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MINING AND EXPLOITATION OF RARE EARTH ELEMENTS IN AFRICA AS AN ENGAGEMENT STRATEGY IN US AFRICA COMMAND

By

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A paper submitted to the Faculty of the Joint Advanced Warfighting School in partial satisfaction of the requirements of a Master of Science Degree in Joint Campaign Planning and Strategy. The contents of this paper reflect my own personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.

This paper is entirely my own work except as documented in footnotes. (or appropriate statement per the Academic Integrity Policy)

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ABSTRACT

Rare earth elements are a key ingredient in high-technology products that are critical to defense, energy and other industries that impact national security and economic viability. The United States enjoyed a monopoly in rare earth mining and exploitation until the late 1990s when China gained monopoly status. They now supply over 95% of rare earths to the world. China's explosive economic growth has put them on a path to consume 100% of all the rare earths they produce in just a few years, leaving nothing for export. Recognition of this fact has led nations all around the world to seek out new sources of rare earths to prevent the loss of these key elements and the disruption in production of end products critical to their interests.

This thesis proposes that the United States, through a whole of government approach including United States Africa Command, can achieve several national objectives by assisting African nations in mining and exploitation of rare earths. This assistance can serve to increase the supply of rare earths as well as improve the governance, human development, and economic well-being of African nations through an increase in revenue. There are many risks which must be weighed before embarking in rare earth mining and exploitation as part of a broader engagement strategy. The likelihood of success must be carefully considered to prevent failure of the engagement strategy, thus negatively impacting both the U.S. and the partner nation.

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CHAPTER 1: INTRODUCTION

Rare Earth Elements are a narrow group of elements found naturally in the earth's crust. Over the last 60 years, their relevance and importance in high-technology products has greatly increased. The United States was the monopoly producer of rare earths until the late 1990s. Due to a combination of factors which will be explored, monopoly control of rare earths passed to China. Over the next two years, China's consumption of rare earths will eclipse its capacity to produce them. This has precipitated global action to identify new sources of rare earths to meet demand as prices of rare earths have increased significantly.

The United States (U.S.) has a stated goal of engagement in Africa to both guarantee long-term U.S. interests as well as improve African partner nations' governance, human development, and economic development. This nexus between U.S. interests and the benefits of capital infusion to African nations able to successfully identify and exploit rare earths has resulted in an opportunity to benefit the U.S. and partner nations in Africa.

This thesis argues that the U.S. should engage the whole of government in mining and exploitation of rare earths in Africa as one part of a broader African strategy of engagement to improve U.S. long term interests, African partner nation governance, human development, and economic development. It is critical to realize that rare earth mining and exploitation cannot be the only effort on the continent as this endeavor is fraught with risks and perils. The time horizon for economic profitability from rare earth exploitation is measured not in months or years but over a decade or more.

The U.S. Government must have a clear reason for acting in this arena. Determination of why one African nation over another is selected must be settled at the outset. The government must determine if it is acting out of U.S. values or interests. It must also determine the level of involvement. Is it leading the effort or facilitating in the background? Finally, the government must determine the likelihood of success and whether it is acting to benefit the U.S., African nations, or both. This is not only measured in tons per day, but in the less measurable areas like: have U.S. efforts increased the supply chain in an economically viable way, has the level of governance improved, has it improved human rights and conditions, and has it improved the economic state of the partner nation?

Chapter two will focus on national strategic guidance with respect to Africa. Next, a review of US Africa Command's operational level strategy will serve to link national guidance with the subject of this thesis, rare earth elements. By identifying rare earth elements as a strategic resource to the U.S., the connection from rare earth exploitation in Africa to advancing national objectives will be made.

Next, in chapter three, a brief scientific description of rare earths will lay a foundation for and appreciation by the reader of the complex role of rare earths play in our modern age. Additional amplifying information not central to the issue, but still important in considering the overall play of rare earths is contained in Appendix A. The balance of the third chapter will delve into the state of rare earths in the current and former monopoly owners, the United States and China. Following this, a catalog of efforts from around the world will describe current efforts around the world by other nations to both increase the supply of rare earths and reduce dependence on China for materials critical to future economic development.

The fourth chapter will describe and catalog current efforts in Africa to explore for and exploit rare earth elements. This will provide a baseline of current and future efforts. This will also reveal just how difficult undertaking rare earth exploitation is, especially in an underdeveloped part of the world.

The fifth chapter takes us back a few decades for a brief historical account. In an effort to guide the Command, an in-depth case study of a successful natural resource mining and exploitation joint venture will be studied. This joint venture involved Exxon and the Colombian government as they sought to mine and exploit coal in the nineteen seventies and eighties. This very successful venture combined the technical and business acumen of a major international corporation with a willing government that lacked the technical abilities to achieve success without outside help. This case study will provide a foundation for the Command, international corporations, and African nations to build a cooperative engagement strategy.

The final section of this paper will deal with how to move forward in rare earth mining and exploitation as part of a broader engagement strategy to further American and African interests. Time will also be spent on discussing the pitfalls and risks to the U.S. government in using rare earth mining and exploitation as a method to serve long-term U.S. and African interests. Finally, a proposed decision making matrix will be presented to be used as a tool by the combatant commander and his staff to prioritize and define where to act.

CHAPTER 2: U.S. STRATEGIC INTERESTS IN AFRICA

National Level Guidance

President Obama signaled in his 2010 National Security Strategy that strategic engagement in Africa would serve to further the goals of the United States and Africa. He recognized that the diversity and complexity of the continent presents our government with unique challenges and opportunities. To solve these challenges and take advantage of the opportunities, he suggests a consultative approach focusing on access to open markets and strategic interventions that foster job and economic growth. By increasing trade and investment, the U.S. can foster improved governance and development.[1]

As the U.S. moves forward in engagement in Africa and other regions, the whole of government approach is a key tool. The President directs the government to, "…invest in diplomacy and development capabilities and institutions in a way that complements and reinforces our global partners."[2] By utilizing this approach, he intends for partner nations to participate in global economic expansion thereby strengthening global and regional partnerships. The increased prosperity will ensure more prosperous and capable democratic states. By cooperating with financial institutions and targeting development investment, we can achieve his overarching goals.[3]

In late August 2010, the President further defined his objectives in Africa. The President declared that, "Africa's prosperity can expand America's prosperity."[4] By linking African nations' successful economic, human rights, and good governance

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[1] Barack H. Obama, *National Security Strategy*, U.S. Government Printing Office, Washington, D.C., 2010, 45.
[2] Ibid., 15.
[3] Ibid.
[4] Barack H. Obama, *Fact Sheet: The President's Engagement in Africa 2010*, 1.

progress to America's progress, he provided broad guidance to all facets of the U.S. government on how to engage.

United States Africa Command Theater Strategy

As the newest combatant command, United States Africa Command (USAFRICOM) is faced with many of the same problems as other combatant commands. What sets USAFRICOM apart is that its area of responsibility (AOR) comprises some of the most under-developed nations in the world with governing structures and educational systems that match. Because of these unique challenges, there are tremendous and numerous opportunities to advance U.S. strategic interests as well as the development level of African nations with respect to economic, governmental, and human development.

For the U.S. to achieve peace and security in the region, it must foster maturation of governments, improvements in human development, and development of economies. The limited resources of the United States and its allies prevent action in every nation in Africa. Instead, the United States, through USAFRICOM and other governmental agencies, must prioritize its efforts in the most cost-effective manner to achieve short and long-term goals. By utilizing all of the instruments of national power (diplomatic, information, military, and economic), the government attempts to achieve these goals in this most economically efficient manner while maximizing the return on investment measured by the advancement of strategic goals.

During a visit to Ghana in 2009, President Obama defined five priority areas to secure Africa's future. Opportunity was one of the priority areas.[5] There exists

[5] William Ward, *Commander's Intent 2010*, (Stuttgart: United States Africa Command Public Affairs, 2010), 1.

significant opportunity for African nations to develop rare earth elements to provide an income stream to provide economic opportunity for their people.

General William Ward, the first commander of U.S. Africa Command, stated that, "…our national interests lie in a stable continent of Africa."[6] The general defines a stable Africa as requiring three key elements: effective governance, economic advancement, and social advancement. Gen Ward concludes his intent stating that, "Only through security and development can there be stability, and only through stability can there be HOPE for the future."[7] Clearly, any venture that shows promise of generating wealth that can be harnessed by African nations will be beneficial in improving these three areas, if the wealth generated is shared among the people either through direct transfer, or in other ways such as education or infrastructure investment.

Rare Earth Elements

As part of the annual professional military education institutions' call for topics, USAFRICOM identified the potential for development of rare earth element mining and exploitation in Africa to provide a source of economic and social development for the nations on the continent to meet U.S. strategic goals. This should be considered one part of a multi-faceted engagement strategy for the U.S. government and U.S. business interests.

Rare earths are critical to many industries today and the demand for these elements continues to increase rapidly each year. Over the last fifty years, the mining and exploitation of rare earth elements has shifted from a monopoly of the United States to a monopoly of China due to many circumstances, some of which will be explored in detail

[6] Ward, *Commander's Intent 2010*, 1.
[7] Ibid.

in the next chapter. The demand for rare earths has slowly increased over the last 50 years, with significant growth since 2005.

The last five years specifically have revealed that world demand for rare earth elements will soon exceed the supply provided by China (to be explained in detail later in Fig 6) and this has prompted developed nations around the world to seek more sources or re-energize domestic operations. “In recent years, the Chinese have flooded, and thus cornered, about 97 percent of the world market of rare earth metals, and now thanks to high-tech demand and new Chinese restrictions on exports, the price of some of these rare earth elements has skyrocketed as much as 500 percent in the last year alone.”[8] Pursuing foreign sources of rare earths for the United States is an expensive endeavor, but demand for the limited supply will drive exploration, both abroad and at home.

As the United States and other nations seek other sources of rare earth elements for their industries or as an investment opportunity, offers of assistance to develop rare earth mining and exploitation by USAFRICOM and the U.S. government to African nations could serve as a key part of a broader engagement strategy designed to foster U.S. interests and values for both the benefit of the U.S. as well as partner African nations. Successful joint ventures between African nations and international corporations and governments will serve to solve some of the myriad of problems experienced by African nations today and in the future by providing them with a revenue stream. A lack of engagement by the U.S. would result in a missed opportunity to strengthen both U.S. and African nations’ economies and needs. China has been taking steps to exploit the potential for rare earth elements in Africa. If they succeed, their monopoly will only

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[8] Adam Housley, “Mine in Mojave Desert May Hold Key to Beating China in the Race for Raw Materials,” Foxnews.com, April 6, 2011, http://www.foxnews.com/scitech/2011/04/06/mojave-desert-lifeblood-americas-technical-security/ (accessed April 10, 2011), 1.

grow as will other nations' reliance on Chinese export policy for access to rare earths. This will only serve to exacerbate the current problem of the diminishing supply of these critical elements to defense and other critical industries and applications. This is not a problem that shows any signs of receding.

CHAPTER 3: RARE EARTH ELEMENTS AS A STRATEGIC RESOURCE

Classification and Description

Rare earth elements are a grouping of 17 elements from scandium (Sc, atomic number 21), yttrium (Y, atomic number 39), and the 15 additional elements numbered 57 to 71 on the periodic chart; they are also called the lanthanides.[1] The lanthanides in atomic order are lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. (See Fig 1) “The elemental forms of rare earths are iron gray to silvery lustrous metals that are typically soft, malleable, and ductile and usually reactive, especially at elevated temperatures or when finely divided.”[2] The properties of rare earths share many common characteristics and they are typically found trapped together in the earth’s crust.[3]

Though they are called rare, they are not. “The rare earths themselves are pure or mixed oxides of these metals, originally thought to be quite scarce; however, cerium, the most plentiful, is three times as abundant as lead in the Earth’s crust.”[4] Additionally, “they are also found in meteorites, on the Moon, and in the Sun.”[5] Rare earths are relatively abundant in the Earth’s crust, but discovered minable concentrations are less common than for most other ores.[6]

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[1] Britannica Online Encyclopedia, “Rare Earth Element,” Britannica.com, http://www.britannica.com (accessed September 8, 2010), 1.

[2] Global Security.org, “Rare-Earth Elements,” http://www.globalsecurity.org/military/world/china/rare-earth.htm (accessed October 14, 2010) Globalsecurity.org, 2010, 2.

[3] Geology.com, “REE Rare Earth Elements and their Uses,” Geology.com, http://geology.com/articles/rare-earth-elements/ (accessed November 3, 2010), 1.

[4] Britannica, 1.

[5] Ibid., 4.

[6] Global Security.org, 2.

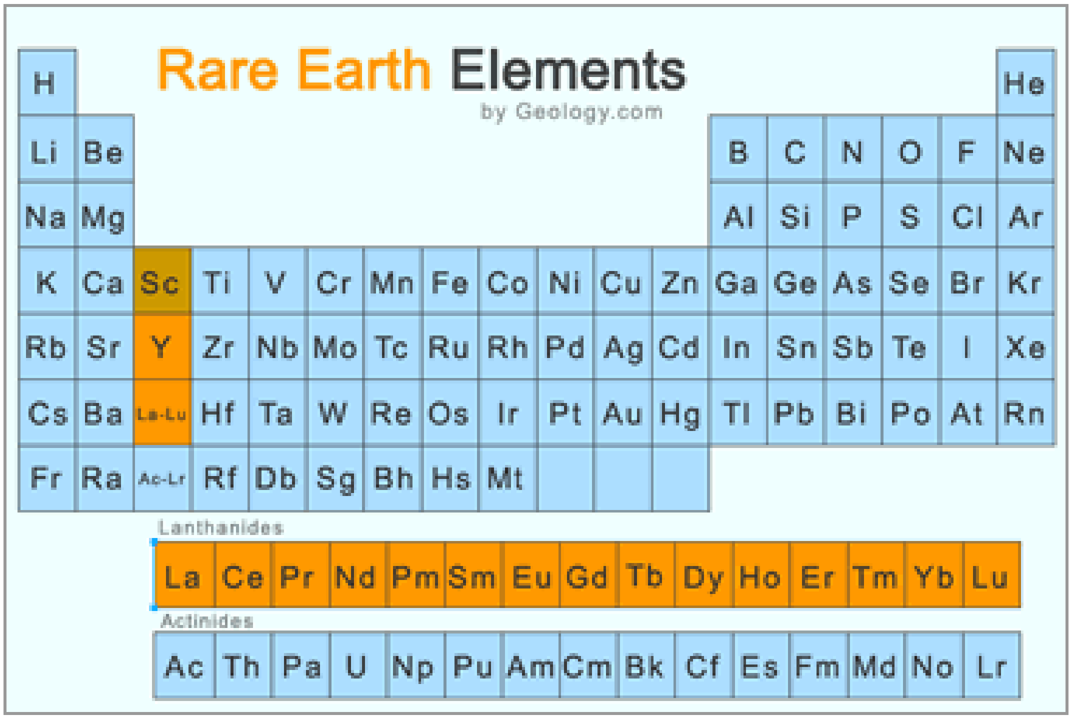

Figure 1- Rare Earth Elements[7]

Though they are found in many places, the challenge lies in finding them in a high enough concentration to make economically feasible to mine and exploit. "…they are expensive, and separating them from ore is costly. Some rare earth minerals are accompanied by radioactive products, such as thorium and radium, which make extraction difficult and costly, since they pose the risk of radiation leaks."[8] "In the few cases in which the rare-earth ion can be oxidized or reduced to another oxidation state, however, chemical separations can be carried out readily."[9] They never occur free, that is, by themselves, and the pure oxides never occur in minerals.[10] "The rare-earth elements all have certain common features in the electronic structure of their atoms, which is the fundamental reason for their chemical similarity."[11] Rare earths have very

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[7] Geology.com, 1.
[8] Global Security.org, 1.
[9] Britannica, 2.
[10] Ibid., 1.
[11] Ibid., 2.

similar properties and remain very tightly mixed with each other, making it essentially impossible to find them by themselves.[12]

The unique challenge of separating rare earths is much different than for isolating gold from a mixture of other elements. Gold is separated out in a relatively simple one-step process. Rare earths are mined, crushed, milled into a fine sand, and subjected to the floatation process which isolates the material bastnaesite which is recovered from the mixture. Acid and other solvents are then applied to the bastnaesite to separate out the rare earths. Once separated, they are reprocessed to increase the purity level. The process takes as long as ten days to complete. The complete process is environmentally hazardous if not done correctly.[13]

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[12] Britannica, 4-5.

[13] Cindy Hurst, "China's Rare Earth Elements Industry: What can the West Learn?" *Institute for the Analysis of Global Security*, March 2010, 4-5.

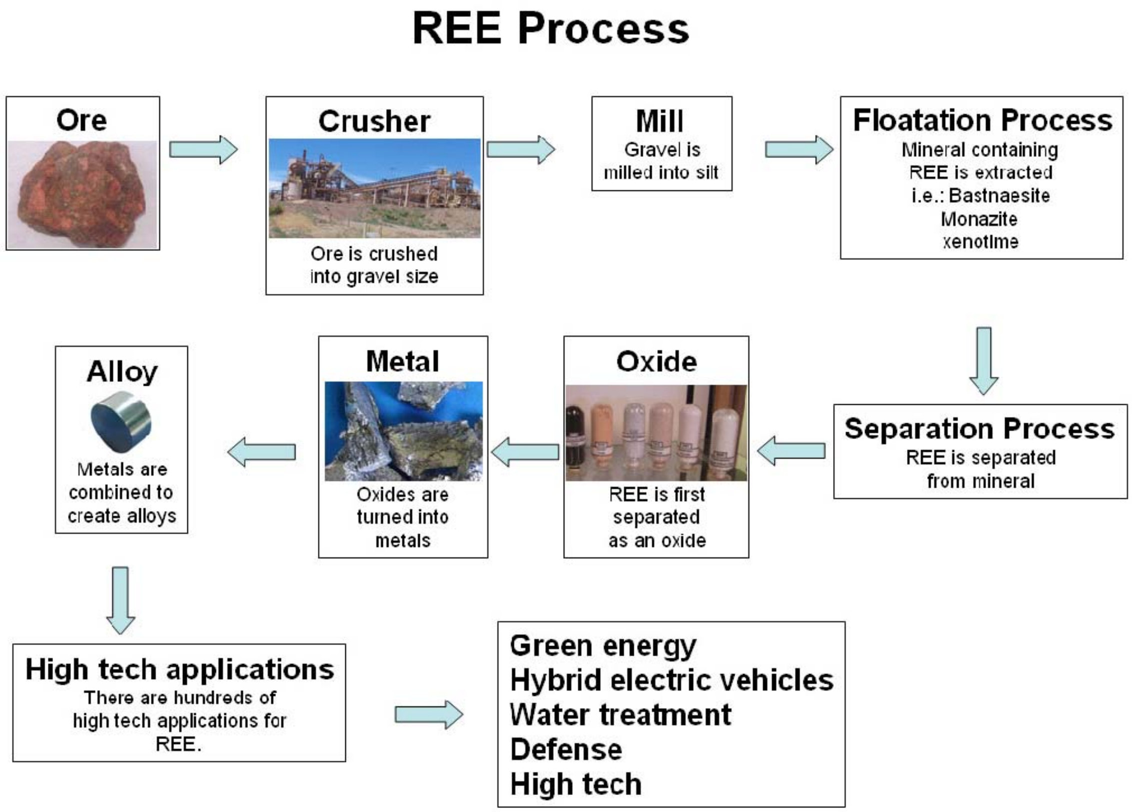

Figure 2 – REE Process[14]

Strategic Importance of Rare Earth Metals

Rare earths are used in a variety of applications important to industrialized nations in technical applications. In many cases, there are other elements or combinations of elements that can substitute for rare earths, but they do not perform as well. Frequently, theses substitutes are much cheaper, but are not efficient enough to be profitable.[15]

Beyond direct technical applications, rare earths are used to facilitate production of and refinement of other products. Rare earths are used in the refining of petroleum, as a catalyst in organic reactions, and in forming polyesters. Their use as catalysts in many chemical processes also makes them valuable.[16] Additionally, they are used in many facets of the glass industry. They act as polishing agents for optical glass, reflex lenses,

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[14] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 5.
[15] Britannica, 19-21
[16] Ibid.

correcting optical anomalies. They can also be used as tinting or coloring agents to achieve unique colors or to decrease glare.[17]

Another use of rare earths is as a component of an alloy of another metal. Their properties can increase or decrease ductility and malleability or make a metal more workable in high-temperature operations. They can also increase metals anti-rusting properties. Another important contribution of a metal with a rare earth alloy is the desired resistance to creep. Creep is found in high temperature, high-tension environments such as the turbine blades of a jet engine. As an engine spins at high revolutions, it has strength to resist breaking apart under the high tension loads. Adding heat reduces this strength. In a jet turbine application, the use of emergency power levels is restricted as short periods of time of over-temperature operations can rapidly deteriorate the ability of a metal to "hold together." Rare earths added to an alloy mixture can increase the resistance of a pure metal to creep.[18]

One of the earliest uses of rare earths was in color televisions. Mixing certain rare earths, europium oxide for example, heightens the red phosphor. Introduction of rare earths into the industry made colors sharper and more brightly colored. Outdoor stadium lighting also benefitted from incorporating rare earths by making their colors more like daylight. The motion picture industry improved its lighting with rare earths as did the application of rare earth in improving searchlights.[19]

Some additional applications of rare earths include microwave filters used in communication equipment. Permanent magnets, nuclear control rods, and x-ray film are other applications of rare earths. They can also be used in the jewelry industry because

[17] Britannica, "19-21.
[18] Ibid.
[19] Ibid.

of their hardness and refraction.[20] Some more practical every day applications include computer memory, DVD players, rechargeable batteries, cell phones, catalytic converters, fluorescent lights, hybrid vehicle batteries, and other pollution control devices.[21]

Figure 3 illustrates predominant rare earth element uses in the United States in 2008.

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Application	**Percentage**
Metallurgy & Alloys	29%
Electronics	18%
Chemical Catalysts	14%
Phosphors for monitors, TV, and lighting	12%
Catalytic Converters	9%
Glass polishing	6%
Permanent magnets	5%
Petroleum refining	4%
Other	3%

Figure 3 – Table of Rare Earth Element Uses in the U.S. in 2008[22]

Rare earth elements play an essential role in our national defense. In the Gulf Wars, night-vision goggles, precision-guided weapons and other defense technology gave the United States military a tremendous advantage. Rare earth metals are key ingredients for making the very hard alloys used to make armored vehicles and projectiles that shatter upon impact in thousands of sharp fragments.

Substitutes can be used for rare earth elements in some defense applications, however, those substitutes are not as effective and that will diminish military superiority. Several uses of rare earth elements are summarized in Figure 4.[23]

[20] Geology.com,, 1.
[21] Britannica, 19-21
[22] Geology.com, 1.
[23] Ibid.

Defense Uses of Rare Earth Elements	
Lanthanum	night-vision goggles
Neodymium	laser range-finders, guidance systems, communications
Europium	fluorescents and phosphors in lamps and monitors
Erbium	amplifiers in fiber-optic data transmission
Samarium	permanent magnets that are stable at high temperatures
Samarium	precision-guided weapons
Samarium	"white noise" production in stealth technology

Figure 4 - Defense Uses of Rare Earth Elements[24]

> The rare earths' unique properties are used in a wide variety of applications. Lanthanum (atomic number 57) is used in batteries. Neodymium (atomic number 60) is used in magnets for electric motors. Europium (atomic number 63) is used in colored phosphors and lasers. Rare earth metals are also used in manufacturing energy-efficient windows and in capacitors, sensors and scintillators used in electricity transmission. Rare-earth elements are key components of the green energy technologies and other high-technology applications. Some of the major applications include hybrid automobiles, plug-in electric automobiles, advanced wind turbines, computer hard drives, compact fluorescent light bulbs, metal alloys, additives in ceramics and glass, petroleum cracking catalysts, and a number of critical military applications. Some of these applications rely on permanent rare earth magnets that have unique properties, such as the ability to withstand demagnetization at very high temperatures.[25]

The current state of production is from a small number of countries throughout the world. Though the United States was once a leader in the production of rare earth elements, this trend was reversed more than a decade ago when China became the world leader in rare earth element production. This will be discussed in detail in later chapters. Figure 5 illustrates the major and minor players in rare earth element production as of 2009.

[24] Geology.com, 1-2.
[25] Global Security.org, 1.

Country	Production (Metric Tons)	Reserves (Metric tons)
United States	Insignificant	13,000,000
Australia	Insignificant	5,400,000
Brazil	650	48,000
China	120,000	36,000,000
Commonwealth of Independent States	Unknown	19,000,000
India	2,700	3,100,000
Malaysia	380	30,000
Other Countries	Unknown	22,000,000

Figure 5 – Table of Major and Minor Players in Rare Earth Element Production[26]

Rare earths are relatively abundant in the Earth's crust, but discovered minable concentrations are less common than for most other ores. U.S. and world resources are contained primarily in bastanite and monazite. Bastanite deposits in China and the United States constitute the largest percentage of the world's rare earth economic resources, while monazite deposits in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States constitute the second largest segment. Apatite, cheralite, eudialyte, loparite, phosphorites, rare-earth-bearing (ion adsorption) clays, secondary monazite, spent uranium solutions, and xenotime make up most of the remaining resources. Undiscovered resources are thought to be very large relative to expected demand.[27]

Rare Earth Elements in the United States

The history of rare earth elements in the United States is an interesting study in market forces, environmental considerations, government regulation, and international competition. In the past the U.S. was the world leader in rare earth element mining and exploitation. It has been completely supplanted in this role by China. Recent actions by

[26] Geology.com,, 2.

[27] U.S. Department of the Interior, Mineral Commodities Summary *Rare Earths*, by James B. Hedrick, U.S. Geological Survey, 2010, 129.

China to limit exports have led the United States to re-enter the mining and production of rare earth elements, but this is not an overnight process.

The race to develop atomic weapons was frantic after World War II. Competition during the Cold War with Russia was intense. The U.S. was working very hard to cement its monopoly on atomic weapons for as long as possible. Uranium, a key component of nuclear weapons was sought after wherever it could be found. This motivated many prospectors to search for the valuable element all over the U.S. in hopes of striking it rich.[28]

Two prospectors stumbled across radioactive material at Mountain Pass in 1949. Thinking it was Uranium, they had the sample analyzed along with the brown colored material in the outcropping. What they had found was not Uranium, but radioactive thorium. The brown material was the rare earth element flourocarbonate bastnaesite.[29]

The discouraged miners moved on. The Molybdenum Corporation laid claim to the area and in 1953 began the mining of bastnaesite and europium. This is the rare earth used in televisions. The era of the cathode ray tube and its domination of television projection had begun. The rare earths at Mountain Pass used in the television industry were extremely pure and of very high quality.[30]

In later years, the mine produced more rare earths including lanthanum, cerium, neodymium and praseodymium. Mountain Pass, now owned by Molycorp Minerals, became the prime source of rare earths for the entire world.[31]

[28] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 10.
[29] Ibid.
[30] Ibid.
[31] Ibid.

American dominance continued unopposed into the 1970s. Rare earth element study and potential uses flourished. "…American students and professors were greatly interested in learning about the properties of these unique materials."[32] Their interest lessened as the 1970s progressed. Professor Karl Gschneider, Jr, considered the father of rare earths offered an opinion on why American scientists and students turned their attention to other areas of research. "US interest seems to have waned, not due to a lack of resources, but a tendency of student's to gravitate toward 'what's hot…as needs arise for new technologies, such as developing advanced biofuels, student interest tends to shift, remaining on top of the latest trends."[33] This shift in attention would eventually cost the United States its leadership in the rare earth industry. This loss of leadership progressed over several decades. The rise of China as a leader in rare earths began during this time.

The seventeen different rare earths have ebbed and flowed in their importance based on the applications of the time. "During the early 1960s, lanthanum was used in the optical glass industry; cerium was widely used to polish media; didymium, a mixture of the elements praseodymium and neodymium, was widely used in the glass industry for coloring."[34] This fluctuation in demand made it difficult to develop long-term strategies for specific elements based on the need of the day. As technologies developed and changed rapidly, the uncertainty in the market made it difficult to make plans for long term stability.

Chinese business acumen was not the only contributing factor to the U.S. loss of rare earth leadership. Ever increasing environmental regulations drove operating costs up and

[32] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 6.
[33] Ibid.
[34] Ibid., 12.

cut into profit margins. China's ability to sell rare earths cheaper forced a migration of business out of the U.S.

> Mining of rare earth is environmentally an extremely hazardous enterprise and the growing environmental awareness in the West also fed into the decision of surrendering the production of rare earths to Chinese control…Thus the present Chinese monopoly on rare earth is not only a result of a conscious strategy on the part of China, but the consumers of rare earth were equally comfortable with this kind of arrangement where China was performing the dirty work of mining the rare earth and advanced economies were busy making high-tech products.[35]

The exodus of U.S. corporations from the rare earth industry was spurred on by crushing environmental regulations. The hemorrhaging of U.S. manufacturers and manufacturing jobs to Mexico, China, and other overseas destinations has been a topic of heated controversy for decades.[36]

Jasper, in his article "Engineered Extinction" specifically mentions U.S. rare earth mining. He details the impact that government regulations and environmental activism has had on the mining industry. By branding the mining industry as ravaging the countryside, they attempt to block all efforts. He notes that the House Resources Committee points out that more than 40 percent of mined areas have been restored and that less than 0.3% of the U.S.'s land has been mined. The intense pressure from environmental lobbies forced closure of Mountain Pass in California (the largest mine producing lanthanide) despite the effect of ceding monopoly control of rare earth

[35] Justin Rohrlich, "How China Came to Dominate the Rare Earths Market," December 29, 2010, http://www.minyanville.com/businessmarkets/articles/rare-earths-china-green-renewable-energy/12/29/2010/id/31922 (accessed January 4, 2011), 2.

[36] William F. Jasper, "Engineered Extinction," December 1, 2003, http://www.stoptheftaa.org/artman/publish/article_55.shtml (accessed January 4, 2011), 1.

production to the Chinese and loss of millions of dollars to the industry. We are now completely dependent on China for critical components for military applications.[37]

The Mountain Pass mine suffered an environmental accident in the late 1990s when a leak of radioactive byproduct of the mining process flowed into the desert and a nearby town. This mishap hastened the eventual shuttering of the operation in 2002. "The central pit in the 55-acre site became a pool of bright green water…white bales of minerals – some mined eight years ago – were stockpiled until such time as prices would rise."[38] In addition to the hoped for change in the market, the dormant period to follow would allow for advances in the necessary technology to make mining and exploitation of rare earths more environmentally friendly. Through a combination of market forces and cleaner mining and exploitation methods, it was hoped that U.S. re-entry in to the market would result.

Another factor which crippled the American rare earth industry was labor costs. As the cost of labor increased and the profit margin decreased, mining and processing of rare earth elements diminished. Stepek notes, "So to successfully mine rare earth minerals, you need to combine cheap labour costs with a – shall we say – relaxed attitude towards health, safety and the environment…step forward, the People's Republic of China."[39] He goes on to foreshadow a possible trade war between the United States and China

[37] Iasper., 3.

[38] Suzanne Goldenberg, "Rare Earth Metals Mine is Key to U.S. Control over Hi-Tech Future," December 26, 2010, http://www.guardian.co.uk/environment/2010/dec/26/rare-earth-metals-us (accessed January 4, 2011), 3.

[39] John Stepek, "Why Rare Earth Elements Could Ignite a Global Trade War," October 25, 2010, http://money.uk.msn.com/investing/articles.aspx?cp-documentid=155083207 (accessed October 27, 2010), 2.

reminiscent of the 1930s. Due to the time horizon to reenter the rare earth industry exceeding 10 years, our manufacturing supply chain is dependent on the Chinese.[40]

The rise of China, increasing labor costs and, and environmental concern resulted in the shutting down of the Mountain Pass site in the late 1990s making the United States completely dependent on China for its rare earth elements. More than a decade of absence from the rare earth mining and production has taken its toll. The departure of the United States from the rare earth industry would not have been noticed were it not for the reduction in export of rare earths by the Chinese to the United States and the world. Chinese reduction of exports began in 2006 and has gotten progressively worse. "At present, China produces 97% of the world's rare earth supply, almost 100% of the associated metal production, and 80% of the rare earth magnets."[41] This dramatic shift over the last decade highlights the strategic implications for the U.S. and the world with respect to the supply of rare earths.

Dudley Kingsnorth, a rare earth researcher, authored a chart (See Fig 6) that started ringing alarm bells around the world. The explosion of China's economy has increased its own internal demand for rare earths. His research indicates that by 2012, Chinese and world demand for rare earths will exceed production. Note the blue line meeting supply. Additionally, last July China has increased tariffs on exports of rare earth elements further increasing the costs.[42] The emerging crisis has not been restricted to just the United States.

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[40] Stepek, 3.

[41] Mark A. Smith, "American Rare Earth Materials:The Indispensible Resource for Clean Energy Technologies," Molycorp Minerals, 5.

[42] Stepek, 2.

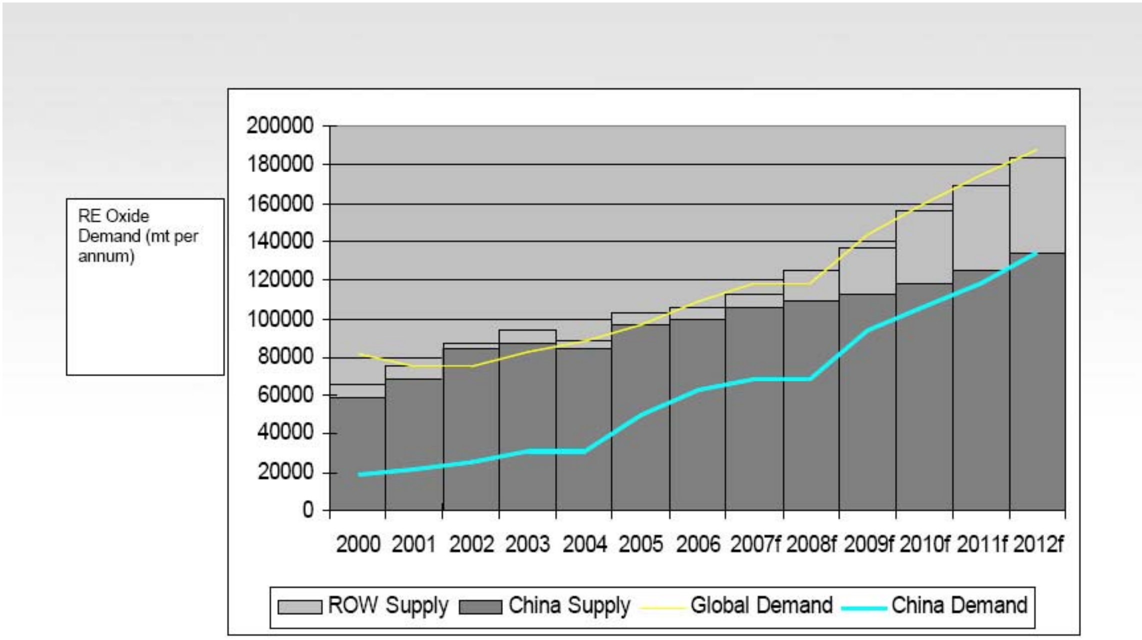

Figure 6 – Rare Earth Element Supply Vs. Demand[43]

In September of last year, a Chinese fishing trawler ran into a Japanese Coast Guard vessel. The fisherman was detained and China responded by halting rare earth exports to Japan.[44] Japan imports 100% of the rare earth elements required for its electronics industry. This wake-up call frightened industries that are wholly or in part reliant on a steady, predictable supply of rare earths. Being subject to the political whims of an unpredictable competitor nation is not a solid foundation for a good business model. This action by the Chinese got the attention of the world.

In March 2010, the U.S. Congress held hearings into the current state of the rare earth industry in the United States. Witnesses testified that, "…the lack of a domestic supply of rare earth minerals could severely affect the U.S.'s ability to manufacture advanced technology products…a rare earth supply shortage would present a threat notably to the emerging clean energy industry but also to the telecommunications and

[43] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 27.
[44] Ibid.

defense sectors."[45] The U.S. Congress has recognized that the Chinese monopoly of rare earth elements will severely limit access to many defense and industrial applications. Because of this, Congress has taken steps to encourage the United States to re-enter the rare earth industry.

House Science and Technology Subcommittee Chairman Brad Miller (D-NC) remarked, "The United States, not so long ago, was the world leader in producing and exporting rare earths. Today, China is the world's leader. If we intend to foster a home-grown capability to make the devices that provide wind energy, we need to rebuild America's capability to supply its own needs in rare earth materials."[46] Congressman Miller outlined a way forward in his closing remarks. "We need to learn how to compete in attracting and retaining manufacturing firms that need access to rare earth elements in light of China's current near monopoly, and their willingness to use their monopoly power to our disadvantage."[47] The committee offered some solutions to overcoming the imbalance of supply and demand which included increasing exploration for domestic sources, finding new overseas suppliers, research to find substitute materials, research to reduce the amount of rare earths needed, and increasing recycling of materials.[48] This four tiered approach to solving the supply crisis relies mainly on domestic solutions. However, in highlighting the need to find new overseas suppliers, Congress opened the door to investing with partner nations to find economically viable alternatives to domestic solutions.

[45] Committee on Science and Technology, US House of Representatives 111.178 2010, "Lack of Rare Earth Minerals Threatens Manufacturers," 2010, 1.
[46] Ibid.
[47] Ibid.
[48] Ibid., 2.

Throughout the summer of 2010, both the House and Senate took up the issue of rare earth elements. On 29 September 2010, the House of Representatives passed HR 6160, the Rare Earths and Critical Materials Revitalization Act of 2010, 324 to 92.[49] Committee Chairman Bart Gordon (D-TN) remarked in the press release, "There have been signs that China is willing to leverage its supplies of rare earths for political gain, and crippling manufacturing elsewhere. This is clearly an untenable position for the U.S.…We can't stake our national defense and economic security on China's goodwill or a false hope that it will choose to compete in a fair and open global marketplace for rare earths."[50] The bill specifically authorizes a program of research and development or rare earths to advance all facets from mining to manufacturing to recycling. It also recommends finding substitutions for rare earths and reducing the quantity of rare earths required for applications.[51]

The Senate Bill, 3521, was introduced by Alaska Republican Lisa Murkowski in June and hearings were held in September 2010. Senators Christopher "Kit" Bond (R-MO) and Evan Bayh (D-IN) co-sponsored SB 4031 that would provide funding for rare earth element research on 17 December 2010.[52] Both senators have since left the Senate and the legislation will have to be reintroduced.

Catalog of Current U.S. Rare Earth Mining and Production

The renewed interest from Congress and the decreasing exports from China have provided financial incentive for U.S. corporations to re-enter the market. In his testimony

[49] Committee on Science and technology, US House of Representatives 111.236, 2010, "House Approves Bill to Overcome Shortage of Elements Critical to Energy, Defense," 2010, 1.
[50] Ibid.
[51] Ibid..
[52] St Louis Dispatch, "Sen. Bond Backs Bill Supporting Rare Earth Production," St. Louis Dispatch, December 18, 2010, http://www.tmcnet.com/usubmit/2010/12/18/5202641.htm# (accessed January 4, 2011), 1.

to the House Science and Technology Committee on 16 March 2010, Mr. Mark Smith, Chief Executive Officer of Molycorp Minerals, LLC (the owner of Mountain Pass Mine), testified that re-entry into the market was critical due to three main points: the indispensability of rare earths in clean energy and defense technologies; the dominance of rare earth production by one country, China; and China's accelerating consumption of their own rare earth resources, leaving the rest of the world without a viable alternative source.[53]

He also detailed that, "…there are only three known and verified locations where a sufficiently high concentration of rare earths exist: Mountain Pass in California; Baotou, China; and Mt. Weld Australia, which has a rich ore deposit but none of the infrastructure necessary to begin extraction, separation, and distribution to the market."[54] This makes Mountain Pass the only resource in the world that could be ready in the short term to begin competing with the Chinese. This effort does not come cheaply though. Molycorp has invested over $20 million to restart the mine, obtain permits, and complete environmental impact.[55] Clearly, the U.S. Government has taken note of the impending crisis and is seeking ways to incentivize industry and investors to re-enter the rare earth industry.

While China has the advantage in production, Molycorp plans on leading the industry in the following areas to carve out their own niche. Their plan incorporates improved manufacturing processes and environmentally sensitive procedures. These new processes and procedures will reduce the wasted ore in past processes by 50% resulting in significantly greater profitability. The new processes also reduce the amount of reagent

[53] Smith, "American Rare Earth Materials," Molycorp Minerals, December 29 2010, 1.
[54] Ibid., 3.
[55] Ibid., 8.

needed as well as a staggering 96% reduction in use of fresh water in the process all while reducing carbon emissions by 50%.[56] By reducing the cost of rare earth exploitation, U.S. and other countries' corporations can be more financially viable and more able to compete with Chinese manipulation of rare earth prices.

Competition with the Chinese will be fierce. Not only have they cornered the supply market, they have been systematically moving production of finished goods using rare earths to China. Though the Mountain Pass Mine could be fully operational by 2012, it currently lacks the manufacturing assets and facilities to process the rare earth ore into finished components, such as permanent magnets.[57]

There have been some bright spots though. Molycorp has been processing the existing stockpiles of rare earths from last decade that were left over after the mine closed. Estimates of how much rare earths exist at Mountain Pass exceed two billion pounds. This coupled with a recently issued thirty year mining permit show potential financial success despite several quarterly losses due to re-startup costs. In the past several months, the company's stock has nearly doubled as tensions between China and Japan over rare earth export policy came to light.[58] This all points to the fact that the Chinese may not be able to maintain their monopoly due to the combination of supply, demand, technological advances, and politics.

[56] Smith, "American Rare Earth Materials," 8-9.

[57] Michael Cooney, "Network World.com," October 7, 2010, http://www.networkworld.com/news/2010/100710-rare-earth-materials.html (accessed October 14, 2010), 2.

[58] Paul Goodwin, "Molycorp Rare and in Demand," September 27, 2010, http://seekingalpha.com/article/227298-molycorp-rare-an-in-demand (accessed January 14, 2011), 2.

Rare Earth Elements in China

China is the main player in the rare earth element industry. Over the past several decades through a quiet strategy they have dismantled all competition. They have employed robust government control and subsidy to push other competitors, including the United States, out of the market. China drove the only U.S. mine out of the business in the 1990s by cutting prices until the U.S. facility shut down.[59] They have ignored or been very lax on environmental considerations, and they have been very fortunate to possess a mine rich in rare earths.

Not only do they have the only fully operational rare earth mine, but they also control the processing and production of products using rare earths. Several international businesses have relocated to China with their intellectual knowledge for exploiting rare earths to produce finished products in China.

This strategy has resulted in the Chinese controlling over 97% of the market.[60] This monopoly has given them great leverage in the world market and it has gone largely unnoticed until the past few years. China's own success as an economic powerhouse now threatens the monopoly they hold as well as the world market. Now some market watchers suspect China is cutting exports and diverting its rare earths to domestic manufacturing operations in an attempt to move up the supply chain and take over the manufacture of components based on rare earth elements.[61] Over the past few years,

[59] Colin R. Johnson, "Rare Earth Supply Chain: Industry's Common Cause," October 24, 2010, http://www.eetimes.com/electronics-news/4210064/Rare-earth-supply-chain--Industry-s-common-cause (accessed October 27, 2010), 3.

[60] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 3.

[61] Johnson, 3.

China has come under increasing scrutiny and criticism over its monopoly of the rare earth industry and for gradually reducing export quotas of these resources.[62]

About the time the United States was losing interest in aggressively researching rare earths, the Chinese began intensive action. Nearly 50 percent of the graduate students who come to study at the U.S. Department of Energy's Ames National Laboratory are from China and each time a visiting student returns to China, he or she is replaced by another Chinese visiting student.[63]

The pursuit of rare earth dominance by the Chinese began in the 1980s as part of a broader domestic strategy. In March 1986, three Chinese scientists jointly proposed a plan that would accelerate the country's high-technology development.[64] The program was titled, Program 863.

The goals of the program were straightforward. It attempted to first enter the rare earth market aggressively, achieve breakthroughs that would benefit the country economically and in national security, gain advantages in the field that would result in strategic dominance, and contribute to the modernization of the nation. The specific areas of study in 863 included biotechnology, space, information, laser, automation, energy, and new materials. March 1997 saw the introduction of Program 973 which was a basic research program designed to complement 863.[65]

The human face of Chinese rare earth element research is Professor Xu Guangxian. In 2009, at the age of 89, he was awarded the State Supreme Science and Technology prize, the Chinese equivalent of the Nobel Prize. He earned a Ph.D. in Chemistry from

[62] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 3.
[63] Ibid.
[64] Ibid., 6.
[65] Ibid.

the Columbia University in New York in the late 1940s, he returned to China upon the breakout of the Korean War to work at the Peking University. His early work was in metal extraction, radiation chemistry, and nuclear fuels.[66]

The Cultural Revolution of the nineteen sixties found Xu interred in a labor camp until the early nineteen seventies. Following release from prison, he resumed his work on extracting uranium isotopes from rare earths. Xu noted in 2000, "Chemistry is thought to be too conventional to be important; but this is because chemists are too humble to claim their great achievements. If the discipline's image as an 'archaic study' deters excellent students from entering the field, there will be a big problem…chemistry is not the accompanying science to physics and biology, but a central discipline. It will never disappear."[67] His observations have formed the basis of the Chinese domination of rare earths.

The main Chinese effort into rare earth research takes place in two laboratories. These are the State Key Laboratory of Rare Earth Materials Chemistry and Applications and the Open Laboratory of Rare Earth Chemistry and Physics. China produces the only two global publications that focus exclusively on rare earth elements: The Journal of Rare Earth and The China Rare Earth Information (CREI) Journal.[68]

The advantage the Chinese have gained from these laboratories has produced singular dominance in rare earth research. A 1996 paper titled *The History of China's Rare Earth Industry* proclaimed, "China's abrupt rise in its status as a major producer, consumer, and supplier of rare earths and rare earth products is the most important event

[66] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 6.
[67] Ibid., 7-8.
[68] Ibid., 8-10.

of the 1980s in terms of development of rare earths."[69] The Chinese leader in 1992, Deng Xiaoping summed up the Chinese position best, "There is oil in the Middle East; there is rare earth in China."[70] This observation was critical to China's future success in the rare earth field. China had recognized the potential windfall from its ability to monopolize an entire industry. While oil captured the world's attention and competition was fierce, the interest level and knowledge of the rare earth industry rose nowhere near that level.

Development of China's internal resources was not the only strategy being pursued at this time. China also attempted and succeeded at stealing technology and intellectual property from the United States and Japan. The case involved some rare earth magnets pioneered by General Motors and Hitachi. General Motors formed a company called Magnequench in 1986 which produced rare earth magnets. The Chinese attempted to acquire the company in 1995. The acquisition was approved by the U.S. government on the condition that the company remained in the United States for at least five years.[71]

The day after the fifth year expired, the Chinese shuttered the operation, fired the employees, and removed everything and shipped it all to China. The business was gone, but more importantly, the technology was stolen, including critical defense applications such as NdFeB magnets which lie at the heart of items such as rangefinders and target designators.[72]

The aggressiveness of the Chinese and the lack of action by the United States saw the lead in rare earth magnets leave the United States. In fact, by September 2007, China

[69] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 11 (See Wang Minnin and Dou Xuehong's book, *The Hisstory of China's Rare Earth Industry.* (Netherlands, Kluwer Academic Publishers, 1996), 131-147.
[70] Ibid.
[71] Ibid. 13.
[72] Ibid..

had more than 130 rare earth manufacturing enterprises and from 1996 to 2007 their production increased from 2,600 tons to 80,000 tons or approximately 30% annual growth.[73]

China attempted to take over Mountain Pass in 1982 and the rare earth mine in Australia in 2009. In the case of Mountain Pass, China attempted to buy out the parent company of the mine by overbidding the nearest competitor by a half billion dollars.[74] In the case of Australia, China stepped in to fill a critical financing shortfall at the Mount Weld project in exchange for a 51.6% stake, but the Australian government pushed back demanding that the Chinese settle for less than 50% control which finally caused the Chinese to retreat.[75]

The status quo from the late 1990s to 2006 was simple. China mined and sold rare earths cheaply using government subsidies and minimal environmental constraints. Another reason they were able to sell rare earths so cheaply is that rare earths from China were a by-product from an iron ore mine in Inner Mongolia.[76] The mining and selling of the iron ore was bought and paid for and the rare earths were essentially “free” which allowed them to sell it cheaply to corner the market.

In 2006, China began to restrict exports of raw rare earths. Several factors contributed to this. The first factor was the rapid economic expansion of China which consumed rare earths at an ever increasing rate. Gareth, Hatch, a metals analyst, posits the effect this has had on the market: “I do not believe that China is trying to chop the

[73] Hurst, “China’s Rare Earth Elements Industry: What can the West Learn?,” 13,
[74] Ibid.
[75] Ibid.
[76] Kate Woodsome, “China Says Rare Earths not a Political Bargainiing Chip,” October 8, 2010, http://www.voanews.com/english/news/China-Says-It-Wont-Use-Rare-Earth-Metals-as-Bargaining-Chip-104503524.html (accessed October 14, 2010), 2.

west off at the knees but it has a growing internal market that is driving the demand…that reduces the amount they are willing to export."[77] Any nation faced with rapid growth will struggle with the balancing of their internal desire to improve their economy and their people's standard of living and their responsibility to the world market as a monopoly provider of a product.

Japan was impacted heavily beginning in 2007. Fears about supply security has grown among Japanese firms amid surges in raw material prices, and as China, the source of around 90 percent of rare earth metals and tungsten supplies for Japan, steps up its control over them.[78]

Second, the lacks of environmental constraints on legal and illegal mines were beginning to have an impact. Villagers from the southern Chinese province of Guangdong are feeling the effect:

> Illegal mining for the lucrative minerals, which are used to manufacture high-tech goods, is a massive environmental problem around Heyuan, where the authorities say they staged a major crackdown in October, closing 462 illegal iron and rare earth mines.
>
> Last February, the Shangmankeng village committee handed over management of the village reservoir, on which villagers depend for irrigation, fish-farming, and drinking water, to three villagers who are known to have triad connections, Li said.
>
> At the same time, the authorities put out a tender notice in the name of Shangmankeng village and the nearby Dongyuan Township to operate a rare earth mine in the village. Since then, the once clear waters of the village reservoir, which were also used as a fish farm, have come to resemble a pool of sewage.
>
> Li is just one of the villagers who are vehemently opposed to the mine. Government scientists discovered the uranium, which is used to make nuclear weapons, under the hill near the village back in 1981, and they

[77] Goldenberg, 2.

[78] George Nishiyama, "Japan Urges China to Ease Rare Earth Metals Supply," November 8, 2007, http://www.reuters.com/assets/print?aid=usl08815827 (accessed September 8, 2010), 1.

> sealed it off, forbidding anyone from mining there. Now that they have begun work there, large volumes of mud have flowed into the village reservoir, some of it radioactive, he said.[79]

Another testimony from a resident of China's Jiangxi province highlighted the environmental problems: "…to extract the rare earth elements, they use sulfates, ammonia, and other chemicals…we used to drink the water in the rivers, but now even fish and shrimp cannot survive in the water."[80] The ability of the Chinese to tightly control internal security and quell internal strife over environmental impact is difficult to maintain as more world attention is focused on rare earths.

Lastly, it is thought that another reason China has reduced exports has been to take over the entire chain of production of goods using rare earths. The method they have used is simple. First, reduce exports to create more demand at a higher price. Second, offer access and lower prices if a foreign company/country will move their rare earth element processing and manufacturing operation to China. This strategy allows China to control everything from start to finish.[81]

> Why reduce exports, especially when they fetch higher prices for the miners? Though never explicitly stated, it was apparently done to help China climb the manufacturing added-value chain. By pressuring foreign companies to relocate factories to China with attractive in-China sourcing costs, Beijing hoped to absorb innovation and expand into those attractive industries. It also strengthens their own high-tech "national champions" which can produce at even lower input costs than their Asian neighbors and mop up domestic demand.[82]

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[79] Lee Yong-tim, "South China Villagers Slam Pollution from Rare Earth Mine," February 22, 2008, http://www.rfa.org/english/news/china_pollution-20080222.html (accessed September 8, 2010), 1.

[80] Rohrlich, 3.

[81] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 21.

[82] Sean Daly, "Molycorp Poised to Benefit from the New world Order in Rare Earths," October 11, 2010, http://seekingalpha.com/article/229327-molycorp-poised-to-benefit-from-the-new-world-order-in-rare-earths (accessed January 14, 2011), 3.

Catalog of Current Chinese Rare Earth Mining and Production

Despite Chinese control of the rare earth element market, it has some internal problems that do not often get reported. Even considering China's tight government control of media, it seems that the Chinese government has had difficulty controlling rare earth element mining within its own border. There are estimates that up to 50% of the world's rare earth elements from China are mined by illegal, non-government controlled operations.[83] This valuable loss of market share and revenue to the government is interesting in that market demands for rare earth elements have resulted in increased supply through illegal operations.

Capitalism, with the goal of finding the ideal balance of supply and demand, has burrowed its way into socialist China and become the government's main and only significant competitor in the world. Dan Cordier of the U.S.G.S. noted, "Where the invisible hand of economics comes in and free market works its way even into the realms of China, the overall expansion of that particular high technology of rare earths will succeed to incite competition and work for everybody's benefit."[84] Rather than embracing a free-market concept, China has begun to try to crack down on these operations and prosecute the crime rings responsible for competing with the government.[85] A recent Chinese statement by Xu Shaoshi, Minister of Land and Resources, revealed that, "China's campaign against illegal rare earths mining and effort

[83] Ash Bennington, "CNBC," December 29, 2010, ttp://www.cnbc.com/id/40844558 (accessed Jan 4, 2011), 2.
[84] Woodsome, 2.
[85] Bennington, 2.

to better manage the industry has achieved notable results."[86] These statements can be misleading as no details followed the unverifiable statement.

Another stressor on the market is that China is currently consuming 60% of the rare earths it produces.[87] Tensions are building around the world as China's internal demand for rare earths continues to increase. To meet their own need for rare earths, the Chinese have begun to reduce exports thus driving the price up and sending shock waves through the market. "Following a boating mishap in the East China Sea, China swiftly banned exports to Japan of rare-earth materials, essential in high-tech manufacturing."[88] This action and Chinese domination of supply has caused concern among western businesses.[89]

The Japanese have called for the Chinese to increase the export of rare earths. The island nation has few natural resources and it relies on other countries for the raw materials it uses to produce intermediate or finished products to supply the world. "Fears about supply security have grown among Japanese firms amid surges in raw material prices, and as China, the source of around 90 percent of rare earth metals and tungsten supplies for Japan, steps up its control over them."[90] Restriction of rare earths has profound impact on the Japanese manufacturing of hybrid cars. The elements Tungsten and Dysprosium are critical to hybrid motors. "Prices of tungsten have approximately quadrupled from 2004, and dysprosium has gone up over three times in the same

[86] Asher Berube, "China Preparing New Rare Earths Standards," January 7, 2011, http://www.raremetal blog.com/2011/01/china-preparing-new-rare-earths-standards.html (accessed Jan 9, 2011), 1.

[87] Molycorp Minerals, "Global Outlook," http://www.molycorp.com/globaloutlook.asp (accessed October 16, 2010), 1.

[88] Michael Richardson, "Yale Global Online," October 8, 2010, http://yaleglobal.yale.edu/print/6575 (accessed Jan 9, 2011), 1.

[89] Ibid.

[90] Nishiyama, 1.

period."[91] Japan's Minister of Economy was quoted recently saying, "China needs to understand that no country can prosper by dominating its resources…It's only natural that China would want to use its resources strategically, but it needs to understand that the basic principle in trade is that you can only prosper if your partner is prosperous."[92] The frustration over China's supply restrictions is not only limited to the Japanese government.

A senior trader from Japan's Advanced Material Japan Corporation comments that, "China is a real threat…we know that we are resource poor and have to depend on the other countries, but the (Japanese) government has not taken steps to deal with that so far."[93] The government did take steps in the early 80's to begin stockpiling natural resources, but rare earths were not among them. He recommended that the Japanese government engage in what he called resources diplomacy by offering aid to other countries to begin exploration for resources to increase supply.[94]

On the environmental front, the Chinese are beginning to take actions to reduce the negative impact that their mostly unrestrained mining has had on its land and people. This however will result in increased prices due to reduced profit margins. In January 2011, the Chinese began writing and implementing new environmental standards. "The rules will limit pollutants allowed in waste water and emissions of radioactive elements and phosphorus…under the rules, expected to pinch rare earth miners with raised environmental protection costs, levels of ammonia nitrogen would be cut from 25 milligrams to 15 milligrams per litre, and radioactive elements and phosphorous

[91] Nishiyama, 1.
[92] Ibid.
[93] Ibid.
[94] Ibid.

emissions would be reduced."[95] It is fascinating that the more tightly the Chinese try to control their monopoly, the more difficult it becomes to deal with internal and external pressures.

Catalog of Current Rare Earth Mining and Production in Greenland

The Greenland Minerals and Energy Limited Corporation have begun exploration in the south of the island nation in an area known as the Ilimaussaq Intrusion. Initial exploration has revealed the potential for a very large quantity of rare earths in a very high concentration so critical for financial feasibility.[96] "This discovery comes at a critical time for Greenland, as it has just gained full sovereignty over its natural resources and is aiming for full independence from Denmark…this site is a country-maker for Greenland and the first big opportunity to represent a monopoly-breaker of Chinese dominance."[97] The site has the potential to begin producing rare earths by 2015 with a projected useful life of over 20 years and an estimated value of over $2B and a rate of return of over 20%. The corporation is currently working through issues with the government's stance on zero uranium exploration. In negotiations, the feasibility of the site will play a critical role in gaining approval to move forward.[98]

Documenting the progress in Greenland may serve as a template for how a developed nation can exploit rare earths while navigating environmental impact and transport of rare earths over long distances to consumers.

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[95] Berube, "China Preparing New Rare Earths Standards," 1.

[96] Simon Davies, "China Controls the Market but Greenland Aims to Compete," June 8, 2010, http://www.suite101.com/content/world-resources-of-rare-earth-metals-a186782 (accessed September 8, 2010), 1.

[97] Ibid.

[98] Proactive Investor, "Rare Earth Elements Part 2: Companies with REE Assets," October 10, 2010, http://seekingalpha.com/article/229257-rare-earth-elements-part-2-companies-with-ree-assets (accessed October 27, 2010), 5.

Catalog of Current Rare Earth Mining and Production in Canada

As the Chinese continue to hold a monopoly on rare earths and reduce exports, the risk-benefit balance to seek new sources of rare earths is tilting in favor of taking risk. The risk is, of course, financial in nature as prospecting, mining, and processing rare earths represents an enormous up-front cost that takes up to a decade to begin turning a profit. In this environment, most corporations cannot afford to proceed without assurances that the market will still be fruitful a decade in the future. Given the rising demand for rare earth, several corporations and governments are beginning to explore for rare earths.

Fueled by a projected 10-20% increase in demand for rare earths annually, Canadian firms are involved in searches in South Africa, Brazil, and the United States.[99] Canadian firms pursuing new mines include Great Western Minerals Group, Rare Earth Element Resources, Avalon Rare Metals, and Neo Material Technologies.[100]

Constantine Karayannopoulos, Chief Executive of Neo Material Technologies commented with respect to China's restricting exports, "I think for any modern state and state signatory of the World Trade Organization, restricting the export of any material which has a stranglehold in the world is just a nonstarter."[101] To protect their position, his corporation has signed an agreement with the Japanese firm Mitsubishi to combine research efforts in other parts of the world.[102]

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[99] Reuters, "Canadian Firms Step Up Search for Rare-Earth Metals," September 10, 2009, http://www.nytimes.com/2009/09/10/business/global/10mineral.html?pagewanted=print (accessed September 8, 2010), 1.

[100] Ibid.

[101] Ibid., 2.

[102] Ibid.

Another Canadian approach is development of rare earths in its Northwest Territories at Lake Thor. This rare earth element deposit is estimated to be the second largest in the world. It has a very high concentration of the heavy rare earths.[103] The Avalon Corporation has spent approximately $25M for the feasibility study and is moving forward on the $900M project expected to be productive in 2015.[104]

Two other Canadian companies, Rare Earth Element Resources, and Quest Rare Minerals have two mines that they are exploring at Bear Lodge and Strange Lake respectively.[105] There are several other smaller Canadian corporation operations planned or in research.

Catalog of Current Rare Earth Mining and Production in Russia

Very little information exists on Russia's rare earth deposits or efforts. In fact, word of rare earths in Russia only began during the Soviet era in 1993. Even then, they recognized the potential for rare earths. The Russian intelligence service realized the importance rare earths had been playing in the development of high-technology products with direct military application and other areas of engineering.[106]

Catalog of Current Rare Earth Mining and Production in North Korea

Efforts in North Korea can most likely be seen as being artificially bolstered up by China. Rare earths can provide needed capital for the isolated communist state. The North Korean government formed a joint venture in 1988 using solvent technology from China with production beginning in 1991.[107] "The Hamhung plant reportedly has the capacity to process 1500 tons per year of monazite, from which 400 tons of rare earth

[103] Proactive, "Rare Earth Elements," 3.
[104] Ibid.
[105] Ibid.
[106] Ibid.
[107] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 125-126.

metals and oxides can be processed."[108] The efforts in North Korea have been personally monitored by Kim Jong-Il who has gone on record to direct increase production.[109]

Catalog of Current Rare Earth Mining and Production in Germany

Germany is a large industrial nation with heavy reliance on rare earths for its manufacturing sector. Their strict environmental laws apply not only within the borders of European Union countries, but can also cause problems when seeking to mine outside of the union proper. "More rigid environmental standards in the European Union and ethical questions over sourcing raw materials from developing nations mean there can be no quick fixes in finding viable alternatives to China."[110] Germany is building "strategic partnerships" with Mongolia, Namibia, Nigeria, Kazakhstan, South Africa, Chile, and Peru to try to source rare earths.[111]

Catalog of Current Rare Earth Mining and Production in Australia

The continent is home to two promising sites. The Lynas Corporation and Arafura Resources are the two corporations behind the mines. The mines are at Mount Weld and Nolans Bore.

Mount Weld, located about 700 km from Perth, contains the richest known Lathanide deposits. Mining has begun and product is being accumulated. Through a joint venture with Malaysia, the rare earths will be shipped there to be processed. The plant in Malaysia is a near turnkey operation for rare earth processing.[112]

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[108] Hurst, "China's Rare Earth Elements Industry: What can the West Learn?," 126.
[109] Ibid.
[110] Brian Parkin and Tony Czuczka, "Race to Replace China's Rare Earths may take Decade," October 26, 2010), http://www.businessweek.com/news/2010-10-26/race-to-replace-china-s-rare-earths-may-take-decade.html (accessed October 27, 2010, 1.
[111] Ibid.
[112] Proactive, "Rare Earth Elements," 1.

Recent events related to the tsunami in Japan have slowed down the environmental impact of the refinery in Malaysia. The government has halted the import of Mt. Weld rare earths for processing in Malaysia while it conducts a 30 day safety review. Continued work on building the refinery has been allowed in the interim. The by-products of rare earth mining and separation results in some radioactive materials. The tsunami and the after-effects of radiation leaks have prompted the safety review.[113]

The Nolans Bore project is projected to start producing rare earths in 2013 and the mined products will be processed at Whyalla in Australia.[114] Whyalla has good access to skilled labor, transportation and port infrastructure, and cooperative local governance.

One other project in Australia is worth detailing. The Dubbo Zirconia Project owned by Alkane Resources Limited with a projected production of approximately 2400 tons per year at a cost of $200M is being researched.[115]

Global Trends in Rare Earth Elements

The Chinese monopoly combined with narrowing surplus Chinese rare earths for export have directly resulted in increased prospecting for new sources and rising prices. Over the last year, shares of Lynas, the corporation behind the rare earth mine in Australia, have increased in price by more than 350% while prices of some rare earths have jumped more than 1000%.[116] The realization that global demand will outpace Chinese production is having real impact on the rare earth market. This fact will result in more exploration as the potential profit margin exceeds the necessary development,

[113] Gan Yen Kuan, "Malaysia Bars Rare-Earth Imports, Starts Review of Lynas Plant," April 22, 2011, http://www.bloomberg.com/news/print/2011-04-22/malaysia-bars-rare-earth-imports-starts-review-of-lynas-plant.html (accessed April 23, 2011), 1.

[114] Proactive, "Rare Earth Elements, 2-3.

[115] Dudley Kingsnorth, "Rare Earths Supply: Alternatives to China," Industrial Minerals Company of Australia, 2008, 18.

[116] Kuan, 1-2.

mining, and processing costs. With continued Chinese yielding to its internal environmental impact of the damage done by their rare earth practices, Chinese supply will be reduced, further driving up prices, possible sooner rather than later.

With world demand for products with rare earths not showing any signs of slowing down, more must be found. This is an interesting parallel to the problem we face with oil prices today. Many alternatives have been proposed, wind, solar, and hybrid vehicles (which use rare earths in their magnets), but none have produced anything approaching the efficiency of oil. Similarly with rare earths, other strategies to reduce dependence on rare earths have been proposed including: substituting other elements for rare earths, develop alternative products to substitute for the current products being made, and reducing the amount of rare earths required for each product. Many of these alternatives hold promise, but none have been able to produce tangible results quickly.

Throughout the modern world over the last few hundred years, the availability of cheap oil and its refined products have fueled the economies and development of the world. Rare earths have played the same role in advanced, high-technology applications but to a lesser degree. However, exploitation of rare earths in the near and short term will continue to revolutionize technical industries.

Additionally, rare earths have demonstrated that they are fault lines in the geopolitical world. The combination of resource demand by the world and China's appetite for world market domination is resulting in political action that is destabilizing. Trade wars and export control limitations rarely foster increased trade and economic vitality. As rare earth prices increase artificially due to Chinese restraints on export, tensions grow around the world.

Defusing this situation can be solved in only two ways: decrease in demand or increase in supply. It is very unlikely that demand for rare earths will decrease as end products made with rare earths are in greater and greater demand in so many of the products that have become a way of life in the developed world. This leaves us to concentrate on the supply side of the equation.

CHAPTER 4: AFRICA AS A REPOSITORY OF RARE EARTH ELEMENTS

Current State

The search for more supply of rare earths has led several corporations and countries to explore Africa. Africa has many challenges. Its 54 nations occupy the bottom 24 spots in the United Nations' Human Development Index and the bottom 35 of the 38 lowest ranked countries.[1] A combination of ungoverned spaces, brutal dictatorships, lack of natural resources, poor or non-existent education, a long history of exploitation of Africa's people and limited resources by nations and corporations from around the world as well as by other African nations have contributed to make Africa a very risky place to conduct any type of legitimate business or exploration. Though there are many challenges, opportunities abound.

China's monopoly on rare earths and its continually decreasing surplus of rare earths available for export have forced many nations and corporations to look to the African continent. The European Union has taken action to pressure China on easing its export quotas as well as seeking cooperation from African nations to open access to the European Union.[2] The next several paragraphs will detail current rare earth exploration efforts in Africa.

Madagascar

The German corporation Tantalus AG has secured mining rights to a promising find in the northern part of the island nation. The target area is composed of both light and heavy rare earths. They have established favorable conditions for mining with the

[1] NationMaster.com, "Human Development Index," 2006, http://www.nationmaster.com/graph/eco_hum_dev_ind-economy-human-development-index (accessed February 18, 2011), 1-5.

[2] DPA, "EU to Pressure China, Africa Over Access to Rare Earth Metals," April 29, 2010, http://www.earthtimes.org/articles/printtory.php?news=321164 (accessed November 8, 2010), 1.

government and there is satisfactory infrastructure that poses little or no environmental impact on the population. [3]

Malawi

A joint venture between Resource Star Limited and Globe Metals and Mining has discovered the potential for rare earths at Machinga mine. "The Machinga Rare Earth Project continues to impress with these early exploration results. The REE-Nb-Ta soil sampling results indicate that this could be a much more extensive mineralized system than originally thought."[4] This effort is in the early stages of discovery and feasibility study.

Namibia

Japan has begun initial coordination with Namibia to explore for rare earths. The Japanese Oil, Gas, and Metals National Corp will work with Namibia to, "…develop technology to remotely sensor and analyse potential mines…through the joint effort, we hope to explore new mining fields…and accelerate joint venture projects with private mining firms to help secure stakes in rare metal resources."[5] Another venture in Namibia is with a private Canadian firm that to confirm a high concentration of rare earths at the Lofdal Carbonatite Complex. This venture, named Namibia Rare earths, Inc, seeks to begin drilling in locations identified by airborne radiometric monitoring to be high in rare earth concentrations.[6]

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[3] Tantalus Rare Earths AG, "The Tantalus Rare Earths-Tantalum-Niobium-Zirconium Project in Northern Madagascar," Prospectus, Dusseldorf: Tantalus, 2010, 7, 9-10.

[4] Resource Star, Limited, "Machinga NB-REE Project – Prospectivity Extended," Press Release, Melbourne: Resource Star, Ltd., 2010, 2.

[5] Africa Times, "Japan in Pact for Rare Earth Exploration in Namibia," July 30, 2010, http://www.africa-times-news.com/2010/07/japan-in-pact-for-rare-earth-exploration-in-namibia/ (accessed November 8, 2010), 1.

[6] Namibia Rare Earths, "The Local Rare Earth Project," Press Release, Namibia Rare Earths, 2010, 1-3.

Sierra Leone

Sunenergy Corp is acquiring a company called Allied Mining and Supply, LLC (Nevada) to gain rights to and exploit an area of Sierra Leone near the Pampana River Concession. The initial analysis of samples from the area show concentrations of rare earths that are commercially exploitable. [7]

South Africa

A $15M joint venture of Great Western Minerals Group, Ltd and Rare Earth Extraction Co, Ltd are exploring options to reopen the Steenkampskraal Mine located in the Cape Province. Production is slated to begin in 2013 at the mine which was active until just over a decade ago. It was forced to close because it became unprofitable due to the Chinese flooding the market and lowering prices. [8]

A second venture in South Africa is to develop the Zandkopsdrift project also in Cape Province. This is undeveloped deposit that could generate over twenty thousand tons of rare earths per annum.[9]

Zambia

A joint venture between African Consolidated Resources and an Australian will explore Nkombwa Hill Rare Earths and Phosphate Project, in Zambia.[10] This effort is in the discovery and feasibility stage.

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[7] Marketwire, "Great Western Minerals Signs Option Agreement to Recommission Rare Earth Mine in South Africa," January 13, 2009, http://www.gwmg.ca/html/media/news/index.cfm?ReportID=203280 (accessed February 18, 2011), 1.

[8] Bloomberg, "Great Western Rare Earth Company may Revive South African Rare-Earth Mine," October 22, 2010, http://www.raremetalblog.com/2010/10/great-western-rareco-may-revive-south-african-rare-earth-mine.html (accessed November 8, 2010), 1.

[9] Proactive, "Rare Earth Elements," 2.

[10] Chanel de Bruyn, "New Joint Venture to Explore Zambia Rare-Earths Project," June 14, 2010, http://www.miningweekly.com/article/new-joint-venture-to-explore-zambia-rare-earths-project-2010-06-14 (accessed November 8, 2010), 1.

CHAPTER 5: CASE STUDY: EXPLOITATION OF COAL IN COLOMBIA

Applicability to Africa

A review of the El Cerrejon case reveals many similarities between the impetus for the exploitation of other energy sources in the early 1970s and the current state of the restricted supply of rare earths. The El Cerrejon formula is a good model for how corporations or governments can interact with African governments and corporations as they attempt to exploit African resources to meet the increasing global demand for rare earths in the face of ever tightening Chinese export.

Background

In the early 1970s, the energy crisis impacted the entire world. Supply had grown short and prices skyrocketed affecting more than just the price of energy. Since energy was the starting point for most industries, prices rose across the economic spectrum resulting in a global economic downturn.

Exxon Mobil Corporation, through its wholly owned subsidiary INTERCOR (International Colombia Resources Corporation) sought to secure energy sources around the world to increase supply to reduce prices with the ultimate goal of ensuring economic viability for its shareholders and helping to end the global crisis. One place they came was to El Cerrejon, Colombia.

Through intensive negotiations with the government of Colombia, Exxon Mobil secured a joint venture agreement based on an association economic model for the long term exploration, mining, and exploitation of coal. This agreement resulted in a very prosperous operation for Exxon Mobil as well as economic success for the Colombian people and government that continues today.

The El Cerrejon Model

As energy prices soared, companies like Exxon Mobil looked for new places to find supplies of energy. El Cerrejon had several things that made it attractive: good quality coal, location, and labor costs. The Colombian government was interested in diversifying, worried about their only cash crop, coffee, dropping out from under them. The Colombians were also suffering from the energy crisis as they were beginning to become a petroleum importer. [1]

As the Colombian government considered how to proceed, they embraced the theory of dependent bargaining. Dependent bargainers "…accept the constraints of dependency and Transnational Enterprises (TNE) participation in energy contracts as givens but employ their political and technical abilities to obtain the best deal they perceive is available to the country."[2] They take a realistic approach to how best to serve their needs based on their strengths and weaknesses. Furthermore:

> The case for private and against governmental oil exploration in oil-importing developing countries rests on three major premises: (1) Oil exploration is a very "risky" business. (2) Because of the "riskiness," considerable diversification of efforts is needed to have a chance of a successful oil exploration program. This necessarily entails great expenses, both in men and money. (3) The international oil companies have the money and technical skills which are required and are sufficiently diversified so that they can afford risk; conversely, the governments of the underdeveloped countries have neither large amounts of capital nor trained manpower and hence cannot afford the 'risk' of oil exploration. It logically follows from the above that governments of underdeveloped countries should not embark alone on an oil exploration program, but rather should leave it to the resources of the international oil companies; at most a government might participate with the companies on some joint-venture basis, where the companies would provide the scarce manpower and foreign exchange.[3]

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[1] Harvey F. Kline, *The Coal of El Cerrejon; Dependent Bargaining and Colombian Policy-Making* (University Park: The Pennsylvania State University, 1987), 3.
[2] Ibid., 9.
[3] Ibid., 11.

As Colombia pursued an agreement with Exxon Mobil, they employed, "…the four factors of the bargaining process: (1) the structure and evolution of the particular industry, (2) the position and interests of a particular firm within the industry, (3) the social, economic, political, bureaucratic factors of the host country, and (4) the negotiating and administrative skills of each party…"[4] Compared to negotiations by other nations in similar ventures, the Colombian result was similar. In the end, the deals typically work out the same way for the TNEs despite the effectiveness or ineffectiveness of the host nation government's negotiating skill. The ruling elites of the country typically bear the blame or receive the praise depending on the outcome.[5]

Prior to El Cerrejon, the Colombian government passed legislation to lay a foundation for any future agreements. They passed Article 1 of Decree-Law 444 of 1967. This law required that the national interest must be served when it comes to foreign investment. Additionally, the government wrote tax code that increased the profit margin for TNEs as time passed to entice them.[6]

An important key for TNEs working with host countries is to train host country citizens to be able to eventually run the mining operation. An example from earlier petroleum exploitation illustrates the point: "Tropical was contracted to run the refinery for ten years, but with the understanding that Colombians would be taught the jobs…when there were momentary shortages, these could be made up from INTERCOR. If ECOPETROL needed some diesel fuel, they (INTERCOR) would lend it to us. It was a very good relationship."[7] This willingness to advance the host nation's people made

[4] Kline, 13.
[5] Ibid., 15.
[6] Ibid., 31-32.
[7] Ibid., 36.

long-term sense for both the TNE and the host nation. As the host nation becomes more and more capable of running an operation, the TNE can withdraw more and more resources while maintaining profitability through resource revenue.

As the Colombians and Exxon Mobil negotiated the contract, Kline describes the four different types of contracts the Colombian government examined:

> The concession model cedes most of the policy control to the TNE in exchange for the TNE supplying the capital, assuming all of the risk, and furnishing the managerial knowledge and technology.
>
> The society model is a joint venture between the host nation and the TNE with the host nation holding 51% of the venture. The host nation exercises significant policy control but also shoulders a large share of risk.
>
> The association model is a joint venture also, but in it, the TNE takes on 100% of the exploration risk. If after exploration it is determined to be feasible to continue with the operation, the decision to proceed rests with the host nation. Once the host nation gives approval to begin mining, the TNE and host nation share both policy control and the risk associated with the operation. The TNE is responsible for daily operations. As the operation proceeds, the TNE and host nation share equally in the profits and liabilities of the operation. When the contract expires, the host nation gains complete ownership of all equipment.
>
> In the national model, control of the operation falls to the host nation completely.[8]

Exxon Mobil proposed an association model contract that would hire, "…the maximum number possible of Colombians."[9] The proposal was debated within the Colombian government intensively. A key requirement of the Colombian government centered on Colombians learning to do the work of exploration and exploitation. "…the government should participate in petroleum exploration and production 'in order that the country might benefit from them to the greatest extent possible and in order that the country might acquire geological, technical, marketing, and transportation knowledge.'"[10]

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[8] Kline, 39-44.
[9] Ibid., 66.
[10] Ibid.,.

The Colombians had the long term interest of their people in sight. Not only were they interested in economic prosperity, they were interested in human development.

Additional recommendations to the Colombian government came in the form of a study by W. W. Olive of the U.S. Geological Survey. "It is for each nation to define these interests [in developing coal], but if it is the desire of the government that the nation's mineral reserves be developed by private capital under the free enterprise system, then private capital can only be attracted by the anticipation of realizing a profit on its equity investment that is commensurate with the degree of risk involved."[11] In other words, don't enter into the coal exploration business if you do not intend to prosecute it in a manner which allows you to be profitable.

The proposed contract was rejected but negotiations continued with Colombia eventually offering El Cerrejon out for bid to which Exxon and several other companies responded. Exxon's bid included infrastructure such as electric plants, railroads, and ports. These and other financial parts of Exxon's bid led them to being selected.[12] Over the next several years the El Cerrejon project would become very successful from the perspective of the Colombian government, the Colombian people, and Exxon.

In considering the pursuit of the project with respect to the negotiating process, Kline concludes that, "…it is more important to convince the political leaders of the political merits of a project than to convince the technocrats of the technical matters."[13] He also reveals some insight on trust among the TNE and the host government:

> Yes, the contract could have been better [for Colombia]. My opinion is that it was time to stop writing and begin working. We Colombians sometimes try to perfect writing during so much time that we never get

[11] Kline, 77-78.
[12] Ibid., 91, 96, and 109.
[13] Ibid., 175.

> around to the project. I thought that it was better to stay with the contract and perfect it later. Also, I feared renegotiation at the last moment. Exxon was trying to sell its board of directors on investing U.S. $1.5B here. They needed to convince the board that this was a country they could trust. So better to leave the contract alone and renegotiate-or change it in other ways-once the work was started.[14]

Throughout the study of the El Cerrejon case, Kline offers an assessment of comparing the Colombian case with other countries attempting faced with a similar situation. He cautions that though every case is different, there are four general conclusions to be reached:

> First, Colombia did begin; just as any developing country with a 'new' mineral does, with a dearth of knowledge and expertise.
> Second, just as similar developing countries have decided, the Colombian leaders chose not to wait first to develop knowledge and expertise before exploiting the new mineral.
> Third, just as in most other developing countries, the Colombian leaders contracted the mining exploration work to foreigners.
> Fourth, the Colombian experience is similar to that of other developing countries in that equity capital was obtained in the North El Cerrejon enterprise, but not day-to-day operation responsibilities. Such has been common not only in hard minerals, but also in petroleum.[15]

The study of the El Cerrejon case illustrates a good model for developing nations to use when faced with the discovery and exploitation of a natural resource. Key components include a mature government, available work force, and trust in the TNE partner.

[14]Kline, 176.
[15] Ibid., 186-187.

CHAPTER 6: U.S. STRATEGIC APPROACHES: A WAY FORWARD

Exploitation of rare earth elements would certainly provide direct economic advancement and collateral social advancement. Effective governance can be achieved through a mature government with the resources necessary to provide for its people.

Goldmann and Sjostedt note in their book on international influence that, "The immediate means toward achieving international economic power is national economic strength which consists of a high degree of control over things of great economic value to other states, and the will and skills with which this leverage is employed."[1] Certainly, efficient exploitation of rare earth elements fits this theory perfectly. The economic value of rare earths continues to rise as demand rises and supply remains mostly static. Africa represents a key strategic area of interest for the U.S. in terms of national security and economic opportunity. Engagement by USAFRICOM and other U.S. interests to develop African nations' ability to exploit this resource will serve to benefit all players.

Consideration for how USAFRICOM can move forward with rare earth engagement strategies must be tempered with some of the dangers of natural resource exploitation risk. It is important to recognize that we act in Africa to advance our own national interests first and the advancement of African nations second.

Rare Earth Element Exploitation Pitfalls and Risks

The economic development of a nation is a multi-faceted enterprise that relies on several factors. Though rare earth exploitation has the potential to bring economic security to African nations, and thereby aid development, it also is fraught with perils.

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[1] Kjell Goldmann and Gunner Sjostedt, *Power, Capabilities, Interdependence: Problem in the Study of International Influence* (London: Sage Publications, 1979), 169

In his testimony before Congress in March 2010, General Ward cautioned that, "…countries solely dependent on oil and extractive commodities revenue were vulnerable to falling prices. In many cases undiversified economies, high unemployment, and corruption, has prevented the wealth generated by Africa's natural resources from finding its way to the neediest segments of African societies."[2] As a strategy for rare earth exploitation is investigated, it follows that it must be a part of a nation's overall strategy for economic development, not the only element.

Since the economic health of African nations varies greatly, exploitation strategies must be tailored based on an objective analysis of the nation's overall economic picture, education level, maturity of the government, relationships with other nations and domestic and international corporations, and actual or predicted resource potential.

Natural resource exploitation is very expensive, time-consuming, and both economically and technically complex. As outlined in the Colombian case study, there can be a high degree of risk to the host nation as well as international partners in exploiting natural resources. Additionally, a significant amount of time is consumed in exploring, negotiating, building infrastructure, mining, and delivering a finished product. The risk to the host nation is increased if the maturity and stability of the government is low. If the host nation is poor at negotiating, it will also net a smaller profit, making the overall effect on economic development smaller.

Workers are subject to significant danger in natural resource exploitation. Even if an operation is able to navigate its way to profit, it must not be done at the expense of the reasonable safety and welfare of the host nation's workers. This would result in less internal stability despite economic advancement.

[2] Ward, *Commander's Intent*, 9.

The Current State of Rare Earth Element Exploitation in Africa

Other than South Africa, there is no significant rare earth mining in Africa. There are several exploratory operations in several African nations as outlined previously. This very immature state of known potential rare earth deposits greatly increases the risk of exploitation to African nations, domestic corporations, and any foreign nations or corporations that African nations may try to partner with.

Risk to the United States Government and USAFRICOM

USAFRICOM, and by default, the United States Government, exposes itself to a very high degree of risk in publicly and aggressively fostering rare earth development in African nations. Because of the pitfalls outlined earlier in the chapter, it is a very real possibility that any large-scale, overt attempts by USAFRICOM to encourage and foster rare earth exploitation has the real potential to fail and achieve the opposite of the Command's stated goal of establishing stability in Africa. A failed venture would result in loss of prestige for the host nation and USAFRICOM as well as decreased economic progress in the host nation. Failure in one nation may lead to a domino effect of lack of interest in other nations to trust USAFRICOM and the U.S. Government.

Because of these risks, an alternative approach may be to act in the background as a facilitator between U.S. and international corporations and the target African nation. Additionally, USAFRICOM can engage the whole of government to implement practices and engagement with African nations to train them in the broad spectrum of skills required to succeed in natural resource exploitation. This would most likely result in a longer time horizon, but may have a more favorable impact on long term stability and economic and developmental progress. Key partners within the U.S. Government would include the Departments of State, Interior, Treasury, Energy, and Commerce as well as the Environmental Protection Agency.

Strategies for Engagement

Due to the number of nations in Africa, there is not a set strategy that USAFRICOM can employ that will work for all nations. A range of different options must be available to the Command and the U.S. Government. These courses of action can be classified by three broad categories: reason for acting, level of involvement, and likelihood of success.

First, the Command and the U.S. State Department must decide how best to advance U.S. interests in the region. This can be broken down into why we are assisting a specific nation. Are we advancing a particular nation because it aligns with our national values or our realistic interests?

If we are advancing a nation because it aligns with our national values then we are deciding to act on behalf of a nation for things like improving human rights, developing a culture or sub-culture of the nation's society, or fostering an emerging democracy. By acting to help a nation exploit rare earth elements in this category, we believe that the improvements in the nation and its people will result in a more stable state, region, and continent. At the end of the process, the tangible benefit to the United States, such as an efficient increase in rare earth supply may not be clear, but the intangibles, will.

Another approach would be to assist a nation with a more realist approach. Some examples are: gaining another source of rare earths for the U.S. or its allies, gaining military access for broader strategic goals in exchange for exploitation assistance, offering assistance to counter terrorism in a nation or region that directly affects U.S.

interests, or assisting a nation in order to prevent them from accepting assistance from a peer or near-peer competitor such as China.

Second, the Command should decide its level of involvement. This level of involvement can be broken down into three degrees. These three degrees are: advocate, facilitator, and intermediary.

The most aggressive posture would be to act as an advocate. This posture is the most public. It would be characterized by direct involvement in the entire process. Actions include: negotiating on behalf of a nation with domestic and international corporations, providing and soliciting direct capital outlays in the forms of loans or grants, providing training and education for host nation management and workers in the rare earth industry, infrastructure design and construction, oversight of operations, and negotiations with sellers. This method might be best suited to the most underdeveloped and least mature nations with high rare earth exploitation potential.

The least intrusive posture would be to act as a facilitator. As a facilitator, the Command or U.S. Government would indirectly work with a host nation that may be higher on the development scale and thus more able to succeed with minimum assistance. In this posture, the Command might provide some broad advice in negotiation, steer potential investors to the host nation, remove trade or legislative barriers to investment, or provide higher level education and training to management and workers.

The middle ground of involvement would be to act as an intermediary. This is a hybrid of the advocate and facilitator rolls. The level of involvement can be further tailored by sub-area depending on the host nation. For instance, a nation with a strong central government but uneducated or unskilled workers could benefit from the U.S.

government providing training in mining techniques, but would not need assistance in negotiating with domestic or foreign corporations. Likewise, a host nation in need of funding might request U.S. Government assistance to obtain loans from U.S. or international banks, but not desire outright grants.

Third, the key to deciding where to act will be to consider the likelihood of succeeding in that nation. This is not easily measured and will likely be the most difficult area to act with certainty. Discovering rare earths is expensive and difficult. It will likely limit the Command and government significantly. This is a key reason why natural resource speculation can be very risky to the Command and U.S. government if made the central or only engagement strategy.

There are efforts underway to make the discovery portion of rare earths easier. The Boeing Corporation has developed remote sensing technology that can map rare earth elements from airplanes or satellites.[3] They are using the technology in the United States but it can be expanded to other parts of the globe. Contracting this type of exploratory technology could be a less invasive method of engagement. It could also serve to reduce costs and increase the likelihood of success as well as easing the fears of potential investors and speculators.

A key recommendation the Command and the U.S. government can make to a host nation will be what type of association the host nation will have with an international corporation. As described in the El Cerrejon case study, there are four predominant models to choose when determining the joint venture with a corporation: concession, society, association, or private.

[3] Jeremy Hsu, "Boeing Launches Search for Crucial Rare Earth Elements," September 20, 2010, http://www.msnbc.msn.com/cleanprint/CleanPrintProxy.aspx?1299463651697 (accessed March 6, 2011), 1-2.

Structuring the joint venture model for rare earth exploitation will be critical to the long-term viability of any project and will directly determine how the nation develops economically and socially. As in Colombia, the association model offers significant advantages that would likely apply to most African nations.

From the El Cerrejon model, it is critical that the long term view be taken with respect to the host nation workers. In Colombia, Exxon purposely went out of their way to develop the local population in all aspects of the operation for long term stability.

Mr. John D. Jorgenson of the U.S. Geological Survey worked in the mining industry for 30 years before joining the U.S.G.S. He spent 6 years in Colombia from 1983-1989 on the El Cerrejon Project. He made several observations regarding the use of host nation workers when interviewed.

> Exxon avoided hiring trans-national workers. Instead, they sponsored skilled worker clinics and trained the local workers to eventually be the managers over time. Significant investments in developing the local infrastructure to support both the mine and the surrounding area were made as well. Exxon maintained professional integrity by keeping their dealings above board and avoided the illegal practice of bribing local and regional officials for short term gain. Additionally, schools, clinics, roads, and other social infrastructure were developed for the local communities. The company worked with the local tribal elders and leaders on issues that impacted the people. This strategy was very effective over the short and long-term. Over the years the Revolutionary Armed Forces of Colombia (FARC) made attempts to infiltrate and control the area, but the locals refused to give them safe haven because the FARC could not offer them a better deal than Exxon and the Colombian government. Essentially, Exxon ran a pre-emptive counter-insurgency campaign against the FARC before an insurgency started.[4]

Exxon's strategy clearly illustrated the long-term strategy of stability and host-nation development over short-term gains and long-term non-viability. By adopting this strategy, they guaranteed long-term revenue and established a reputation among third-

[4] John D. Jorgenson, Telephone Interview by author, November 3, 2010.

world governments that they could be trusted in a joint venture to not sacrifice a host nation's interests for unreasonable profit. This is the key to how to move forward in designing a joint venture.

Decision Matrix

Since African nations are varied and there is not a one size fits all solution, the Command will have to determine how they will apportion resources in the development of rare earth exploitation. These resources may be financial, manpower, political capital, or time. The matrix in Figure 7 can be used to categorize each nation. As each country is analyzed, the matrix can serve as a reference document. Based on commander's intent, resources can be applied using this method.

By taking into account the broad categories described earlier in the chapter, the decision matrix can be built. As a parallel to campaign planning, populating the matrix represents course of action (COA) development. Qualitative or quantitative analysis can be performed to score each COA, or country, against Command criteria (governing factors) to determine priority and scope of action.

	Reasons for Acting		**Level of Involvement**			**Likelihood of Success**		
	Values	**Goals**	**Advocate**	**Intermediary**	**Facilitator**	**High**	**Medium**	**Low**
Country								
Algeria		**X**			**X**	**X**		
Tunisia		**X**			**X**		**X**	
Mali	**X**		**X**			**X**		
Ivory Coast	**X**			**X**				**X**

Figure 7 – Sample Decision Matrix Table

As an example, if the Command desires permanent basing at an airfield in Central Africa, it would make a goals based decision to negotiate with several nations in the region. As part of a broader strategy, the potential to assist a nation in developing rare earth elements for long-term economic and social development could be explored as part of the overall negotiating strategy. By leveraging a whole of government approach, the Command could use the decision matrix to determine the likelihood of rare earth element exploitation success coupled with the degree and level of involvement. Through quantitative and/or qualitative analysis of the matrix, a rank order of nations in the region would be assembled to inform the commander's decision. He, of course, would use this information, coupled with other efforts, to determine the overall plan.

As alluded to earlier, a whole of government approach is critical for success in using rare earth element exploitation as a vehicle for furthering U.S. national interests or values. No combatant commander will have the expertise or resources to effectively use this strategy for development. However, by acting as the process leader, a combatant commander and his staff could engage and energize multiple federal agencies and Congress to include rare earth exploitation in a global or regional plan of action.

It is also critical to note that any strategy using rare earth exploitation must have a long time horizon. The history of rare earth exploitation in the United States and China as well as coal exploitation in Colombia reveals that these are projects that are measured in decades, not years or months. This must be carefully considered by the Command to determine if rare earth engagement has the staying power in terms of rotating commanders every few years, Congressional and whole of government interest, stability and reliability of the host nation and its people, and the demand in the world market for the product.

CHAPTER 7: CONCLUSION

The long-term security, development, and prosperity of the African continent are keys to our nation's long-term security. Engagement in Africa faces significant obstacles. Among these obstacles are maturation of African governments, improvements in human development, and development of economies. None of these are easy or inexpensive. One of the driving factors in preventing the increasing of the standard of living across Africa is the lack of wealth and poor governance.

The rise of the importance of rare earth elements over the last fifty years has propelled theses resources to a position of high importance in the world market. Over the last twenty years, the monopoly on rare earths has shifted from the United States to China. With China's rising internal demand for rare earth elements, surplus rare earth elements available for export to the world market have been decreasing. Additionally, China's challenge in dealing with the realization of the impact of their lax internal environmental controls has further strained their ability to produce rare earth elements. This perfect storm of supply and demand has started to make it financially feasible for other nations to re-enter the competitive rare earth market.

Efforts around the globe are in full swing and new technologies to identify potential rare earth deposits are emerging. Known deposits in Africa are small, but significant interest in the continent as a potential rare earth stockpile is rising.

In this era of world economic difficulties, U.S. Africa Command is faced with the challenge of engaging African nations. The mining and exploitation of rare earth elements has the potential to provide some African nations with a valued natural resource as well as increase the world supply of rare earths thereby benefitting the U.S. and other nations. Developing this resource can result in a significant infusion of cash and the ensuing economic development. Properly guided and assisted by the U.S. Government, African nations can raise their level of governance and human development with successful rare earth mining and exploitation. It is a project worthy of undertaking by the U.S. government.

It cannot be overstated how critical it is that controls be in place to prevent exploitation of the people by their government or the international corporation. Corruption in the host nation or rampant profit taking by the corporation can quickly sour the venture and result in less stability and development, not more. Without proper governance, our assisting a weak or failing state with a sudden infusion of capital and the development of a valuable commodity may only serve to further corrupt the government and concentrate wealth in the hands of the dishonest.

The historical case study of the El Cerrejon project in Colombia provides a blueprint for how less developed and poorer nations can structure joint ventures with international corporations and governments to result in a profitable enterprise that potentially advances the nation as a whole. By serving as a facilitator in the process of rare earth mining and exploitation, the Command can use rare earths as part of their overall engagement strategy. By engaging the whole of the U.S. Government, valuable oversight of the negotiation of these joint ventures can serve to ensure that the exploitation of rare earths serves the development of the target nation as a whole while advancing U.S. interests or values.

The Command must also recognize that entering the natural resource enterprise is filled with hazards. Successful speculation in natural resources is highly dependent on the ever-changing market. The current market is very unstable due to the monopoly that China holds and the uncertainty of how users of rare earth end products will adjust to counter decreasing supplies.

Additionally, failure in a project with an African nation could lead to a substantial reduction in prestige for that nation as well as a negative impact on the Command's ability to influence and assist other African nations. One setback despite other successes could lead to other nations not willing to risk its limited capital or reputation in a joint venture with the U.S.

Once the decision is made to proceed, the Command must decide how, why, and to what degree they will engage. The Command must determine if we are acting out of our own realistic interests or on values. Next the Command must decide whether we will play a minor role or act more as an advocate leading the way until the process is self-sustaining. A realistic assessment of our likelihood of success must be made as a major factor in determining our decision to act or not. The suggested matrix is a tool to catalog these answers and provide the commander with a resource to make an informed decision or assign priorities to actions in a constrained resource environment.

USAFRICOM and the U.S. Government should proceed with helping African nations develop and exploit rare earth metals as part of an overall strategy of engagement while remaining critically cognizant of the risks in natural resource exploration all the while considering the likelihood of success and how it ties back to meeting the President's stated goals from the National Security Strategy.

APPENDIX A

History

The discovery of the rare earth elements is a relatively new event. Not until the nineteenth century generated the application of technology that required rare earths did the rare earth elements mature. The following is a brief history of rare earths.

> The early Greeks defined earths as materials that could not be changed further by the sources of heat then available. Until late in the 18th century, this Greek conception remained strong in chemistry, and oxides of metals such as calcium, aluminum, and magnesium were known as earths and were thought to be elements.
> In 1794, Johan Gadolin, a Finnish chemist, while investigating a rare Swedish mineral, discovered a new earth in impure form, which he believed to be a new element and to which he gave the name ytterbia, from Ytterby, the village where the ore was found. The name, however, was soon shortened to yttria. In 1803, from the same mineral, later named gadolinite in Gadolin's honour, another new earth was reported in the literature independently by several chemists. The new earth became known as ceria, from the asteroid Ceres, which had just been discovered (1801). Since yttria and ceria had been discovered in a rare mineral, and they closely resembled other known earths, they were referred to as the rare earths. Not until 1808 did Sir Humphry Davy demonstrate that the earths as a class were not elements themselves but were compounds of oxygen and metallic elements. Later, a number of chemists verified the existence of ceria and yttria in gadolinite and found that these oxides were also present in a wide variety of other rare minerals. The elements of which yttria and ceria were the oxides were then given the names yttrium and cerium, respectively.
> In the period from 1839 to 1843, Carl Gustaf Mosander, a Swedish chemist (and student of Berzelius), found that yttria and ceria were not even the oxides of single elements but were, in fact, mixtures. He reported that if the oxides were dissolved in strong acid and the resulting solution subjected to a long series of fractional precipitations as various salts (oxalates, hydroxides, and nitrates), two new elemental substances could be split off from the main component of each oxide. The two new oxides found in ceria he called lanthana and didymia, and the elements contained in them were named lanthanum and didymium. The new elements found (as their oxides) in yttria he called erbium and terbium, and the oxides were referred to as erbia and terbia. Mosander also was the first to obtain the rare-earth metals themselves from their oxides, although only in impure form. Mosander's researches puzzled the scientists of his time. He seemed to be finding a new group of elements of an entirely different type from any known previously. All formed the same classes of compounds with almost the same properties, and the elements could be distinguished from one another—at that time—only by slight differences in the solubilities and molecular weights of the various compounds.

In the next few years the literature on the rare earths became confused. There was, for example, considerable controversy for a number of years over the existence of didymium. The situation was considerably clarified in 1859 when an instrument called the spectroscope was introduced into the study of the rare earths. This instrument indicated the patterns of light emission or absorption characteristic of the elements, and, with it, didymium was shown to have a characteristic absorption spectrum. From then on determination of spectra of various types became one of the most important tools in following the progress of the fractionation of rare earths. Somehow during this period the names used for the various fractions differed from laboratory to laboratory. Around 1860, by general agreement, it was decided to interchange the names of Mosander's earths, erbia and terbia.

In 1869, when Mendeleyev first proposed the periodic table, he found it necessary to leave a blank at the position now occupied by scandium. He predicted, however, that a new element would be found to fit that blank in the table, and he also predicted certain properties of the element. The discovery of scandium a few years later (1879) and the agreement of its properties with those predicted by Mendeleyev helped to bring about general scientific acceptance of Mendeleyev's periodic table. Interestingly enough, one of the greatest weaknesses in the table was that it provided no logical place for the lanthanoids, a difficulty that was not resolved for some years.

From 1843 to 1939 chemical fractionation of the mixed rare-earth salts obtained from many minerals was intensively investigated in both Europe and North America. Mosander's didymia was resolved into several oxides—samaria (samarium; 1879), praseodymia (praseodymium; 1885), neodymia (neodymium; 1885), and europia (europium; 1901). His terbia and erbia were resolved into holmia (holmium; 1878), thulia (thulium; 1879), dysprosia (dysprosium; 1886), ytterbia (ytterbium; 1876), and lutetia (lutetium; 1907).

During this period many of these elements were discovered independently by more than one investigator, but the credit for the discovery was usually given to the man who first separated sufficient quantities of the oxide to determine some of its properties and who published his results first.

As the scientists carried out their fractionations, they frequently observed changes in colour, apparent molecular weight, and spectra of the substances. Such changes were mainly responsible for the more than 70 claims for the discovery of new rare-earth elements during this period. Many of the observed changes were brought about by the concentration of different impurities, particularly the transition elements, in various fractions of the series. It is now known that such trace impurities in the rare-earth oxides can give rise to such colour changes and that such oxides can be made to fluoresce strongly and exhibit unique spectra.

Shortly after Auer von Welsbach isolated praseodymia and neodymia in 1885 he invented an illuminating device that bears his name (Welsbach gas mantle), and a little later he produced a practical lighter flint. Both devices depended upon rare-earth elements. Although minerals rich in rare earths had up to that time been thought to be very rare, the demand for rare earths that developed as a result of Auer von Welsbach's inventions resulted in a worldwide search for rare-earth minerals, and it was found that one of them, monazite, existed in extensive deposits. Monazite, a phosphate of several rare-earth elements, was ideal for Auer von Welsbach's

purposes, because it contained a high percentage of the element thorium, which was also used for the mantles. These were prepared by impregnating a cloth fabric with a solution of about 90 percent thorium nitrate, 10 percent cerium trinitrate, and minor amounts of other salts. When heated by a gas flame, these salts were converted to their oxides, which, when heated by the flame, gave off an intense white light. Cerium and iron form an alloy that emits sparks when struck. The discovery of this alloy by Auer von Welsbach started the flint industry. In 1913 about 3,300 tons of monazite were refined to produce the thorium and cerium used in gas mantles and the mixed rare-earth metals for flints and related products.
The British physicist H.G.J. Moseley, while studying the X-ray emission spectra of the elements in 1913–14, found a direct relationship between the X-ray frequencies and the atomic numbers of the elements. This relationship made it possible to assign unambiguous atomic numbers to the elements and to verify their locations in the periodic table. In this way, Moseley was able to show clearly that there could be only 14 lanthanoids following lanthanum, starting with cerium and ending at lutetium, and, at that time, all of the rare-earth elements had been discovered except for element 61. Because no stable isotopes (forms of the element with differing mass) of this substance exist in nature, it was not isolated until 1945, when one of its radioactive isotopes was separated from atomic fission products produced in a nuclear reactor. The element was named promethium after the Greek Titan who stole fire from the gods and gave it to mankind."[1]

Where are Rare Earth Elements?

Rare Earth Elements can be found in Monazite deposits. "Monazite, a mixed phosphate of calcium, thorium, cerium, and various lanthanoids, occurs in extensive deposits and is one of the main sources used commercially to obtain the light rare-earth elements."[2]

> Monazite contains about 50 percent by weight rare-earth elements, in the approximate proportions 50 percent cerium, 20 percent lanthanum, 20 percent neodymium, 5 percent praseodymium, and lesser amounts of samarium, gadolinium, and yttrium. It also contains small amounts of the heavy rare-earth elements. The actual amounts of each element in the mineral vary considerably, depending on the point of origin of the monazite, because the various metallic elements can substitute for one another in the crystal lattice. The mineral probably formed as small crystals in rocks as they cooled, but as the mountains eroded away and were washed into the sea, the monazite, being denser than most other materials, settled first, while the lighter materials were carried farther out to sea. Apparently as a result of this action, sandbars containing monazite

[1] Britannica Online Encyclopedia, *Rare Earth Element* (2010), 2-4.
[2] Ibid., 12.

are found along the coasts of Brazil and southwestern India. Concentrated deposits are also found on certain uplands, which are thought to have been the beaches of ancient seas or oceans and which were later uplifted. Such deposits in massive amounts are found in Australia, in South Africa, and in the United States in South Carolina, Florida, and Idaho, as well as in many other locations. The mineral is dredged or scooped up, pulverized if necessary, and concentrated by flotation methods. Sometimes a magnetic-belt separator is used to pull the more magnetic monazite to one side in order to separate it from the nonmagnetic materials. The monazite is then shipped to rare-earth chemical plants.

Another important source of light rare earths and europium is the mineral bastnaesite, a fluorocarbonate of lanthanum and cerium, with smaller amounts of neodymium and praseodymium. It is found in extensive deposits in eastern California. It contains almost no heavy rare earths, but there is enough europium (about 0.1 percent) to supply much of the world demand for this element. The rock is broken up by blasting and then is crushed and ground to a fine powder. The bastnaesite is separated from the other materials by the usual flotation methods and is then treated chemically so that it can be separated into europium, lanthanum, and cerium fractions by liquid–liquid extraction methods (*see below* Liquid–liquid extraction).[3]

[3] Ibid.

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VITA

Lt Col Gene Becker received his commission from the Air Force ROTC and a Bachelor of Engineering degree in Civil Engineering from the Stevens Institute of Technology in 1990. He attended Undergraduate Pilot Training at Ft. Rucker, Alabama and was designated his class' Distinguished Graduate.

After flying the HH-1H Huey supporting the ICBM security plan, he qualified in the MH-53 Pave Low special operations helicopter. Over the next 13 years he progressed from co-pilot to flight examiner and served in squadron leadership roles culminating as a squadron operations officer and commander. He has served in Group and Major Command staff billets. He commanded and oversaw the deactivation of the 20th Special Operations Squadron in 2008. Following squadron duty, he served as Deputy Commander for the 1st Special Operations Group and the Air Force Special Operations Training Center at Hurlburt Field, Florida before attending the Joint Advanced Warfighting School in Norfolk, Virginia.

His combat deployments include operations in Bosnia, MH-53 detachment command in Afghanistan, Rotary-Wing Assault Force coordinator and pilot for the Al Faw Raid in 2003 in Iraq with the British Royal Marines, operations in Haiti in 2004, service on a Joint Task Force staff in Iraq in 2006, and deployed MH-53 squadron command in Iraq in 2007 and 2008 supporting the Combined Joint Special Operations Task Force. He also flew the last USAF H-53 combat sortie in Iraq in 2008.

Lt Col Becker holds Masters Degrees from Embry-Riddle Aeronautical University and the Air University.