. 3

“China’s Monopoly on Rare Earths: Implications for US foreign and security policy”. 2011. *Hearing before the Subcommittee on Asia and the Pacific of the Committee on Foreign Affairs*. House of Representatives, One hundred twelfth Congress, First Session, September 21, 2011. Serial No. 112–63.

Clapper, James. 2013. “Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community, Senate Select Committee on Intelligence”. March 12, 2013. Accessed at http://www.dni.gov/files/documents/Intelligence%20Reports/2014%20WWTA%20%20SFR_SSCI_29_Jan.pdf.

Cordier, Daniel J.; Hedrick, James B. 2008. “Rare Earths”. *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2008-raree.pdf.

Cordier, Daniel J. 2009. “Rare Earths [Advance Release]”. *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2009-raree.pdf.

“Dang He Zhengfu Tichu De ‘Ke Chixu Fazhan’ Zhanlue Juti Neirong Shi Shenme?”. “党和政府提出的‘可持续发展’战略具体内容是什么？”. “What is the Specific Content of ‘Sustainable Development’ as Refered to by the Party and the Government?”. 2006. *Zhongguo Gongchandang Xinwen*. 《中国共产党新闻》. *News of the Communist Party of China*. Accessed at http://cpc.people.com.cn/GB/64156/64157/4418468.html.

Davis, Bob. 2014. “The End of China’s Economic Miracle?” *The Wall Street Journal*. November 21, 2014. Accessed at http://www.wsj.com/articles/the-end-of-chinas-economic-miracle-1416592910.

“Deng Xiaoping Tongzhi ‘Heimao Baimao Lun’ Beihou De Gushi”. “邓小平同志‘黑猫白猫论’背后的故事”. “Stories Behind Comrade Deng Xiaoping’s ‘Black-Cat-White-Cat Theory’ ”. 2006. *Zhongguo Gongchandang Xinwen*. 《中国共产党新闻》. *News of the Communist Party of China*. Accessed at http://cpc.people.com.cn/GB/85037/8530953.html.

Dennehy, Kevin. 2013. “For Metals of the Smartphone Age, No Plan B”. *Yale News*. December 2, 2013. Accessed at http://news.yale.edu/2013/12/02/metals-smartphone-age-no-plan-b.

Dispute Settlement: Dispute DS433. 2014. “China — Measures Related to the Exportation of Rare Earths, Tungsten and Molybdenum”. World Trade Organization. Accessed at http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds433_e.htm.

Doerr, M.; Rotter, M.; Lindbaum, A. 2005. “Magnetostriction in rare-earth based antiferromagnets”. *Advances in Physics*. Vol. 54, No. 1, January/February 2005, 1-66.

Du, Xiaoyue; Graedel, T.E. 2013. “Uncovering the end uses of the rare earth elements.” *Science of the Total Environment*, 461-462, 781-784 .

Els, Frik. 2014. “China's rare earth industry will look very different in 5 months”. *Mining.com*. August 8, 2014. Accessed at http://www.mining.com/chinas-rare-earth-industry-will-look-very-different-at-the-end-of-the-year-53315/.

Emsley, J. 2001. *Nature’s Building Blocks: An A–Z Guide to the Elements*. Oxford, England: Oxford University Press.

Encyclopaedia Britannica. 2014. “Sir William Crookes”. Accessed at http://www.britannica.com/EBchecked/topic/143944/Sir-William-Crookes.

Extavour, Marcius. 2011. “Rare Earth Elements: High Demand, Uncertain Supply”. *Optics and Photonics News*. Accessed at http://www.osa-opn.org/home/articles/volume_22/issue_7/features/rare_earth_elements_high_demand,_uncertain_supply/#.VSLo_BwZGPo.

Fairbank, John King. 1992. *China: A New History*. Cambridge, Massachusetts; London, England: The Belknap Press of Harvard University Press.

“Foreign Ministry Spokesperson Liu Weimin’s Regular Press Conference on March 13, 2012”. 2012. *Ministry of Foreign Affairs of the People’s Republic of China*. Accessed at http://www.fmprc.gov.cn/mfa_eng/xwfw_665399/s2510_665401/2511_665403/t914266.shtml.

Gambogi, Joseph. 2012. “Rare Earths”. Mineral Commodity Summaries, *US Geological Survey*, February 2014. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/mcs-2012-raree.pdf.

Gambogi, Joseph. 2013. “Rare Earths”. Mineral Commodity Summaries, *US Geological Survey*, February 2014. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/mcs-2013-raree.pdf.

Gambogi, Joseph. 2014. “Rare Earths”. Mineral Commodity Summaries, *US Geological Survey*, February 2014. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/mcs-2014Wet-raree.pdf.

Gambogi, Joseph; Cordier, Daniel J. 2010. “Rare Earths [Advance Release]”. *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2011-raree.pdf.

Gambogi, Joseph. 2011. “Rare Earths [Advance Release]”. *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2010-raree.pdf.

Generalic, Eni. 2014. “Rare Earth Elements (REE).” EniG. Periodic Table of the Elements. KTF-Split. September 26, 2014. Accessed at http://www.periodni.com/rare_earth_elements.html.

“Geological Survey Circular 831”. 1980. U. S. Bureau of Mines and U. S. Geological Survey. Accessed at http://pubs.usgs.gov/circ/1980/0831/report.pdf.

Green, Jeffery A. 2012. “The Defense Implications Of Rare Earth Shortages”. National Center for Policy Analysis. Issue Brief No. 112. Accessed at http://www.ncpa.org/pub/ib112.

“Guochan Mengzu Heibai Lao Dianying ‘Caoyuan Chenqu’”. (国产蒙族黑白老电影《草原晨曲》). “Domestic Mongolian Black and White Old Movie ‘Morning Song Over the Prairie’”. 1959. Accessed at http://www.youtube.com/watch?v=TGFDNQfnCW4.

“Guojia Gaojishu Yanjiu Fazhan Jihua” (国家高技术研究发展计划) “State High-tech Development Plan”, accessed at http://www.863.gov.cn/1/1/index.htm.

“Guojia Yankuang Huashi Biaoben Ziyuan Gongxiang Pingtai” (国家岩矿化石标本资源共享平台). “National Infrastructure of Mineral Rock and Fossil Specimen Resources”. Guojia Keji Jichu Tiaojian Pingtai. (国家科技基础条件平台) National Science & Technology Infrastructure. Accessed at http://www.nimrf.net.cn/ept/eptKcDetail.action?id=2.

“Guotu Ziyuan Bu Guanyu Xiada 2014 Niandu Xitu Kuang Wu Kuang Kaicai Zongliang Kongzhi Zhibiao De Tongzhi” (国土资源部关于下达2014年度稀土矿钨矿开采总量控制指标的通知). “Notice by the Ministry of Land and Resources Regarding the Imposition of Yearly Mining Quotas for Rare Earths and Tungsten for the year 2014.” 2014. Zhonghua Renmin Gongheguo Guotu Ziyuan Bu, Kuangchan Kaifa Guanli Si (中华人民共和国国土资源部、矿产开发管理司). Bureau of Mineral Development and Management, Ministry of Land and Resources of the People’s Republic of China. Guozi Fa [2014] 65 Hao. June 19, 2014. Accessed at http://www.mlr.gov.cn/zwgk/zytz/201406/t20140619_1321001.htm.

“Guowuyuan Guanyu Cujin Xitu Hangye Chixu Jiankang Fazhan De Ruogan Yijian” (国务院关于促进稀土行业持续健康发展的若干意见). “Several Opinions of the State Council Regarding the Promotion of the Healthy Development of the Rare Earths Industry”. 2011. Guofa [2011] 12 Hao. Accessed at http://www.gov.cn/zwgk/2011-05/19/content_1866997.htm.

Haberman, Clyde. 1986. “Ideas & Trends; For Japan, Even the War Takes a Back Seat to Trade.” *The New York Times*, August 10, 1986.

Hao, Yufan; Liu, Weihua. 2011. “Rare earth minerals and commodity resource nationalism.” In: Herberg, M.E. (Ed.), *Asia’s Rising Energy and Resource Nationalism: Implications for the United States, China, and the Asia-Pacific Region*. National Bureau of Asian Research, p. 15.

Haxel, Gordon B.; Hedrick, James; Orris, Greta J. 2002. “Rare Earth Elements—Critical Resources for High Technology”. *United States Geological Survey*. Accessed at http://pubs.usgs.gov/fs/2002/fs087-02/fs087-02.pdf.

Hayes-Labruto, Leslie; Schillebeeckx, Simon J.D.; Workman, Mark; Shah, Nilay. 2013. “Contrasting perspectives on China's rare earths policies: Reframing the debate through a stakeholder lens.” *Energy Policy*, Vol. 63, pp. 55–68.

Hedrick, James B. 1980. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 669-678. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1980v1/reference/econatres.minyb1980v1.jhedrick.pdf.

Hedrick, James B. 1981. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 697-707. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1981v1/reference/econatres.minyb1981v1.jhedrick.pdf.

Hedrick, James B. 1982. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 705-714. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1982v1/reference/econatres.minyb1982v1.jhedrick.pdf.

Hedrick, James B. 1983. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 713-723. Accessed at http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=article&did=EcoNatRes.MinYB1983v1.JHedrick&id=EcoNatRes.MinYB1983v1&isize=M.

Hedrick, James B. 1984. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 751-762. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1984v1/refere nce/econatres.minyb1984v1.jhedrick.pdf.

Hedrick, James B. 1985. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 791-803. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1985v1/reference/econatres.minyb1985v1.jhedrick.pdf.

Hedrick, James B. 1986. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 771-782. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1986v1/reference/econatres.minyb1986v1.jhedrick.pdf.

Hedrick, James B. 1987. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 717-728. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1987v1/reference/econatres.minyb1987v1.jhedrick.pdf.

Hedrick, James B; Templeton, David A. 1988. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 779-789. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1988v1/reference/econatres.minyb1988v1.jhedrick.pdf.

Hedrick, James B; Templeton, David A. 1989. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 825-844. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1989v1/reference/econatres.minyb1989v1.jhedrick.pdf.

Hedrick, James B. 1990. “Rare Earths: the Lanthanides, Yttrium, and Scandium”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 903-922. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1990v1/reference/econatres.minyb1990v1.jhedrick.pdf.

Hedrick, James B. 1991. “Rare Earths: the Lanthanides, Yttrium, and Scandium”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 1211-1237. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1991v1/reference/econatres.minyb1991v1.jhedrick.pdf.

Hedrick, James B. 1992. “Rare Earths: the Lanthanides, Yttrium, and Scandium”, "Bureau of Mines Minerals Yearbook, Metals and Minerals", *United States Geological Survey*, pp. 1035-1061. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1992v1/reference/econatres.minyb1992v1.jhedrick.pdf.

Hedrick, James B. 1993. "Rare Earths: the Lanthanides, Yttrium, and Scandium", "Bureau of Mines Minerals Yearbook, Metals and Minerals", *United States Geological Survey*, pp. 857-883. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1993v1/reference/econatres.minyb1993v1.jhedrick.pdf.

Hedrick, James B. 1994. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740494.pdf.

Hedrick, James B. 1995. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740495.pdf.

Hedrick, James B. 1996. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740496.pdf.

Hedrick, James B. 1997. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740497.pdf

Hedrick, James B. 1998. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740498.pdf.

Hedrick, James B. 1999. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740499.pdf.

Hedrick, James B. 2000. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/740400.pdf.

Hedrick, James B. 2001. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/raremyb01.pdf.

Hedrick, James B. 2002. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/raremyb02.pdf.

Hedrick, James B. 2003. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/raremyb03.pdf.

Hedrick, James B. 2004. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/raremyb04.pdf.

Hedrick, James B. 2005. "Rare Earths". *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/raremyb05.pdf.

Hedrick, James B. 2006. “Rare Earths”. *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2006-raree.pdf.

Hedrick, James B. 2007. “Rare Earths”. *United States Geological Survey*. Accessed at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/myb1-2007-raree.pdf.

Huan, Jia. 2014. “Xitu Guansi Tuxian Xifang ‘Guize Qishi’: Benguo Ziyuan ‘Feng Er Bu Cai’; Qiangpo Zhongguo Fangkai Chukou” (稀土官司凸显西方“规则歧视” 本国资源“封而不采” 强迫中国放开出口). “Rare Earths Case Reveals West’s ‘Regulation Discrimination’; China’s Resources ‘Mining-Sealed’: China Forced to Open Up Exports”. *Renmin Ribao* (人民日报). *The People’s Daily*. March 28, 2014. Accessed at http://paper.people.com.cn/rmrbhwb/html/2014-03/28/content_1407677.htm.

“Huang Chunjiang Jiaoshou” (黃春江 教授). Guoli Taiwan Daxue Dizhi Xuekexi Ji Yanjiusuo. (國立台灣大學地質學科系暨研究所). Department of Geosciences, National Taiwan University. Accessed at http://web.gl.ntu.edu.tw/index.php?option=com_k2&view=item&id=2078%3AProfessor+Chun-Kiang+Huang%3Blang%3Dzh&lang=zh.

Hurst, Cindy. 2010. “China’s Rare Earth Elements Industry: What Can the West Learn?” *Institute for the Analysis of Global Security*. March 2010.

Inuzuka, Ako. 2013. “Remembering Japanese Militarism Through the Fusosha Textbook: The Collective Memory of the Asian-Pacific War in Japan.” *Communication Quarterly*, Vol. 61(2), April–June, pp. 131–150.

Jacques, Martin. 2012. *When China Rules the World: the End of the Western World and the Birth of a New Global Order*. New York: Penguin Books.

“Japan, China Agree On Rare Earth Cooperation.” *Japan Economic Newswire: Asian News-China*. May 4, 1988.

“Japan and China to Hold ‘Rare Earth’ Meeting.” *Japan Economic Newswire: Asian News-China*. October 15, 1988.

“Japan minister to visit China to discuss rare earth trade.” 2011. *BBC Monitoring Asia Pacific – Political*. July 15, 2011.

“Japan Attempts to Depend Less on China Rare Earth.” *Sinocast Daily Business Beat*. October 22, 2012.

Jin, Shulan; Huang, Yizong. 2014. “Turang Zhong Xitu Yuansu De Shengtai Duxing

Yanjiu Jinzhan” (土壤中稀土元素的生态毒性研究进展). *Shengtai Duli Xuebao* (《生态毒理学报》). *Asian Journal of Ecotoxicology*. 2014 Nian Di 9 Juan, Di 2 Qi, 213-223. 2014年第9卷，第2期213-223页. Vol. 9, 2014; No. 2, 213-223.

Kaiman, Jonathan. 2014. “China Strengthens Environmental Laws”. *The Guardian*. April 25, 2014. Accessed at http://www.theguardian.com/environment/2014/apr/25/china-strengthens-environmental-laws-polluting-factories.

Kang, Su-Jeong. 2013. “Anti-Japanese Popular Nationalism and China’s Approach Towards Japan amid Sino-Japanese Political Tension, 2001–2006.” *East Asia*, Vol. 30(2), pp. 161-181.

King, Amy; Armstrong, Shiro. 2013. “Did China really ban rare earth metals exports to Japan?” *East Asia Forum*, April 18, 2013.

Krugman, Paul. 2010. “Rare and Foolish”. *The New York Times*. October 17, 2010. Accessed at http://www.nytimes.com/2010/10/18/opinion/18krugman.html?_r=0.

Kuhn, Anthony. 2015. “The Anti-Pollution Documentary That’s Taken China By Storm”. *NPR*, Parallels. March 4, 2015. Accessed at http://www.npr.org/blogs/parallels/2015/03/04/390689033/the-anti-pollution-documentary-thats-taken-china-by-storm.

Liu, Lanyong; Wang, Zhen. 2013. “Gannan Xitu Kaicai Yu Huanjing Baohu” (赣南稀土开采与环境保护). “Rare Earths Mining and Environmental Protection in Southern Jiangxi”. Dangdai Jingji Guanli (《当代经济管理》). Contemporary Economy & Management. 2013 Nian 12 Yue, Di 35 Juan Di 12 Qi. 2013年12月，第35卷第12期. Dec. 2013, Vol. 35 No. 12.

Liu, Wenyan. 2013. “Woguo Xitu Maoyi Cunzai De Wenti Yu Duice Fenxi” (我国稀土贸易存在的问题与对策分析). *Zhongguo Jingmao* (《中国经贸》). *China Business Update*. Di 24 Juan, 2013 Nian. 第24卷，2013年. Vol. 24, 2013.

Luo, Lan. 2012. “Xitu Guansi Baolu Xifang Hongqiang Ziyuan Zuilian (Redian Jujiao)” (稀土官司暴露西方哄抢资源嘴脸（热点聚焦）). “Rare Earths Case Exposes the Panic-Buying Face of the West (Hot-topic Focus).” *Renmin Ribao Haiwai Ban* (人民日报海外版) *The People’s Daily (Overseas Edition)*. March 28, 2012. Accessed at http://paper.people.com.cn/rmrbhwb/html/2012-03/28/content_1027517.htm.

Mancheri, Nabeel; Sundaresan, Lalitha; Chandrashekar, S. 2013. “Dominating the World: China and the Rare Earth Industry”. International Strategic and Security Studies Programme, National Institute of Advanced Studies, Bangalore, India.

Mao, Kezhen; Wu, Yiding. 2012. “Xitu Chukou Jiage Yu Xitu Chubei” (稀土出口价格与稀土储备). *Youse Jinshu Kexue Yu Gongcheng*. 《有色金属科学与工程》. *Nonferrous Metals Science and Engineering*. Di 3 Juan Di 5 Qi, 2012 Nian 10 Yue. 第3卷第5期，2012年10月. Vol. 3, No. 5. Oct. 2012.

Massari, Stefania; Ruberti, Marcello. “Rare earth elements as critical raw materials: Focus on international markets and future strategies.” *Resources Policy*, Vol. 38, pp. 36–43.

McLellan, B.C.; Corder, G.D.; Golev, A.; Ali, S.H. 2014. “Sustainability of the Rare Earths Industry.” *Procedia Environmental Sciences*, 20 (2014) pp. 280-287.

McLeod, Charlotte. 2014. “Increased Chinese Stockpiling Could Push REE Prices Up”. *Resource Investing News*. April 17, 2014. Accessed at http://resourceinvestingnews.com/69816-china-stockpiling-rare-earth-elements-export-quotas.html.

McNeill, J.R.; McNeill, William H. 2003. *The Human Web: A Bird’s Eye View of Human History*. New York: W.W. Norton.

“Mei Ri Ou Lianshou Shiya Zhongguo Xitu Chukou” (美日欧联手施压中国稀土出口).“The United States, Japan, and the European Union Unite in Putting Pressure on China’s Rare Earths Exports”. 2012. *Renmin Wang*. 人民网. *The People’s Daily Online*. Accessed at http://world.people.com.cn/GB/8212/191606/240757/.

“Mineral Reserves, Resources, Resource Potential, and Certainty”. Accessed at http://www.nwrc.usgs.gov/techrpt/sta13.pdf.

Moore, Christine, M. 1979. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 735-742. Accessed at http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=article&did=EcoNatRes.MinYB197879v1.CMoore&id=EcoNatRes.MinYB197879v1&isize=M.

Moran, Theodore H. 2010. *China’s Strategy to Secure Natural Resources: Risks, Dangers, and Opportunities.* Washington, D.C.: Peterson Institute for International Economics.

Morrison, Wayne M.; Tang, Rachel. 2012. “China’s Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States.” *Congressional Research Service*. April 30, 2012.

“No discrimination in rare earth supply”. 2012. *The People’s Daily Online*. Accessed at http://english.peopledaily.com.cn/90778/7719811.html.

“Of metals and market forces; China and rare earths.” 2012. *The Economist.* February 4, 2012: 75(US). Academic ASAP. Web. September 22, 2014.

Pang, Wuji. 2014. “Zhongguo Ba Bumen Lianshou Kaizhan ‘Xitu Dahei’ Jiang Chixu Jin Bannian” (中国八部门联手开展“稀土打黑”将持续近半年). “China: Eight Ministries Set Out Together on Near-Half-Year Battle Against Illegal Rare Earths Activity”. *Renmin Wang* (人民网) *The People’s Net*. October 13, 2014. Accessed at http://politics.people.com.cn/n/2014/1013/c70731-25822934.html.

Parker, John G. 1962. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 1025-1034. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1962v1/reference/econatres.minyb1962v1.jparker.pdf.

Parker, John G. 1969. “Rare-Earth Minerals and Metals”, “Bureau of Mines Minerals Yearbook, Metals and Minerals”, *United States Geological Survey*, pp. 951-958. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1969v1and2/reference/econatres.minyb1969v1and2.jparker2.pdf.

Peerally, Jahan Ara, and Ekaterina Turkina. “China’s rare earth and Japan.” *International Journal of Case Studies in Management*, 11.3 (2013): 1+. Expanded Academic ASAP. Web. 17 Sept. 2014.

Perkowski, Jack. “Behind China’s Rare Earth Controversy.” *Forbes*. June 6, 2012. Accessed at http://www.forbes.com/sites/jackperkowski/2012/06/21/behind-chinas-rare-earth-controversy/

Perry, Elizabeth. 1995. “Most-favored-nation status and the political potential of Chinese labor”. Center for Labor Studies, University of Washington. Accessed at https://depts.washington.edu/pcls/documents/research/Perry_MostFavoredNation.pdf.

“Petroleum Reserves”. Office of Fossil Energy, U. S. Department of Energy. Accessed at http://energy.gov/fe/services/petroleum-reserves.

Piesing, Mark. 2013. “Rare-earth mineral substitutes could defeat Chinese strangelhold”. *Wired.co.uk*. July 31, 2013. Accessed at http://www.wired.co.uk/news/archive/2013-07/31/race-for-rare-earth-minerals.

Qian, Jiuhong; Li, Guoping. 2003. "Zhongguo Xitu Chanye De Fazhan Xianzhuang" (中国稀土产业的发展现状). "Current Development Situation of China's Rare Earths Industry". *Chinese Journal of Rare Metals*. Vol. 27, No. 6. November 2003.

Ralph, Jolyon; Chau, Ida. 2014. "Hezuolinite". *Mindat.org*. Accessed at http://www.mindat.org/min-41142.html.

Rapoza, Kenneth. 2014. "China May Be Slowing, But Still Fastest Growing Economy On Earth". *Forbes*. November 18, 2014. Accessed at http://www.forbes.com/sites/kenrapoza/2014/11/18/china-maybe-be-slowing-but-still-fastest-growing-economy-on-earth/3/.

"Rare Earth Elements". 2013. *Rare Element Resources*. Accessed at http://www.rareelementresources.com/rare-earth-elements#.VNpWEhwZGsh.

"Rare Earth Elements: A Review of Production, Processing, Recycling, and Associated Environmental Issues". 2012. Engineering Technical Support Center, Land Remediation and Pollution Control Division, National Risk Management Research Laboratory, Office of Research and Development, Cincinnati, Ohio. Office of Research and Development, *The United States Environmental Protection Agency*. December, 2012. Accessed at http://nepis.epa.gov/Adobe/PDF/P100EUBC.pdf.

"Rare Earth Materials in the Defense Supply Chain". Briefing for Congressional Committees. April 1, 2010. United States Government Accountability Office. Accessed at http://www.gao.gov/new.items/d10617r.pdf.

"Rare Earths". *Hearing before the Subcommittee on Energy of the Committee on Energy and Natural Resources*. United States Senate, One Hundred Eleventh Congress, Second Session. September 30, 2010.

"Rare Earths Supply Deal Between Japan and Vietnam". *BBC News*, Asia-Pacific. October 31, 2010. Accessed at http://www.bbc.com/news/world-asia-pacific-11661330.

"REE – Rare Earth Elements and their Uses". *Geology.com: Geoscience News and Information*. Accessed at http://geology.com/articles/rare-earth-elements.

"Report of the World Commission on Environment and Development: Our Common Future". 1987. United Nations. Accessed at http://www.un-documents.net/our-common-future.pdf.

Shambaugh, David L. 2013. *China Goes Global: The Partial Power*. New York: Oxford University Press.

Shen, Hongpo. 2014. "China's consolidation campaign to fight illegal rare earth exports".

Investor Intel. October 31, 2014. Accessed at http://investorintel.com/rare-earth-intel/china-readying-unveil-new-measures-rare-earths-sector/.

Shen, Hongpo. 2015. "China to end rare earth export tariffs in May 2015 and replace with more stringent global control methods". *Investor Intel*. January 22, 2015. Accessed at http://investorintel.com/rare-earth-intel/china-end-rare-earth-export-tariffs-may-2015-replace-stringent-global-control-methods/.

Shen, Hongpo. 2015. "China's new blueprint for rare earth control to reduce supply". *Investor Intel*. January 22, 2015. Accessed at http://investorintel.com/rare-earth-intel/chinas-new-blueprint-rare-earth-control-reduce-supply/.

Shirk, Susan. 2008. *China: Fragile Superpower*. Oxford; New York: Oxford University Press.

"Situation and Policies of China's Rare Earth Industry". 2012. Information Office of the State Council, the People's Republic of China. June 2012, Beijing. Accessed athttp://www.miit.gov.cn/n11293472/n11293832/n12771663/n14676956.files/n14675980.pdf.2

Song, Yong; Yang, Tiping. 2013. "Gannan Lizixing Xitukuang Dizhi Huanjing Huifu Zhili Cuoshi Yanjiu" (赣南离子型稀土矿地质环境恢复治理措施研究). "Research on Geological Environment Restoration and Control Measures at Ion-Adsorbed Rare Earths Mines in Southern Jiangxi". *Kexie Luntan* (《科协论坛》). *Science & Technology Association Forum*. 2013 Nian Di 12 Qi. 2013年第12期. 2013, No. 12.

Sun, Zhangwei. 2011. "Xitu Maoyi He Guanli Zhengce Bijiao Yanjiu—Yi Riben, Meiguo, Zhongguo Wei Li" (稀土贸易和管理政策比较研究——以日本、美国、中国为例). "A Comparative Research on Rare Earth Trade and Administrative Policy—A Case Study of Japan, U.S. and China". Taipingyang Xuebao (《太平洋学报》). Pacific Journal. Di 19 Juan, Di 5 Qi, 2011 Nian 5 Yue. 第19卷，第5期，2011年5月. Vol. 19, No. 5, May 2011.

Tan, Lee. 2012. "Lynas rare earth project sparks huge campaign in Malaysia". *Friends of the Earth Australia*. Accessed at http://www.foe.org.au/lynas-rare-earth-project-sparks-huge-campaign-malaysia.

"The long arm of the state". 2011. *The Economist*. June 23, 2011. Accessed at http://www.economist.com/node/18832034.

Thomas Jefferson National Accelerator Facility - Office of Science Education. "The Element Lanthanum". Accessed on November 7, 2014, at http://education.jlab.org/itselemental/ele057.html.

Ting, Ming Hwa; Seaman, John. 2013. "Rare Earths: Future Elements of Conflict in Asia?" *Asian Studies Review*, Vol. 37(2), pp. 234-252.

Torrisi, Antonio. 2014. "Investigation Reveals Involvement of Government in the Chinese Rare Earth Black Market". *Industrial Minerals*. November 26, 2014. Accessed at http://www.indmin.com/Article/3404179/Investigation-reveals-involvement-of-government-in-the-Chinese-rare-earth-black-market.html.

Tse, Pui-Kwan. 2014. Email correspondence between Gregory J. Bryant and Dr. Pui-Kwan Tse, USGS.

Tsukasa, Furukawa. 1995. "Japan, China in Rare Earth Accord." *American Metal Market*, December 15, 1995, p. 7.

Tyler, Paul M. 1937. "Minor Metals", "Bureau of Mines Minerals Yearbook", *United States Geological Survey*, pp. 759-786. Accessed at http://images.library.wisc.edu/EcoNatRes/EFacs2/MineralsYearBk/MinYB1936/reference/econatres.minyb1936.ptyler.pdf.

U.S. Geological Survey. 2014. Rare earth statistics, in Kelly, T.D., and Matos, G.R., comps., Historical statistics for mineral and material commodities in the United States: U.S. Geological Survey Data Series 140, accessed at http://minerals.usgs.gov/minerals/pubs/historical-statistics/.

Venton, Danielle. 2012. "Rare-earth Mining Rises Again in United States". Wired. May 11, 2012. Accessed at http://www.wired.com/2012/05/rare-earth-mining-rises-again/.

Wang, Guande; Liu, Chengzong; Li Huacheng. 2003. *Zhongguo Gongchandang Shi* (《中國共產黨史》). *A History of the Communist Party of China.* Taipei: Wunan Tushu Chuban Gongsi (五南出版公司). Taipei: Wunan Tushu Publishing Company.

"Wang Qishan Kaocha Baogang Xitu Yanjiuyuan" (王岐山考察包钢稀土研究院) ("Wang Qishan Visits Baotou Research Institute of Rare Earths"). 2011. *Baogang Xitu Bao* (《包钢稀土报》), *Baogang Rare Earth Paper*. Vol. 13. Accessed at http://www.reht.com/sitefiles/services/cms/page.aspx?s=1&n=315.

Wang, Shihua. 1993. "Riben Qinlue Zhanzheng Shiqi Dui Huabei Gongkuang Ziyuan De Kongzhi He Lueduo". (日本侵略战争时期对华北工矿资源的控制和掠夺). "Japan's Control and Plundering of Northern China's Industry and Mining Resources During the War of Agression Period". *Kangri Zhanzheng Yanjiu* (《抗日战争研究》) *Journal on the War of Japanese Resistance*, Vol. 1, 1993. Accessed at http://jds.cass.cn/UploadFiles/zyqk/2010/12/201012160858394752.pdf.

Wang, Yanan; Li, Wenjun. 2014. “Zai Xiafeng Zhong Tuokuan Lantian” (在狭缝中拓宽蓝天) “Broadening Blue Skies in a Narrow Crevice”. *Zhongguo Kuangye Bao*. (《中国矿业报》) *China Journal of Mining*. Accessed at http://szb.zgkyb.com/Img/2014/10/p20141023e603fe9988c448b7bb2b8e54202da052.pdf.

Wang, Zheng. 2012. *Never Forget National Humiliation: Historical Memory in Chinese Politics and Foreign Relations*. New York: Columbia University Press, 2012.

Wasserstrom, Jeffrey N. 2005. “Chinese students and anti-Japanese protests, past and present.” *World Policy Journal* 22.2 (2005): 59+. Academic ASAP. Web. 22 September 22, 2014.

Weslosky, Tracy. 2015. “China tightens control on the world’s supply of rare earths in 2015”. *Investor Intel*. Accessed at http://investorintel.com/rare-earth-intel/china-tightens-control-worlds-supply-rare-earths-2015/.

Wong, Edward; Bradsher, Keith. 2010. “Chinese Leader Denies Using Mineral Exports for Political Ends.” *The New York Times*. October 8, 2010. Accessed at http://www.nytimes.com/2010/10/09/world/asia/09china.html?_r=0.

Wu, Haimin; Yu, Xuehua. 2012. “Woguo Xitu Chanye Fazhan Xianzhuang Yu Duice Yanjiu” (我国稀土产业发展现状与对策研究). Yunnan Caijing Daxue Xuebao (《云南财经大学学报》). Journal of Yunnan Finance & Economics University. Di 27 Juan Di 2 Qi. 第 27 卷第 2 期. Vol. 27, No. 2.

Wu, Lei; Zhou, Yueping; Zhong, Hongjing. 2003. “Gannan Xitu Kuangqu Baixuebing Bingli Duizhao Yanjiu” (赣南稀土矿区白血病病例对照研究). “A Case Control Study on the Risk Factors of Leukemia in Mining Areas of Rare Earth in South Jiangxi”. *Zhonghua Liuxingbingxue Zazhi* (《中华流行病学杂志》). *China Journal of Epidemiology*. 2003 Nian 10 Yue, Di 24 Juan Di 10 Qi. 2003 年 10 月第 24 卷第 10 期. October 2003. Vol. 24, No. 10.

Wu, Yiding; Liao, Liefa. 2012. “Xitu Hanghe Zhenghe De Beijing, Wenti Ji Celue” (稀土行业整合的背景、问题及策略). Youse Jinshu Kexue Yu Gongcheng (《有色金属科学与工程》). Di 3 Juan Di 4 Qi, 2012 Nian 8 Yue. 第 3 卷第 4 期，2012 年 8 月. Vol. 3, No. 4, August 2012.

“Wu Jingkuang Chengjiao Jiao Pingwen Xitu Yongci Gegu Puzhang” (钨精矿成交较平稳 稀土永磁个股普涨). 2014. Kuang Mishu Wang (矿秘书网). December 27, 2012. Accessed at http://www.kms88.com/news/html/2012/0227/201202271415459rge1.shtml.

Wübbeke, Jost. 2013. “Rare earth elements in China: Policies and narratives of reinventing an industry.” *Resources Policy*, Vol. 38, pp. 384–394.

"Xitu Chukou Guanshui Quxiao Yuqi Luokong" (稀土出口关税取消预期落空). "Cancellation of Rare Earths Export Tariffs Expected to Fail". 2014. *Xinlang Caijing* (新浪财经). *Sina Financial News*. December 16, 2014. Accessed at http://finance.sina.com.cn/chanjing/cyxw/20141216/214521091827.shtml.

"Xitu Gongye Wuranwu Paifang Biaozhun" (稀土工业污染物排放标准). "Emission Standard of Pollutants for Rare Earths Industry." 2011. Huanjing Baohu Bu; Guojia Zhiliang Jiandu Jianyan Jianyi Zongju (环境保护部；国家质量监督检验检疫总局). (Ministry of Environmental Protection; General Administration of Quality Supervision, Inspection and Quarantine). GB-26451-2011. January 24, 2011.

"Xitu Jiage Ru Guoshanche Cong Baicai Jia Shunjian Zhang Zhi Huangjin Jia" (稀土价格如过山车：从白菜价涨至黄金价) "Rare Earths Price Roller Coaster: From Cabbage Prices to Gold Prices", 2014. *Zhong Zheng Wang*. 《中证网》. *China Securities Net*. 2014 Nian 6 Yue 27 Ri. 2014年6月27日. June 27, 2014.

"Xitu Jichu Zhishi (San)". (稀土基础知识（三）) "Rare Earths Basics (Part 3)". "Zhongguo Xitu Hangye Xiehui". (中国稀土行业协会) Association of China Rare Earth Industry. Accessed at http://www.ac-rei.org.cn/portal.php?mod=view&aid=51.

"Xitu Peie Quxiao Hou De Liansuo Fanying". (稀土配额取消后的连锁反应) 2015. "Post Rare Earth Export Quota Cancellation: the Chain Reaction". Huanqiu Wang. 《环球网》. Accessed at http://world.huanqiu.com/hot/2015-01/5419261.html.

"Xitu Yelian Hangye Wuran Fangzhi Kexing Jishu Zhinan (Zhengqiu Yijian Gao)" (稀土冶炼行业污染防治可行技术指南（征求意见稿）). ("Guideline on Available Technologies of Pollution Prevention and Control for Rare Earth Metallurgical Industry (Draft)"). 2014. Huanjing Baohu Jishu Wenjian, Huanjing Baohu Bu (环境保护技术文件、环境保护部). (Environmental Protection Technology Documents, Ministry of Environmental Protection). April 14, 2014. Huanban Han [2014] 412 Hao. Accessed at http://www.mep.gov.cn/gkml/hbb/bgth/201404/W020140418578648367420.pdf.

"Xitu Ziyuan Zhi Zheng: Woguo Ying You Jiji Zuowei" (稀土資源之爭 我國應有積極作為). "The Struggle Over Rare Earths Resources: Taiwan Should Have Positive Behavior". 2014. *Lianhe Caijing Wang* (聯合財經網). *Money.udn.com*. August 16, 2014. Accessed at http://money.udn.com/storypage.php?sub_id=5628&art_id=228011.

Yan, Baocheng; An, Zhongmei; Hao Wu. 2011. "Wo Guo Xitu Chanye Ke Chixu Fazhan De Zhanlue Sikao" (我国稀土产业可持续发展的战略思考). *Kaifa Yanjiu* (《开发研究》). *Research on Development*. 2011 Nian, Di 2 Qi. 2011年第2期. No. 2, 2011.

Yang, Qiang. 2011. “Xitu Zhi Zheng Beijing Xia De Sikao” (稀土之争背景下的思考). “Considerations in Light of the Rare-Earths Struggle”. *Zhongguo Waizi* (《中国外资》). *Foreign Investment in China*. 2011 Nian, Di 3 Qi. 2011年第3期. No. 3, 2011.

Yang, Tiping; Chen, Tao. 2013. “Gannan Mou Xitukuang Kuangshan Huifu Zhili Cuoshi” (赣南某稀土矿矿山恢复治理措施). “Restoration and Control Measures of at a Rare Earths Mine in Southern Jiangxi”. *Keji Bolan*, Di 555 Ye. 《科技博览》第555页. *China Science and Technology Review*, p. 555.

Yap, Chuin-Wei. 2015. “China Ends Rare-Earth Minerals Export Quotas”. *The Wall Street Journal*. January 5, 2015. Accessed at http://www.wsj.com/articles/china-ends-rare-earth-minerals-export-quotas-1420441285.

“Yenei: Xitu Chukou Guanshui Mingnian Quxiao Duoxiang Xinzheng Tiaokong Ziyuan” (业内：稀土出口关税明年取消 多项新政调控资源). 2014. *Xinlang Caijing* (新浪财经). *Sina Financial News*. December 18, 2014. Accessed at http://finance.sina.com.cn/chanjing/cyxw/20141218/143421109197.shtml.

Zeng, Guohua; Wu, Wenwen. 2012. “Zhongguo Nanbei Xitu Chanye Jingzhengli De Bijiao Ji Chayihua Fazhan Celue” (中国南北稀土产业竞争力的比较及差异化发展策略). “A North-South Comparison of Rare Earth Competitive Power and ” Youse Jinshu Kexue Yu Gongcheng (《有色金属科学与工程》). Nonferrous Metals Science and Engineering. Di 3 Juan Di 4 Qi, 2012 Nian 8 Yue. 第3卷第4期，2012年8月. Vol. 3, No. 4, August 2012.

“Zenmeyang Bian ‘Xitu Daguo’ Wei ‘Xitu Qiangguo’ ” (怎么样变“稀土大国”为“稀土强国”). “How to Change from a ‘Great Rare Earths Power’ to a ‘Strong Rare Earths Power’ ”. 2014. *Xitu Xinxi* (《稀土信息》). *Rare Earth Information*. 2010 Nian, Di 9 Qi. 2010年第9期. No. 9, 2010.

Zhang, Qizhi; Chen, Zhenjiang; Jiang, Pei. 1999. *Zhongguo Lishi: Wanqing Minguo Shi* (《中國歷史 晚清民國史》). *History of China: The Late Qing and Republican Period*. Taipei: Wunan Tushu Chuban Gongsi (五南出版公司). Taipei: Wunan Tushu Publishing Company.

Zhang, Yuanyuan. 2012. “Zhongguo Xitu Maoyi Wenti De Falu Yanjiu” (中国稀土贸易问题的法律研究). *Zhonggong Chengdu Shiwei Dangxiao Xuebao* (《中共成都市委党校学报》). *Journal of the Chengdu Municipal Party College of C.P.C.* 2012 Nian Di 3 Qi. No. 3, 2012.

Zhang, Zhuo. 2014. “Meiguo Yongyou Fengfu Xitu Ziyuan Chuliang Quanqiu Di Er Jin Ciyu Zhongguo” (美国拥有丰富稀土资源储量全球第二仅次于中国). “America

Possesses Rich Rare Earths Resources: Second in Production Worldwide, Second Only to China". *Xinlang Junshi*. 《新浪军事》. *Sina Military*. 2014 Nian 4 Yue 21 Ri. 2014年4月21日. April 21, 2014. Accessed at http://mil.news.sina.com.cn/2010-04-21/0943591367.html.

Zhao, Song. 2014. "Riben Jiang Shouci Cong Yindu Jinkou Xitu Yi Jiangdi Dui Zhongguo Yilai" (日本将首次从印度进口稀土以降低对中国依赖). "Japan Prepares to Import Rare Earths from India for the First Time in Order to Decrease its Dependence on China". *Renmin Wang* (人民网). *The People's Net*. August 28, 2014. Accessed at http://world.people.com.cn/n/2014/0828/c1002-25558010.html.

"Zhongguo De Xitu Zhuangkuang Yu Zhengce" (中国的稀土状况与政策). "Situation and Policies of China's Rare Earth Industry". 2012. Zhonghua Renmin Gongheguo Guowuyuan Xinwen Bangongshi. 中华人民共和国国务院新闻办公室. Information Office of the State Council, The People's Republic of China. Accessed at http://www.scio.gov.cn/zfbps/gqbps/2012/Document/1175422/1175422.htm.

"Zhongguo Shishi Qiannian Fazhan Mubiao Jinzhan Qingkuang Baogao: Gaige Kaifang 30 Nian Yu Zhongguo Fazhan" (中国实施前年发展目标进展情况报告：改革开放30年与中国发展). "China Implements Millennium Development Goals: Progress Report (30 Years of Reform and Opening Up and China's Development". 2008. Lianheguo. 联合国. Accessed at http://www.un.org/chinese/millenniumgoals/china08/reform.html.

"Zhongguo Xitu Bei Jianmai Huangjin Maichu Luobo Jia" (中国稀土被贱卖：黄金卖出萝卜价). "China's Rare Earths Go For a Low Price: Gold Sells For the Price of Carrots". 2014. *Tengxun Xinwen*. 《腾讯新闻》. *Tencent News*. March 19, 2010. Accessed at http://news.qq.com/a/20100319/001546.htm.

"Zhongguo Xitu Lishi Huigu" (中国稀土历史回顾). "Looking Back on China's Rare Earths History". 2013. 2015 Shenzhen Guoji Gongneng Cailiao, Xitu Cailiao Ji Yingyong Chanye Zhanlanhui. 2015深圳国际功能材料、稀土材料及应用产业展览会. 2015 Shenzhen (China) International Functional Material, Rare Earth Materials and Application Exhibition. Accessed at http://www.reexpo.cn/News/174.html.

"Zhongguo Xitu Zhi Shang" (中国稀土之殇). "China's Rare Earths Casualties". 2011. *Wangyi Xinwen*. *Wangyi News*. July 24, 2011. Accessed at http://focus.news.163.com/11/0724/00/79MHVEHB00011SM9.html.

"Zhongguo Yanguan Xitu Yingzhan Ou Mei Ri Chansong" (中國嚴管稀土 迎戰歐美日纏訟). 2012. "China Levels Strict Controls on Rare Earths: Going In for the Long-haul in the Lawsuit with the European Union, America, and Japan". *Wenhui Wang*. 《文匯網》. Wenhui Online. July 23, 2012. Accessed at http://news.wenweipo.com/2012/07/23/IN1207230026.htm.

“Zhonghua Renmin Gongheguo Daqi Wuran Fangzhi Fa” (《中华人民共和国大气污染防治法》). “Law of the People’s Republic of China on the Prevention and Control of Atmospheric Pollution”. Accessed at http://big5.gov.cn/gate/big5/www.gov.cn/ziliao/flfg/2005-08/05/content_20945.htm and http://www.china.org.cn/english/environment/34422.htm.

“Zhonghua Renmin Gongheguo Huanjing Baohu Fa” (《中华人民共和国环境保护法》). “Environmental Protection Law of the People’s Republic of China”. 2014. Accessed at http://www.kam-cn.com/uploads/10中华人民共和国环境保护法.pdf.

“Zhonghua Renmin Gongheguo Shui Wuran Fangzhi Fa” (《中华人民共和国水污染防治法》). “Law of the People’s Republic of China on Prevention and Control of Water Pollution”. Accessed at http://big5.gov.cn/gate/big5/www.gov.cn/flfg/2008-02/28/content_905050.htm and http://www.china.org.cn/government/laws/2007-04/17/content_1207459.htm.

“Zhongyang Renmin Zhengfu Dizhi Diaocha Dui Pucha Baiyun Ebo Zhukuang”. (中央人民政府地质调查队普查白云鄂博主矿). “The Central People’s Government Geological Survey Team Makes a General Survey of the Main Mine At Bayan Obo”. Accessed at http://www.cre.net/show.php?contentid=17236.

“973 Jihua Qidong Xitu Gaoxiao Tichun Zhongda Yanjiu Xiangmu”. (973计划启动稀土高效提纯重大研究项目) “973 Program Commences Important Research Project on the High-efficiency Purification Rare Earths”. Zhonghua Renmin Gongheguo Kexue Jishu Bu. (中华人民共和国科学技术部). Ministry of Science and Technology of the People’s Republic of China. Accessed at http://www.most.gov.cn/kjbgz/201204/t20120426_93941.htm.

APPENDIX

In 1787, Swedish army lieutenant and chemist Carl Axel Arrhelius discovered a unique black mineral in a feldspar and quartz mine (Hedrick, 2003) near the village of Ytterby, not far from Stockholm, Sweden. The mineral proved to be a mixture of several different types of rare earths, and the first rare earth element to be separated was cerium. Cerium (atomic number 58), the most abundant of the rare earth elements (making up about 0.0046% of the earth's crust by weight) was discovered by three scientists in two places in one year. Jöns Jakob Berzelius and Wilhelm Hisinger, of Sweden, and Martin Heinrich Klaproth of Germany were responsible for the 1803 find of cerium (Thomas Jefferson National Accelerator Facility - Office of Science Education, 2014), which Berzelius named after the dwarf planet Ceres, itself just recently discovered in 1801. Cerium is used widely in many applications ranging from glass to lighting ("Xitu Jichu Zhishi (San)").

Lanthanum (atomic number 57), often found in combination with cerium, was discovered in 1839 by Carl Gustaf Mosander, a Swedish chemist, who was examining what he thought to be impurities in cerium deposits. Uses for lanthanum include carbon arc lights used in the motion picture industry for studio lighting and Misch metal (of which lanthanum makes up 25%), used to make flints for lighters (Thomas Jefferson National Accelerator Facility - Office of Science Education, 2014).

In 1885, Carl F. Auer von Welsbach, a German chemist, discovered praseodymium. He separated praseodymium from another element, neodymium. Both elements were found in a material called didymium. Praseodymium is used as an alloying agent along with magnesium to strengthen metals used in aircraft engines, as well as having uses in glass coloring, carbon arc lighting, and accounting for 5% of the Misch metal used in lighter flints.

Welsbach's discovery of one twin—praseodymium—led to the natural discovery of its "other half", neodymium. Neodymium, though commonly classed as one of the rare earth elements, is in fact found in the earth's crust not more rarely than cobalt, nickel, and copper. Since early days, neodymium has been used as a glass additive, and more recently, neodymium has become well-known for its uses in the permanent magnet industry.

Promethium, or "element 61", is an element all of whose isotopes are radioactive, and which rarely occurs in the natural world. In 1902, Bohuslav Brauner suggested its existence when he predicted that there must be an element whose properties fell between the then-known elements neodymium (atomic number 60) and samarium (atomic number 62). For years, "element 61" remained a phantom of the laboratory, until it was first produced in 1945, although a sample of the metal was not made until 1963. Promethium-147, the only type of promethium used outside the laboratory, finds applications in luminous paint, atomic batteries, and thickness measurement devices.

Paul Emile Lecoq de Boisbaudran, a French chemist, is traditionally credited with the final discovery of element 62, samarium, in 1879. Samarium was named after the mineral from which it was extracted, samarkite. Underscoring the fact that "rare earths" are not necessarily "rare", samarium is the 40th most common element in the earth's crust, and is more abundant than tin. Samarium's most widely-known application is the samarium-cobalt magnet, which has permanent magnetic properties only second to neodymium, and can withstand temperatures above 700 degrees Celsius without losing its magnetic properties. In addition, Samarium also has applications in cancer-fighting drugs and control rods in nuclear reactors.

Europium (atomic number 63) was first discovered in 1896 by French chemist Eugene-Anatole Demarcay, who was the first to successfully isolate it (and subsequently named it). Europium is an element from which phosphorescent europium compounds are formed in combination with other elements. One of the most widespread uses for europium is in the red phosphors used for television and computer screens. After this use for europium was discovered in the 1960s, europium demand increased considerably.

Atomic number 64 belongs to gadolinium, a rare earth element discovered by Jean Charles Galissard de Marignac in 1880. Gadolinium was named after the mineral in which it was found, gadolinite, which was also named after its discoverer, Johan Gadolin. Gadolinium was first successfully isolated by de Boisbaudran in 1886. Apart from being used as a phosphor in green television tubes, gadolinium has many other specific applications in the fields of neutron therapy, metallurgy, MRI technology (as part of an intravenous MRI contrast agent), imitation diamonds, and magnetic refrigeration.

Lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, and gadolinium, the eight elements above, are part of the Light Rare Earth Elements (LREEs). The following eight elements are part of the Heavy Rare Earth Elements (HREEs) group: terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, and yttrium. The final rare earth is scandium (atomic number 21).

Terbium (atomic number 65) was discovered in 1843 by Carl Gustaf Mosander, the Swedish chemist who had discovered lanthanum in 1839. Terbium was discovered as an impurity in yttrium oxide. Like many of the other rare earths, terbium does not occur alone in nature, but is found in deposits of monazite, xenotime, and euxenite. Terbium finds application in crystal stabilizers for fuel cells, naval sonar systems, and green phosphors used in fluorescent lamps and color television tubes, etc.

In 1878, de Boisbaudran, who would in 1879 discover samarium, laid claim to the discovery of dysprosium (atomic number 66). At the time of discovery, de Boisbaudran was experimenting on holmium oxide, from which he separated dysprosium oxide. He was successful in isolating dysprosium from the dysprosium oxide through a tedious process of dissolving and precipitation. It is claimed that de Boisbaudran succeeded in isolating dysprosium after thirty attempts of his method. Thus, he named the element dysprosium, which comes from the Greek "δυσπρόσιτος", meaning "difficult to get". Dysprosium is used in laser materials, commercial lighting, control rods in nuclear reactors, as well as being used in Terfenol-D, a material with the highest known room-temperature magnetostriction.

Holmium (atomic number 67) was discovered and named after the city of Stockholm by Per Theodor Cleve in 1878. It was discovered using the same method by which Mosander had discovered lanthanum, erbium, and terbium. Cleve's method produced two oxides, one called holmia, and the other called thulia. Holmia oxide contains holmium, and thulia oxide contains thulium, both rare earth elements. Holmium has the distinction of having the strongest magnetic properties of any element, and is used in high-strength magnets as a magnetic flux concentrator.

The village of Ytterby, Sweden, was the site where the first of rare-earth-latent minerals were discovered in 1787. It is not surprising that, then, that over the years, Ytterby would be linked to more rare earths. In fact, four of the rare earths were named after the village (yttrium, terbium, erbium and ytterbium). In 1843, the Swedish chemist Carl Gustaf Mosander discovered erbium (atomic number 68), in addition to terbium. Erbium has specific uses in fiber-optic technology as an optical amplifier, as well as having uses in laser technology critical to medical surgery procedures.

Atomic number 69, thulium, was discovered by Cleve in 1879, but not obtained in its pure state until 1911 by researcher Charles James at New Hampshire College in Durham. After promethium, thulium is the second rarest of the lanthanides, and is used in solid state lasers and as a source of radiation in portable X-ray devices.

The fourth rare earth element to be named after the “rare earth capital” Ytterby, Sweden, is ytterbium (atomic number 70). It was separated and named in 1878 by Swiss chemist Jean Charles Galissard de Marignac, one hundred years after the first rare earths were discovered in Ytterby in 1787.

Lutetium (atomic number 71), one of the rarest of the rare earths (though not as rare as silver in the earth’s crust), was discovered independently by three chemists in the same year. French scientist Georges Urbain, Austrian mineralogist Baron Carl Auer von Welsbach, and American Chemist Charles James all laid claim to the discovery of the element in 1907. In the end, Urbain and von Welsbach disputed the issue of first discovery, with the International Commission on Atomic Weights weighing in favor of Urbain. Lutetium’s uses are limited in scope by its scarcity, but by no means limited in importance. Lutetium has catalyst applications in key processes such as petroleum cracking, alkylation, hydrogenation, and polymerization.

Yttrium (atomic number 39) hails back to the early days of rare earth discovery. Originally discovered in the ytterbite mineral found by Carl Axel Arrhenius in 1787, Yttrium oxide was discovered by Johan Gadolin in 1789, and was named yttria by Anders Gustaf Ekeberg. Although yttrium is technically not part of the lanthanide series, because of its chemical affinity to the lanthanides, it has traditionally been treated as a rare earth element. Yttrium is used in the making of red phosphors that are critical to the production of cathode ray tubes used in color televisions and LEDs, as well as playing an important role in the making of superconductors and lasers.

It was not until the 1970s that applications were found for scandium (atomic number 21), an element that has sometimes been classified as a rare earth due to its common presence in rare earths ores. Scandium was discovered by Lars Fredrik Nilson in 1879, proving the earlier intuition of Dmitri Mendeleev that such an element existed. Its main applications are in aluminum alloys, finding its way into high-end products such as fighter planes and high-intensity discharge lamps, as well as lower-end applications such as baseball bats and firearms.