RARE EARTH MINERALS AND 21ST CENTURY INDUSTRY

HEARING

BEFORE THE

SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

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March 16, 2010

Appendix: Answers to Post-Hearing Questions

RARE EARTH MINERALS AND 21ST CENTURY INDUSTRY

TUESDAY, MARCH 16, 2010

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 2:01 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Brad Miller [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
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Subcommittee on Investigations and Oversight

Hearing on

Rare Earth Minerals and 21st Century Industry

Tuesday, March 16, 2010
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. Stephen Freiman
President
Freiman Consulting, Inc.

Dr. Steven Duclos
Chief Scientist & Manager, Material Sustainability
General Electric Global Research

Dr. Karl A. Gschneidner, Jr.
Anson Marston Distinguished Professor
Department of Materials Science and Engineering
Iowa State University

Mr. Mark Smith
Chief Executive Officer
Molycorp Minerals, LLC

Mr. Terence Stewart, Esq.
Managing Partner
Stewart and Stewart

HEARING CHARTER

Purpose

The United States, as part of its strategy to reduce emissions from electricity generation and transportation, is investing significant funds in renewable energy technologies such as wind power and hybrid vehicles. The American Recovery and Reinvestment Act provides $2.3 billion for advanced energy manufacturing facilities, including wind turbine manufacturing plants. The Act further makes available $2 billion ". . . for Advanced Battery Manufacturing grants to support the manufacturing of advanced vehicle batteries and components . . ." Yet these investments may fail to prompt the desired outcome—a buoyant industry producing renewable energy systems—for lack of rare earth minerals.[1]

The United States finds itself dependent on the People's Republic of China for a commodity without which it would be hard to compete in high-technology industries. With a near-monopoly in supplies of rare earths, the Chinese government threatens to limit exports and tries to induce manufacturing firms to locate their facilities in Inner Mongolia. The main American supplier is seeking funding to restart its mining operation, which closed in 2002, having suffered from low prices as China expanded into the market and from a late start on renewing its environmental permits in California. Support for research has diminished.

This hearing by the Subcommittee on Investigations and Oversight will examine these intertwined threads to determine ways of redressing the expected imbalance between available supplies of rare earths and the Nation's need for them. The hearing will also ask why the policy structure put in place thirty years ago precisely to identify and respond to situations like this before they became acute bottlenecks failed to do its job.

Witnesses

Dr. Stephen W. Freiman
President, Freiman Consulting, Inc.
Member, National Research Council Committee on
Critical Mineral Impacts on the U.S. Economy

Dr. Freiman will present the findings and recommendations of the most recent National Research Council study evaluating potential responses to fluctuations in the supply-demand balance for minerals and materials. The Council included rare earth minerals among the cases analyzed, concluding that there are sufficient supply risks for rare earths to be classified as a critical resource. Dr. Freiman, a materials scientist, served as Chief of the Ceramics Division and Director of the Materials Science and Engineering Laboratory during a career at the National Institute of Standards and Technology that spanned 28 years. A specialist in the fracture of brittle materials, he has published more than 150 scientific papers.

Dr. Steven Duclos
Chief Scientist and Manager, Material Sustainability
General Electric Global Research

Dr. Duclos will testify on the process underlying General Electric's Materials Sustainability Initiative, which assesses the company's businesses for risks posed by lack of raw materials. If a problem is identified, are there steps to reduce that risk by finding substitutes, reducing the need for the material or recycling? Terbium, one of the rare earths, was identified as a high risk for GE by the Initiative. Dr. Duclos managed the company's Optical Materials Laboratory, working with GE units to develop advanced materials. He came to GE from a post-doctorate position at the AT&T Bell Labs studying superconductivity in buckminsterfullerene, the form of carbon popularly known as "buckyballs."

Dr. Karl A Gschneidner, Jr.
Anson Marston Distinguished Professor
Department of Materials Science and Engineering
Iowa State University

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[1] These minerals were named "Rare Earths" at the time of their discovery as they were originally found in the form of oxides (bound together with oxygen; compounds were called "earths" by scientists in the late 18th Century). "Rare" reflected the fact that the Swedish scientists who originally separated the various compounds had not encountered them before. Today, the name is somewhat misleading in that ". . . even the two least abundant, thulium and lutetium, are nearly 200 times as abundant as gold . . .." Committee on Critical Mineral Impacts on the U.S. Economy, *Minerals, Critical Minerals and the U.S. Economy* (Washington: National Research Council, 2008); p. 133 (hereafter cited as NRC Report).

Dr. Gschneidner's testimony will focus on current studies of rare earths and the processes needed to convert the ores into industrially-useful materials. He has also been asked for comments to recommend improvements in the existing U.S. research program. In addition to his professorship at Iowa State University, Dr. Gschneidner holds the position of Senior Metallurgist at the Ames National Laboratory of the Department of Energy. He has researched the properties of rare earth minerals, has served as the Senior Editor of the *Handbook of the Physics and Chemistry of Rare Earths* since 1976 and was for years Director of the Ames Laboratory Rare Earth Information Center. Dr. Gschneidner is currently funded by DOE to design a refrigerator using magnets to control temperatures. He was elected to the National Academy of Engineering in 2007.

Mr. Mark Smith
Chief Executive Officer
Molycorp Minerals, LLC

Mr. Smith's company is focused on restarting the mine in Mountain Pass, California, holding the primary source of rare earth minerals in the United States. The mine was previously owned by the mining subsidiary of the Chevron Corporation, which acquired it as part of its purchase of the Union Oil Company of California. Mr. Smith, who served as head of Chevron's mining subsidiary, left to become President and CEO of Molycorp in April 2006 and negotiated to buy the Mountain Pass mine from his old company in 2007. Operations at the mine were halted after accidental spills and failure to complete environmental permits required by the State of California. Mr. Smith has been asked to describe his plan for restoring mining operations and for expanding the company into the production of magnets for next-generation wind turbine generators.

Mr. Terence Stewart, Esq.
Managing Partner
Stewart and Stewart

Mr. Stewart has an extensive history in international trade and customs law. He is a leading expert on the World Trade Organization and has assisted industry and labor groups with trade issues. Given China's outsized role in the rare earths market and its efforts to increase its influence in high-technology industries, Mr. Stewart has been invited to present his insights into China's policies and actions on resource issues and into their ramifications for U.S. industry and the economy.

Background

In November 2009, the Australian Broadcasting Corporation summarized the rare earths issues quite succinctly:

> The rare earth metals story is one lens through which we can view changing world economics, the ways and the pitfalls of how China integrates with the capitalist world, and global trade. China provides more than 90% of the world's supply of rare earths. The business media in particular is full of stories of how if the Chinese hold back on their supply of rare earths, your iPhone won't work. And more, much more. Climate change comes into it, too, because the green technologies are very dependent on rare earths.[2]

The current issues relating to rare earths supply and demand represent the latest instance of a continuing story in which what was an obscure, commodity mineral or material suddenly assumes outsized importance. Industry finds new uses that strain supplies, and American firms find that there are no domestic suppliers. In 1985, the Office of Technology Assessment (OTA) published Strategic Materials: Technologies to Reduce U.S. Import Vulnerability in response to concerns that

> Three nations, South Africa, Zaire, and the U.S.S.R., account for over half of the world's production of chromium, cobalt, manganese, and platinum group metals. These metals are essential in the production of high-temperature alloys, steel and stainless steel, industrial and automotive catalysts, electronics, and other applications that are critical to the U.S. economy and the national defense . . ..[3]

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[2] Stan Correy. "Background Briefing: Rare Earths and China." Australian Broadcasting Corporation transcript, November 15, 2009. Accessed at *http://www.abc.net.au/rn/backeroundbriefing/stories/2009/2738774.htm,* January 28, 2010.

[3] *Strategic Materials: Technologies to Reduce U.S. Import Vulnerability* (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA–ITE–248, May 1985); p.3.

At that time, OTA identified the following as options for the Federal Government to pursue: increase exploration for domestic sources, find new overseas suppliers, find substitutes or reduce the need. Many of these same options apply to the case of rare earth minerals—although the unique properties that make these elements valuable may not be found in any substitute materials or minerals.[4]

The Global Rare Earths Playing Field

The United States Geological Survey's Minerals Information Team annually publishes *Mineral Commodity Summaries,* collecting information on supply, demand and market activity on some 90 minerals and materials, among them the rare earths. In January 2010, the most recent summary for the rare earths was issued, with data current to 2008.[5] USGS reported there that the United States was completely dependent on imports: between 2005 and 2008, 91% of its consumption came from China, 3% from France, 3% from Japan, 1% from Russia and 2% from other sources. The estimated cost of processed ore suitable for extracting rare earths rose from $6.61 to $8.82 per kilogram between 2007 and 2008, then dropped back to $5.73 during 2009.[6]

USGS issued the following assessment of global rare earths supply: [7]

World Mine Production and Reserves: Reserves data for Australia, China, and India were updated based on data from the respective countries.

	Mine production[e] 2008	Mine production[e] 2009	Reserves[6]
United States	—	—	13,000,000
Australia	—	—	5,400,000
Brazil	650	650	48,000
China	120,000	120,000	36,000,000
Commonwealth of Independent States	NA	NA	19,000,000
India	2,700	2,700	3,100,000
Malaysia	380	380	30,000
Other countries	NA	NA	22,000,000
World total (rounded)	124,000	124,000	99,000,000

[e] Estimated

[6] **Reserves.** -That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

Actions by the Chinese government (see the next section) and growing world investment in renewable energy equipment have reinvigorated efforts to identify new sources for rare earths. Molycorp restarted its separation plant in 2007 and is processing residual materials from its mine tailings. Australia has begun production at its Mt. Weld deposit. Evaluation of the economic viability of producing in Canada and Malawi is underway.[8] An Australian mining company is also studying a deposit in Greenland that could satisfy some 25% of world needs over the next fifty years.[9] Still, as Mr. Smith of Molycorp notes, it takes significant funding and time to bring new mines into production, and volatility in a commodity market can upset even well-laid plans.

China and the Global Market

Indications that China intended to reduce exports of the rare earth materials is a major reason that this issue has recently gained prominence. Reports last year indicated that the Ministry of Industry and Information Technology had submitted the draft of a six-year plan to the State Council of China that contemplated deepening existing cuts in shipments of minerals like dysprosium.[10] The ministry stated

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[4] NRC Report, p. 131.

[5] James B. Hedrick, "Rare Earths," in Mineral Commodity Summaries 2009 (Reston, VA: United States Geological Survey; January 2010); pp. 128–129.

[6] *Ibid.,* p. 128.

[7] *Ibid.,* p. 129.

[8] *Ibid.*

[9] Leo Lewis, "Greenland Challenge to Chinese Over Rare Earth Minerals," London *Times*, October 5, 2009; p. 39.

[10] Keith Bradsher, "China Tightens Grip on Rare Minerals," New York *Times*, September 1, 2009; p. B1. See also Ambrose Evans-Pritchard, "World Faces Hi-Tech Crunch as China Eyes Ban on Rare Metal Exports," Telegraph.co.uk on August 24, 2009 at 5:58 PM BST. Accessed

Continued

that it was concerned that China lacked enough of the minerals to meet its own needs.[11] The Japanese Ministry of Economy, Trade and Industry had earlier developed a "Strategy for Ensuring Stable Supplies of Rare Metals" after the threat that China might limit supplies came to the attention of the Cabinet in Tokyo.[12]

The rare earths issue showcases two major elements of China's strategy for economic development:

- the targeting of critical industries that are to be kept under government control; and
- the use of subsidies and other incentives to attract foreign investment that will result in moving China's production up the value chain, bringing advanced technology into the country, and generating sophisticated exports.

Non-ferrous metals, the category into which rare earths fall, represent one of six industries that the Chinese government considers most central to economic performance and growth. The other five of these "Heavyweight Industries" are machinery; automobiles; information technology; construction; and iron and steel. Plans to keep the nation's economy under control call for state ownership of the three largest firms in each industry.[13]

China's government has long been aware of its rare earths deposits' potential value and thought of them in strategic terms. An official publication quotes a 1992 statement by then-Paramount Leader Deng Xiaoping that "there is oil in the Middle East; there is rare earth in China." In conjunction with a 1999 visit to Inner Mongolia, where China's largest deposit of rare earth minerals is located, then-President Jiang Zemin wrote: "Improve the development and applications of rare earth, and change the resource advantage into economic superiority."[14]

Although China has reportedly abandoned a provision in its Rare Earths Industry Development Plan 2009–15 that would have placed an absolute ban on the export of five of the 17 rare earths, a ban on exports of raw ores continues, as does the progressive lowering of exports quotas on other forms of the materials that began in 2006. Officials in China make no secret of their desire to bring the manufacturing of the high-value-added products containing rare earths into China. "We want rare-earth industries to locate in Inner Mongolia," Zhao Shuanglin, vice chairman of Inner Mongolia Autonomous Region, stated in September 2009.[15] At around the same time, Zhang Peichen, the deputy director of Baotou Rare Earth Research Institute in Inner Mongolia, predicted: "Rare earth usage in China will be increasingly greater than exports."[16]

While its current near-monopoly in rare earths gives it a potent stick, China has had outstanding success in using the carrot to enlist foreign-based corporations' help in building up its economy. For the past 15 years or more, multinational companies have shown themselves eager to establish a presence in China to gain access to the country's potentially huge market. But that is not the only reason they have sited production and, more recently, research capacity there. "China has attracted the world's largest manufacturers by offering discounted land, energy, and taxes to relocate in China and to use China as a global export platform," according to the U.S.-China Economic and Security Review Commission. As a result, "more than half of China's exports originate from foreign-invested manufacturing enterprises located in China."[17]

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at *http://www.telegraph.co.uk/finance/commentlambroseevans_pritchard/6082464/World-faces-hi-tech-crunch-as-China-eves-ban-on-rare-metal-exports.html,* October 15, 2009.

[11] Feiwen Rong and Xiao Yu, "Shortage of Rare Earths Used in Hybrids, TVs May Loom in China," Bloomberg News on September 3, 2009 at 4:54 AM EDT. Accessed at *http://www.bloomberg.com/apps/news?pid=20601080&sid=afn.hOk6eEHq,* October 17, 2009.

[12] Ministry of Economy, Trade and Industry, "Announcement of 'Strategy for Ensuring Stable Supplies of Rare Metals," July 28, 2009. Accessed at *http://www.meti.go.jp/english/press/data/20090728_01.html,* October 15, 2009.

[13] A similar plan is in place for the country's seven "Strategic" industries: armaments; power generation and distribution; oil and petrochemicals; telecommunications; coal; civil aviation; and shipping. The firms in this sector are to be subject to "absolute control" by the government, while, in the "Heavyweight" sphere, the government is looking for no more than a "dominant presence." U.S.-China Economic and Security Review Commission, *Hearing on China's Industrial Policy and its Impact on U.S. Companies, Workers, and the American Economy,* testimony of George Haley, March 24, 2009.

[14] "Rare Earth: An Introduction," Baotou National Rare Earth Hi-Tech Industrial Development Zone, accessed at *http://www.rev.cn/en/int.htm,* January 29, 2010.

[15] Chuin-Wei Yap, "Will China Tighten 'Rare Earth' Grip?," *Wall Street Journal,* September 3, 2009; p. C12.

[16] Bradsher, *loc. cit.*

[17] U.S.-China Economic and Security Review Commission, *2009 Report to Congress* (Washington: U.S. Government Printing Office, November 2009); p. 43.

"Preferential Policies" designed to attract foreign firms to the Baotou National Rare Earth Hi-Tech Industrial Development Zone, located less than 100 miles from China's huge rare earths mine at Bayan Obo in Inner Mongolia, include both funding mechanisms and significant tax incentives. For example, "hi-tech enterprises" and venture capital companies are exempt from income tax for their first five years operating in the Zone, then pay at only half of the regular 15 percent rate during a second five-year period. They receive breaks on VAT and operations taxes as well.[18] The Baotou Industrial Development Zone's Web site lists 25 options on a page titled "Projects Seeking Investment," many of them focusing on rare earths and several of them in the area of "green technologies." Among these projects are:

- "Nickel Hydrogen Power Battery Polar Plate";
- "Hydrogen-Store Alloy Powder Cathode Material of Ni-Hydrogen Power Battery";
- "Industrialization of Rare Earth Ceramic Piston Ring";
- "Production Line of Rare Earth Giant Magnetostrictive Alloy";
- "The Technology of Special Rare Earth Ceramic Thermocouple Tube";
- "Industrialization of Nanometer Crystal Rare Earth Alloy Magnetic Powder"; and
- "Annual Production of 200000 Units of Magnet Motor for Electric Bicycle.[19]

Reviving Research

Iowa State University (ISU) became a hub of rare earth research as its contribution to the Manhattan Project.[20] Dr. Gschneidner carries on the tradition in rare earth research, focusing today on the behavior of rare earths at low temperatures or in high magnetic fields. He is currently receiving funds from the Department of Energy to build a refrigerator that achieves cooling by magnetism, employing magnets containing rare earths. Dr. William McCallum has recently begun seeking a cheaper or more readily available substitute for the rare earths incorporated into the permanent magnet used in a hybrid vehicle's generator. If his project is successful, a potential bottleneck for hybrid vehicle manufacturers will be eliminated. These are elements of the broader effort on magnet development at the Lab.[21] Both Drs. Gschneidner and McCallum served as director for the Rare Earth Information Center at Ames. Established as an information clearinghouse on the minerals by the Atomic Energy Commission in 1966, it was closed in 2002.

In discussing the needs for research in minerals and materials, the NRC Committee on Critical Mineral Impacts on the U.S. Economy drew heavily on a 2006 industry study by the Industrial College of the Armed Forces.[22] That analysis placed rare earths in a category recommended for government support to develop materials offering superior properties for defense and commercial applications. Designers and engineers prefer materials with well-understood properties, but this conservative tendency can stymie innovation by limiting the opportunity to improve performance or efficiency. Agencies like NASA and the Department of Defense invest in studies of materials to put real-world data into the handbooks that program managers consult when writing system specifications. The decision to employ a new

[18] "Preferential Policies," Baotou National Rare Earth Hi-Tech Industrial Development Zone, accessed at *http://www.rev.cn/en/pre.htm,* January 29, 2010.

[19] "Catalog," Baotou National Rare Earth Hi-Tech Industrial Development Zone, accessed at *http://www.rev.cn/en/pro.htm,* January 29, 2010.

[20] The first chain reaction, initiated December 2, 1942, used natural uranium, which is very low in the fissionable isotope U–235. When a U–235 atom splits, rare earths may be among the resulting fragments. Because these might soak up the excess neutrons in the reactor that would sustain the chain reaction, research was needed on how to separate rare earths from uranium and plutonium. Iowa State succeeded in developing separation methods that could produce rare earths that were sufficiently purified to permit the needed research program. Harry J. Svec, "Prologue," in Gschneidner and Eyring, eds., *Handbook on the Physics and Chemistry of the Rare Earths,* Vol. 11 (Amsterdam: Elsevier Science Publishers, BV, 1988); p. 15. In 1947, the newly-formed Atomic Energy Commission chose the school as the home for the Ames National Laboratory and appointed Dr. Frank Spedding as its first director. Spedding, a leader in rare earth chemistry, improved his original processing methods to the point where Ames became the major supplier to the scientific community and the AEC laboratories. Spedding oversaw an extensive basic research effort characterizing the properties of rare earths in solutions and continued to develop industrial-scale processing for these materials. *Ibid.,* p. 16.

[21] Communication from Iver Anderson, Senior Metallurgist, Ames National Laboratory, January 7, 2010.

[22] Lt. Col Carl Buhler, USAF *et al. Strategic Materials: AY 2005–2006 Industry Study Final Report.* Industrial College of the Armed Forces, National Defense University, Ft. McNair, Washington, D.C., 2006. (hereafter cited as *ICAF Report*)

material often requires reworking existing production methods or introducing entirely new processes. Perfecting these can consume years, and the government may be alone in its willingness to support a project lasting that long.[23]

The NRC report notes: "Many government efforts specifically focus on innovative research in materials specialties. These efforts support a variety of worthwhile research in materials science. However, individual agencies award many of these grants on an individual or somewhat ad hoc basis that is not the product of a coordinated research strategy. In particular, they rarely address mineral information needs or consider mineral supply and demand data or criticality, either short or long term." [24] The panel therefore calls for:

- Theoretical geochemical research to better identify and quantify virgin stocks that are potentially minable;
- Research on extraction and processing technology to improve energy efficiency, decrease water use, and enhance material separation;
- Research on remanufacturing and recycling technology, key components in increasing the rate and efficiency of material reuse; and
- The characterization of stocks and flows of materials, especially imports and exports, as components of products, and of losses upon product discard. This lack of information impedes planning on many levels.[25]

This proposed program is consistent with the research effort required by the National Materials and Minerals Policy, Research and Development Act of 1980.[26]

The Policy Framework

Thirty years ago, the National Materials and Minerals Policy, Research and Development Act was enacted because

> . . . [T]he United States lacks a coherent national materials policy and a coordinated program to assure the availability of materials critical for national economic well-being, national defense, and industrial production, including interstate commerce and foreign trade . . ..[27]

The Congress declared it the President's responsibility to coordinate a plan of research and other actions that would ". . . promote an adequate and stable supply of materials necessary to maintain national security, economic well-being and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs.[28] Our current situation with rare earth minerals indicates that successive Administrations failed to carry out this policy.

The 1980 Act directed development of a plan that would, among other outcomes, produce continuing assessments of demand for minerals and materials in the economy; conduct a "vigorous" research and development effort; collect, analyze and disseminate information; and cooperate with the private sector and other nations.[29] In April 1982, President Reagan delivered a response to that directive.[30]

Dissatisfied with the plan and its implementation, Congress decided in the National Critical Materials Act of 1984 to establish a National Critical Materials Council in the Executive Office of the President to serve as the focal point for critical materials policy. The Council was tasked to assist the President in carrying out the requirements of the 1980 Act.[31] Yet by 1989, as the first Bush Administration took office, reports indicated that the Council was effectively moribund and that President Reagan's final budget request recommended that it be eliminated.[32] Senator Harry Reid took strong exception to the view of Acting Council Chairman Thomas Moore ". . . that there is no need for a centralized agency like the council because other agencies already are authorized to address critical material issues." [33] The Council survived that brush with extinction, but ultimately succumbed to a rec-

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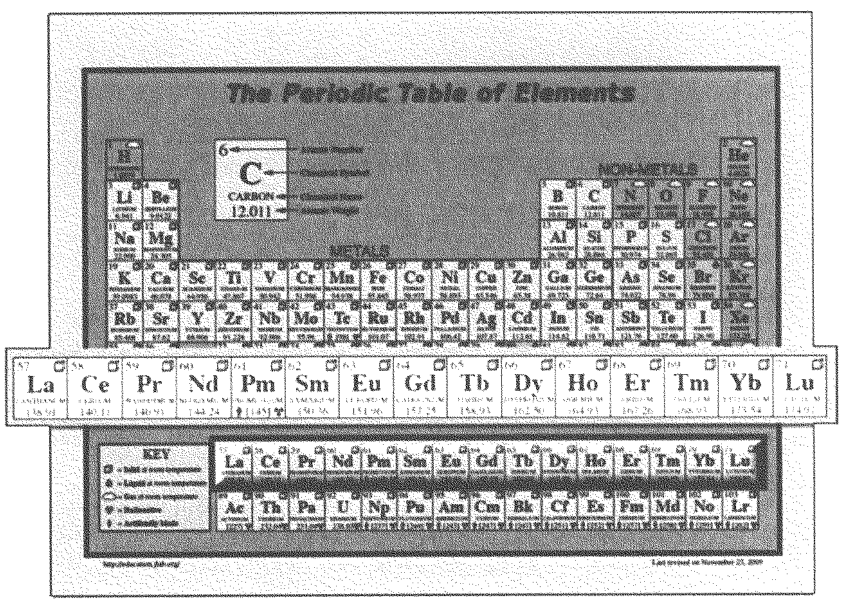
[23] *Ibid.,* pp. 6–9.
[24] *NRC Report,* p. 195.
[25] *Ibid.,* p. 192.
[26] 30 U.S.C. 1602(2).
[27] 30 U.S.C. 1601(a)(6).
[28] 30 U.S.C. 1602.
[29] 30 U.S.C. 1603.
[30] "National Materials and Minerals Program Plan and Report to Congress," April 1982.
[31] 30 U.S.C. Chapter 30.
[32] "New budget to cut NCMC, R&D at Mint and land purchases," *Metals Week*, January 16, 1989; p. 3.
[33] Marilyn Werber, "Senator Blasts Plan to Abolish NCMC," *American Metal Market*, April 6, 1989; p. 2.

ommendation by President Clinton's science advisor, Director of the Office of Science and Technology Policy (OSTP) Dr. John Gibbons, to terminate the Council and transfer its responsibilities to the National Science and Technology Council (NSTC) established within OSTP by Executive Order 12881.[34] Funding for the Critical Materials Council was dropped in the Fiscal Year 1994 General Government Appropriation Act.[35]

In 1995 and 1996, the NSTC published reports on *The Federal Research and Development Program in Materials Science and Technology.* No equivalent report has been produced since, however, and inquiries made of OSTP failed to locate the "long-range assessments of materials needs related to scientific and technological concerns" or "scientific and technical changes over the next five years" whose annual preparation the statute requires.[36] It empirically demonstrates the failure to implement the responsibilities assigned by Congress in the 1980 Act through multiple administrations. The Committee has learned that the situation with rare earth supplies has galvanized OSTP to convene a group of senior officials and subject-matter experts from a number of Federal agencies to discuss the potential utility of White House coordination in the matter. The Committee has decided to revisit policy issues it thought it had settled decades ago to determine how to avoid finding ourselves in similar straits in the future.

Appendix: The Value of Rare Earth Minerals

The subject of today's hearing is the 15 elements found in the so-called lanthanide series of the Periodic Table.[37] The U.S. Geological Survey describes them as "iron gray to silvery lustrous metals that are typically soft, malleable, ductile, and usually reactive, especially at elevated temperatures or when finely divided."[38]



[34] Ex. Ord. 12881, "Establishment of the National Science and Technology Council," November 23, 1993; 58 *Fed. Reg*. 62491. Dr. Gibbons tied the reorganization both to President Clinton's decision to reduce staff within the White House and to the National Performance Review conducted by Vice President Gore. Bill Loveless, "Gibbons to Propose Formation of Science and Tech Council," *Federal Technology Report*, September 2, 1993; p. 1.

[35] Public Law 103–123, October 28, 1993.

[36] 30 U.S.C. 1604(b)(2) and (3).

[37] As scandium and yttrium fail within the same period (column) on the Periodic Table, they are often counted as rare earths. The actinide series (the elements between actinium and lawrencium) can also be included, but they are noted mostly for their radioactive properties and are not the subject of the hearing.

[38] James D. Hedrick, 2007 *Minerals Yearbook.* Rare Earths (Reston: U.S. Geological Survey, 2009); p. 60.1.

These elements are normally obtained as byproducts from mining for other materials. The chemical properties of these elements are quite similar, which complicates separating them; the production process must be tailored to the composition of the ore extracted from a given deposit.

Industry tends to divide these into "light" and "heavy" elements, moving from lanthanum to the right along the row. The "heavy" elements tend to have greater economic value. One aspect of the supply problem for the United States is that the Mountain Pass deposit lacks many of the heavier elements, whereas the major Chinese producer, the Bayan Obo mine, can provide the more valuable dysprosium and terbium.

Rare earths contribute to a number of industries, usually incorporated into metal alloys to enhance electrical or magnetic capabilities. The hearing today will consider their major contributions to renewable energy applications. Electrical generators need magnets; a smaller magnet producing a stronger field can reduce the final size of a wind turbine even as its power output increases. Combining neodymium with iron and boron, or samarium with cobalt, can produce these more efficient components. Hybrid automobiles, such as Toyota's Prius or the new Chevrolet Volt, depend on rechargeable batteries. Incorporating lanthanum into the nickel-metal-hydride battery electrolyte enhances the power output, resulting in increased vehicle range even as the battery itself gets smaller and lighter.

The following chart gives some sense of the breadth of other uses:

Cerium	Optical lens polishing; petroleum cracking catalysts
Praseodymium	High-strength metals in aircraft engines
Promethium	Portable X-ray units
Europium	Compact fluorescent bulbs; red phosphors for computer monitors
Gadolinium	Neutron radiography
Terbium	Magnets; generates green spectrum in fluorescent light
Holmium	Glass tinting
Erbium	Signal repeaters in fiber-optic cables
Thulium	Lasers
Ytterbium	Stainless steel

Having applied the criticality matrix developed as part of their study, the NRC committee concluded:

> The relatively high composite weighted score for REs [rare earths] of 3.15 . . . [on a scale of 1–4] reflects the diversity of applications for the RE family, the importance of those applications, and the steady growth in consumption and has led our committee to suggest that disruptions in the availability of REs would have a major negative impact on our quality of life . . .. In our view, most of the applications are somewhat to very important since substitutes are generally less effective.[39]

[39] *NRC Report,* p. 133.

Chairman MILLER. This hearing will now come to order. Good afternoon. Welcome to today's hearing entitled *Rare Earth Minerals and 21st Century Industry*.

Before we begin, we have a request from the gentleman from Colorado, Mr. Coffman, to join the Subcommittee for this hearing, and unless there is an objection—hearing none, I would like to invite him to join us on the dais, which he is already there. You may remain where you are, and I will remind folks that non-committee members are only recognized for questions after all committee members have been recognized—which will not be that much of a problem today, it does not look like.

We will now recognize Mr. Gordon is here, and I understand that he has votes in another committee shortly, so we will recognize him first so he may go to vote.

Chairman GORDON. Thank you, Chairman Miller, and Ranking Member Broun for having this hearing, and I want to thank the staff for doing a good job in gathering this material. I do want to attend as much as I can. I will be back after these votes.

Last September, I saw an article on this issue [1] that raised a number of questions in my mind about whether the committee—this committee and Congress were doing enough to support American business and American jobs.

Rare earth minerals are an essential component of a wide array of emerging industries: clean energy, telecommunications, and our defense industry. And I noticed that one country, and we are not here to beat up on that one country, but nature made one country seem to have about 90 percent of these rare earth materials, and they seem to be trying to capture the rest of—or a large part of that other ten percent, which gives me pause.

This is not the first time the committee has been concerned with the competitive implications of materials such as rare earths. In 1980, 30 years ago, this committee established a national minerals and materials policy.[2] One core element in that legislation was the call to support for a vigorous, comprehensive and coordinated program for the materials research and development.

Unfortunately, over successive administrations, the effort to keep the program going fell apart. Now, it is time to ask whether we need to revive and coordinate an effort to level the playing field on rare earths.

In particular, I want to learn if there is a need for increased research and development to help address this Nation's rare earth shortage or if we need to re-orient the research we already have underway.

Based on my review of the written submissions, it appears that we could benefit from more research both in basic and applied materials.

The rare earths are not the only materials in which the United States is largely or exclusively dependent on foreign sources. Ac-

[1] Keith Bradsher. "China Tightens Grip on Rare Minerals." *New York Times,* September 1, 2009; pp. B1, B4.

[2] Public Law 96–499, the National Materials and Minerals Policy, Research and Development Act of 1980; enacted October 21, 1980.

cording to the U.S. Geological Survey, there are 18 other minerals [3] and materials where the United States is completely dependent on foreign sources.

And a bit of a collateral subject that I would like for you to address is, there are those minerals and elements that aren't rare or close to being rare, but go through periods of time where they are being very vogue in using manufacturers. So they can become—or our resources can become strained during those periods of time. And then a new manufacturing process comes in and they may go down. Do we need to have some kind of inventory? Do we need to be watching out for those other?

So Mr. Chairman and Mr. Broun, thank you for having this hearing. I think this is going to be very informative and hopefully can lead us to some potential legislation that would be good for our national defense and our national competitiveness.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

I'd like to thank Chairman Miller for calling this hearing. Last September, I saw an article on this issue that raised a number of questions in my mind about whether the Committee and the Congress were doing enough to support American business and American jobs.

Rare earths are an essential component in a wide array of emerging industries.

This is not the first time the Committee has been concerned with the competitive implications of materials such as rare earths. In 1980—30 years ago—this Committee established a national minerals and materials policy. One core element in that legislation was the call to support for "a vigorous, comprehensive and coordinated program of materials research and development."

Unfortunately, over successive administrations, the effort to keep that program going fell apart. Now, it is time to ask whether we need to revive a coordinated effort to level the playing field in rare earths.

In particular, I want to learn if there is a need for increased research and development to help address this Nation's rare earth shortage, or if we need to re-orient the research we already have underway.

Based on my review of the written submissions, it appears that we could benefit from more research both in basic and applied materials sciences.

Rare earths are not the only materials in which the U.S. is largely or exclusively dependent on foreign sources. According to the U.S. Geological Survey, there are eighteen other minerals and materials where the United States is completely dependent on foreign sources.

Someone needs to be telling us what's going on with those before we read about it in the *New York Times*. Legislation may be the best way to institutionalize a renewed focus and expanded commitment to identifying shortages and needs before they become a crisis.

Again, Mr. Chairman, I appreciate you holding this hearing and expect a stimulating discussion. I yield back my time.

Chairman MILLER. Thank you, Mr. Gordon. I neglected to mention in my quick introduction that this is an issue in which Mr. Gordon has shown a great interest and that this hearing is at Mr. Gordon's urging. It is one of the habits of highly effective subcommittee chairs to pay attention to what the Full Committee Chair urges, and I have done so in this case.

The usual order would be Democrat, Republican, Democrat, so you want me to go? All right.

Well, I also want to welcome everyone to this hearing on something that most of us have either never heard of or promptly forgot after our test on the periodic table in high school chemistry. Dr.

[3] U.S. Geological Survey. *Mineral Commodity Summaries 2009* (Washington: Government Printing Office, 2009; p. 6.

Broun may have taken it up in medical school, but for me, if I was exposed to it at all, it was some considerable time ago.

Today we will be discussing rare earth elements, which really aren't all that rare, but rare earth elements are crucial to making the magnets and batteries needed for the energy industry of the 21st century. With a little of one of those elements you can get a smaller, more powerful magnet, or an aircraft engine that operates at higher temperatures or a fiber-optic cable that can carry your phone call much greater distances.

The United States, not so long ago, was the world leader in producing and exporting rare earths. Today, Mr. Gordon delicately said another nation—or one nation—controlled much of the world's market. I will be less delicate and name the nation. China is the world's leader. We are having this hearing in part to recognize that the Chinese have some different ideas about how to get the greatest benefit from this suddenly valuable commodity beyond simply digging it up and selling it to those who want to use it in their high-tech manufacturing. China appears to view rare earths as one of the incentives they can offer a technology firm scouting for a new plant location. How do we compete in attracting and retaining manufacturing high-tech 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?

The most immediate step would be to get some competition back into the supply of rare earths. One of our witnesses, Mr. Mark Smith, is proposing to do just that. His company owns a mine that could produce, has in the past, many rare earth elements if it were to reopen. He will describe today not only what it would take to restart the mine but also his intent to augment America's capability to produce the magnets needed for electrical generators in wind turbines.

From what he has told us in preparation for the hearing, he has found it hard to get help in making his vision a reality. If we intend to rebuild America's capability to supply our own needs in rare earth materials, if we intend to foster a home-grown capability to make the devices that provide wind energy, we can't succeed unless Mr. Smith and others like him succeed.

Further, are we investing enough in research, as Mr. Gordon said, looking into ways to recover and recycle those materials and looking for alternatives or synthetic options? Are there efficiencies that could be gained in the use of rare earth minerals? For example, if you work with rare earths at the nanoscale level, could you get the same improvements in material performance using micrograms where today you need kilograms? There aren't a lot of places where people are currently working to answer those questions even as the answers could go far in helping the United States compete in the alternative energy technology industries springing up around the world.

This is not the first time this committee has wrestled with rare earth and critical materials issues. It is the first time in my service here but not the first time the committee has struggled with the issue.

Our committee established a national policy in minerals and materials three decades ago. That 1980 law requires a continuing assessment of mineral and materials markets to alert us to looming problems such as supply disruptions, price spikes and the like.

Four years later we followed up by establishing the Critical Materials Council[4] to assure that someone was minding the store. However, you won't find the Critical Materials Council in the White House organization chart today. It disappeared into the National Science and Technology Council in 1993,[5] and the high level attention to rare earths, and other materials, dropped off as a priority.

While preparing for this hearing, we have learned that the Office of Science and Technology has recently organized a new interagency committee to respond to our rare earth problems. An obvious question arises. If the Critical Materials Council had been maintained, might we be in a better position now to protect our Nation's interests in a strong rare earths industry? How can we reverse the result of that history of neglect?

The Subcommittee thanks the witnesses for helping us address these issues, and I anticipate an interesting discussion when the questions begin.

[The prepared statement of Chairman Miller follows:]

PREPARED STATEMENT OF CHAIRMAN BRAD MILLER

Welcome to our hearing this afternoon on something most of us have never heard of at all, or promptly forgot after our test on the Periodic Table in high school chemistry. Today we will be discussing rare earth elements, which aren't really all that rare. Rare earth elements are crucial to making the magnets and batteries needed for the energy industry of the 21st Century. With a little of one of these elements you can get a smaller, more powerful magnet, or an aircraft engine that operates at higher temperatures or a fiber-optic cable that can carry your phone call much greater distances.

The United States, not so long ago, was the world leader in producing and exporting rare earths. Today, China is the world's leader. We're having this hearing in part to recognize that the Chinese have some different ideas about how to get the greatest benefit from this suddenly-valuable commodity beyond simply digging it up and selling it to those who want to use it in their high-tech manufacturing. China appears to view rare earths as one of the incentives they can offer a technology firm scouting for a new plant location. How do we 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?

The most immediate step would be to get some competition back into the supply of rare earths. One of our witnesses, Mr. Mark Smith, is proposing to do just that. His company owns a mine that could produce many rare earth elements if it were to reopen. He will describe today not only what it will take to restart the mine, but also his intent to augment America's capability to produce the magnets needed for electrical generators in wind turbines. From what he has told us in preparation for the hearing, he's found it hard to get help at making his vision a reality. If we intend to rebuild America's capability to supply its own needs in rare earth materials, if we intend to foster a home-grown capability to make the devices that provide wind energy, we can't succeed unless he and others like him succeed.

Further, are we investing enough in research looking into ways to recover and recycle these materials and looking for alternatives or synthetic options? Are there efficiencies that could be gained in the use of rare earth materials? For example, if you work with rare earths on the nanoscale level, could you get the same improvements in material performance using micrograms where today you need kilograms? There aren't a lot of places where people are currently working to answer these questions even as the answers could go far in helping America compete in the alternative energy technology industries springing up around the globe.

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[4] See Title II of Public Law 98–373, the National Critical Materials Act of 1984; enacted July 31, 1984.

[5] See Executive Order 12881; November 23, 1993 (58 *Fed. Reg.* 226, pp. 62491–62492).

This is not the first time the Committee has wrestled with rare earth and critical materials issues.

Our Committee established a national policy in minerals and materials three decades ago. That 1980 law required a continuing assessment of mineral and materials markets to alert us to looming problems such as supply disruptions, price spikes and the like.

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While preparing for this hearing, we have learned that the Office of Science and Technology Policy has recently organized a new interagency committee to respond to our rare earth problems. An obvious question arises: if the Critical Materials Council had been maintained might we be in a better position to protect our nation's interests in a robust rare earths industry? How can we reverse the result of that history of neglect?

The Subcommittee thanks the witnesses for helping us address these issues and I anticipate an interesting discussion later. I now recognize Dr. Broun, our Ranking Member, for his opening remarks.

Chairman MILLER. I should let everyone be on notice that the rule in this Subcommittee is that current Members of the Committee can take credit for all the work of our predecessors, but we get none of the blame for any mistakes that they have made.

I now recognize Dr. Broun, our Ranking Member, for his opening statement.

Mr. BROUN. Thank you, Mr. Chairman. Let me welcome our witnesses here today, and I thank you all for participating.

The topic of today's hearing, Rare Earth Minerals, is timely and important. Rare earths are slated to play an increasingly important role as we seek to meet our future energy needs, to remain competitive in the international marketplace and to continue to defend our Nation. Rare earths are essential elements in renewable technologies, such as wind turbine magnets, compact fluorescent light bulbs and hybrid vehicle batteries. They are also used in technologies critical to national security like lasers, aircraft engines, and fiber optics. After the closure of the Mountain Pass Mine in the 1990s, the United States became dependent upon foreign sources for rare earths with China currently producing roughly 95 percent of the world's supply. They have created a near monopoly and are actively exploiting that advantage.

While China recently eased its export quotas for rare earths, over the past three years, they have steadily cut export quotas saying they need additional supplies to develop their own domestic clean energy in high-tech sectors.

I hope today's hearing will call attention to the current state of dependence that our Nation finds itself in. We have assembled an experienced panel to provide insight into how we can ensure that we have access to rare earths in the future. What industrial information is needed to guarantee continued availability of critical minerals, what role the Federal Government should play, and what further research and development needs to be done in that area.

With that, Mr. Chairman, I yield back my time so that we can hear from this esteemed panel.

[The prepared statement of Mr. Broun follows:]

PREPARED STATEMENT OF REPRESENTATIVE PAUL C. BROUN

Thank you Mr. Chairman.

Let me welcome our witnesses here today and thank them for appearing.

The topic of today's hearing—Rare Earth Minerals—is timely and important. Rare Earths are slated to play an increasingly important role as we seek to meet our future energy needs, remain competitive in the international marketplace, and continue to defend our Nation.

Rare Earth Minerals are essential elements in renewable technologies such as wind turbine magnets, compact fluorescent light bulbs, and hybrid vehicle batteries. They are also used in technologies critical to national security like lasers, aircraft engines, and fiber-optics.

After the closure of the Mountain Pass mine in the 90s, the United States became dependent upon foreign sources for rare earths. With China currently producing roughly 95% of the world's supply, they've created a near monopoly and are actively exploiting that advantage. While China recently eased its export quotas for Rare Earths, over the past three years they have steadily cut export quotas, saying they need additional supplies to develop their own domestic clean energy and high-tech sectors. I hope today's hearing will call attention to the current state of dependence our nation finds itself in.

We have assembled a superb panel to provide insight into how we can ensure that we have access to Rare Earths in the future, what industrial information is needed to guarantee continued availability of critical minerals, what role the Federal Government should play, and what further research and development needs to be done in the area.

With that Mr. Chairman, I yield back my time so that we can hear from this esteemed panel.

Chairman MILLER. Thank you, Dr. Broun. At the time of Mr. Gordon's opening statement and mine, China controlled 90 percent of rare earths, and by the time of Dr. Broun's, it had grown to 95 percent. That should give us a sense of the urgency with which we need to address this issue.

I now ask unanimous consent for any additional opening statements submitted by members to be included in the record. Without objection, that is so ordered.

It is now my pleasure to introduce our witnesses. First, Dr. Stephen Freiman is currently a member of the National Research Council Committee on Critical Mineral Impacts on the U.S. Economy. Dr. Steve Duclos is Chief Scientist and Manager of Material Sustainability at General Electric Global Research. Dr. Duclos managed GE's optical materials laboratory where he worked to develop advanced materials. Dr. Karl Gschneidner is Anson Marston Distinguished Professor at the Department of Materials Science and Engineering at Iowa State University and a Senior Metallurgist at the Ames National Laboratory. And Mr. Terence Stewart is a managing partner at the law firm of Stewart and Stewart, specializing in international trade and customs issues.

I would now like to recognize the gentleman from Colorado, Mr. Coffman, to introduce our final witness today. Mr. Coffman?

Mr. COFFMAN. Thank you, Mr. Chairman. Chairman Miller and Ranking Member Broun, thank you for allowing me to introduce Mark Smith today. I first became aware of the looming crisis of the rare earth mineral supply and manufacturing capability last year. In my subsequent study on the problem, I quickly learned that the greatest concentration of rare earth minerals, now known as the Mountain Pass Mine in California, and the company working that mine is headquartered in my district, in Greenwood Village, Colorado. That company is Molycorp Minerals, Limited Liability Corporation, and I spoke about the rare earth supply chain problem with Chief Executive Officer Mark Smith.

Prior to Molycorp, Mr. Smith was the President and Chief Executive Officer of Chevron Mining, Incorporated. Mr. Smith was appointed President and Chief Executive Officer in April 2006. Prior to this appointment, Mr. Smith was the Vice President for Unocal Corporation where he was responsible for managing the real estate remediation and mining divisions. Mr. Smith worked for Unocal for over 22 years.

Mr. Smith received his Bachelor of Science degree in agricultural engineering from Colorado State University in 1981 and his Juris Doctorate from Western State University College of Law in 1990. He is a registered professional engineer and an active member of the State Bar of California and Colorado. Mr. Smith and his wife live in Denver, Colorado.

As he will testify, the U.S. has significant rare earth resources at Molycorp's rare earth mine at Mountain Pass, California. However, the U.S. no longer possesses the manufacturing capability to convert its raw rare earth minerals into the critical metals and magnets that power so many key technologies. I hope we can work with industry through knowledgeable leaders such as Mr. Smith to address the crucial need for rare earth mineral supply and industrial capability.

Mr. Chairman, I yield back.

Chairman MILLER. Thank you, Mr. Coffman. As our witnesses should know, you will each have five minutes for your spoken testimony, your oral testimony. Your written testimony will be included in the record for the hearing. When all have completed your spoken testimony, we will begin with questions, and each member will have five minutes to question the panel.

This committee is a Committee on Investigations and Oversight, although this hearing is more really like a legislative than investigative hearing, but it is our practice to receive testimony under oath. Do any of you have any objection to taking an oath? The record should reflect that all nodded in the negative, they had no objection.

You also have the right to be represented by counsel. Do any of you have counsel here? And the record should reflect that all nodded in the negative with the exception of Mr. Smith who said no. And we ask you these questions to put you at ease.

If you would now please stand and raise your right hand. Do you swear to tell the truth and nothing but the truth? The record should reflect that all the witnesses said yes and have taken the oath. Let us now begin with Dr. Stephen Freiman. Dr. Freiman, you are recognized for five minutes.

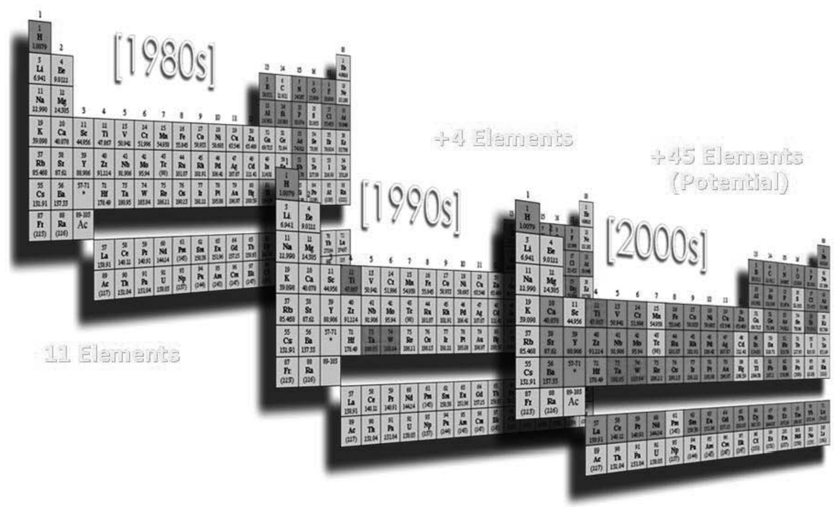
STATEMENT OF DR. STEPHEN FREIMAN, PRESIDENT, FREIMAN CONSULTING, INC.

Dr. FREIMAN. Thank you, Mr. Chairman. I retired as Deputy Director of the Materials Science Engineering Laboratory at the National Institutes of Standards and Technology to start a small consulting business. I served on the Committee on Critical Mineral Impacts on the U.S. Economy of the National Research Council and am testifying in place of the Committee Chairman, Dr. Roderick Eggert, who could not be present today.

As you observed, mineral-based materials are ubiquitous—aluminum in jet aircraft, steel in bridges and buildings, and lead in batteries to name but a few examples.

[The information follows:]

Two Decades of Computer Chips



The slide that you see illustrates the expanded use of new minerals over the years in important technologies such as computer chips.

The emergence of new technologies and engineered materials creates the prospect of rapid increases in demand for some minerals previously used in relatively small quantities in a small number of applications such as lithium in automotive batteries, rare earth elements in permanent magnets and compact fluorescent light bulbs and indium and tellurium in photovoltaic solar cells.

At the same time the supplies of some minerals seemingly are becoming increasingly fragile due to more fragmented supply chains, increased U.S. import dependence, export restrictions by some nations on primary raw materials, and increased industry concentration.

It was in this light that the Standing Committee on Earth Resources of the National Research Council initiated a study and established an ad hoc committee to examine the range of issues important in understanding the evolving role of non-fuel minerals in the U.S. economy and the potential impediments to the supplies of these minerals to domestic users. The U.S. Geological Survey and the National Mining Association sponsored the study, the findings of which appear in the volume *Minerals, Critical Minerals, and the U.S. Economy.*[6]

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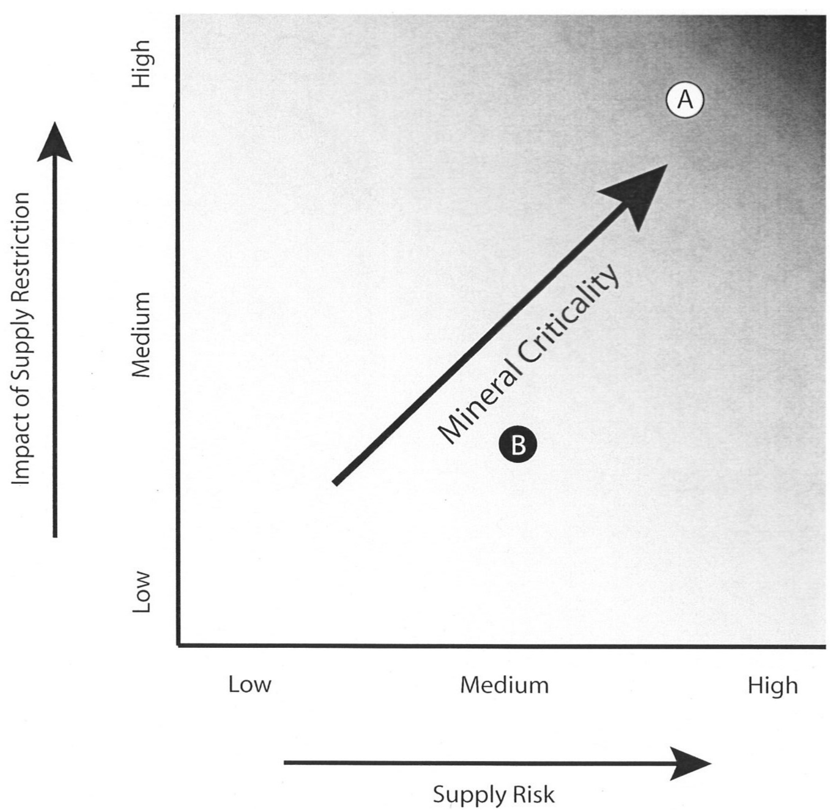
[6] National Research Council. Committee on Critical Mineral Impacts on the U.S. Economy. *Minerals, Critical Minerals, and the U.S. Economy* (Washington: National Academy Press, 2008).

In my testimony today, I highlight two parts of the report, its analytical framework and empirical findings and its recommendations.

The analytical framework begins by defining critical minerals as those that are both essential in use—that is, difficult to substitute away from, and subject to supply risk. The idea is illustrated in the slide that you see, a criticality matrix. The horizontal axis represents the degree of supply risk associated with a particular mineral, which increases from left to right. Supply risk is higher, the greater the concentration of production in a small number of companies, mines, et cetera. The smaller the existing market, the greater the reliance on byproduct production of a mineral and the smaller the reliance on post-consumer scrap as the source of supply.

Import dependence by itself is a poor indicator of supply risk. Rather it is import dependence combined with concentrated production and perhaps geopolitical risk, the first of the four factors above, that lead to supply risk.

[The information follows:]

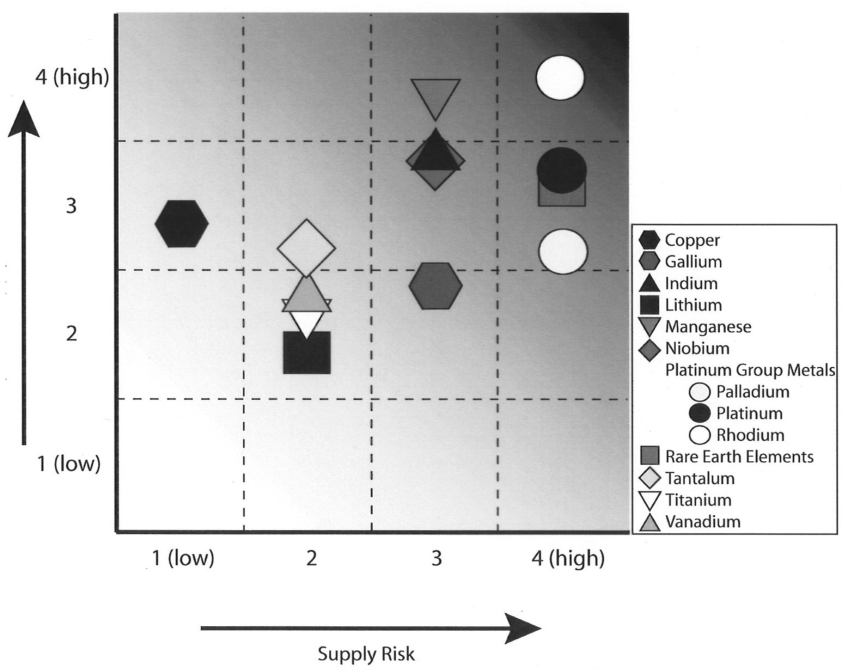


In the next slide, the hypothetical mineral A is subject to greater supply than mineral B. So the overall risk of criticality increases as one moves from the lower-left to the upper-right corner of the diagram.

Implementing the framework requires specifying a prospective timeframe. From the perspective of a mineral-using company, for example, will likely be different than that of a national government. The degree of criticality in the short to medium term, one to a few years, up to a decade, depends on existing technologies and production facilities. Substituting one material for another in a product typically is difficult in the short term, due to constraints imposed by existing product designs and production equipment. In contrast, over the longer term, the degree of criticality depends much more importantly on technological innovation and investments in new technology and equipment on both the demand side and the supply side.

Taking the perspective of the U.S. economy overall and in the short to medium term, the Committee evaluated 11 minerals or mineral families. It did not assess the criticality of all important non-fuel minerals due to limits on time and resources.

[The information follows:]



Slide three summarizes the Committee's evaluations, and I am sure you have trouble seeing it, but of the 11 minerals those deemed most critical, those that plot in the upper-right portion of the diagram, are indium, magnesium—manganese, rather—niobium, platinum group metals and rare earth elements.

A final point: criticality is dynamic. A critical mineral today may become less critical either because substitutes of new sources of supply are developed. Conversely, a less critical mineral today may become more critical in the future because of a new use or change in supply risk. Such could be the case with lithium which the committee did not evaluate as one of the more non-critical minerals.

It should be recognized, however, that this analysis tool can be no better than the quality and timeliness of the date used to create it. And in the interest of time, the committee had several recommendations which you have in your written document, and I don't think I need to read them to you. I would just say, however, that my personal opinion that research and development in topics, such as recycling of specialty materials used in small quantities in emerging uses as well as enhanced coordination of research efforts between departments and agencies as suggested in the National Materials and Minerals Policy Research and Development Act of 1980 would also be very beneficial.

Thank you for allowing me to testify today, and I will be happy to answer any questions the Subcommittee may have.

[The prepared statement of Dr. Freiman follows:]

PREPARED STATEMENT OF STEPHEN FREIMAN

Good afternoon, Mr. Chairman and members of the Committee. My name is Dr. Stephen Freiman. A few years ago I retired as Deputy Director of the Materials Science and Engineering Laboratory at the National Institute of Standards and Technology to start a small consulting business. I served on the Committee on Critical Mineral Impacts on the U.S. Economy of the National Research Council (NRC). The Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1 863 to advise the government on matters of science and technology.

Mineral-based materials are ubiquitous—aluminum in jet aircraft; steel in bridges and buildings, and lead in batteries, to name but a few examples. The emergence of new technologies and engineered materials creates the prospect of rapid increases in demand for some minerals previously used in relatively small quantities in a small number of applications—such as lithium in automotive batteries, rare-earth elements in permanent magnets and compact-fluorescent light bulbs, and indium and tellurium in photovoltaic solar cells. At the same time, the supplies of some minerals seemingly are becoming increasingly fragile due to more fragmented supply chains, increased-U.S. import dependence, export restrictions by some nations on primary raw materials, and increased industry concentration.

It was in this light that the U.S. Geological Survey (USGS) and the National Mining Association sponsored a National Research Council study to examine the range of issues important in understanding the evolving role of nonfuel minerals in the U.S. economy and the potential impediments to the supplies of these minerals to domestic users. The study was conducted under the purview of the NRC's standing Committee on Earth Resources. The findings of the study are contained in the volume *Minerals, Critical Minerals, and the U.S. Economy* (National Academies Press, 2008).

In my testimony today, I highlight two parts of the report: its analytical framework and empirical findings, and its recommendations. In addition, I provide answers to the questions you posed in your letter of invitation to me.

Analytical Framework

The analytical framework begins by defining critical minerals as those that are both essential in use (difficult to substitute away from) and subject to supply risk. The idea is illustrated in Figure 1, a 'criticality matrix.' The horizontal axis represents the degree of supply risk associated with a particular mineral, which increases from left to right. Supply risk is higher (1) the greater the concentration of production in a small number of mines, companies, or countries, (2) the smaller the existing market (the more vulnerable a market is to being overwhelmed by a rapid increase in demand due to a large new application), (3) the greater the reliance on byproduct production of a mineral (because the supply of a byproduct is determined largely by the economic attractiveness of the associated main product), and (4) the smaller the reliance on post-consumer scrap as a source of supply. Import dependence, by itself, is a poor indicator of supply risk; rather it is import dependence combined with concentrated production and perhaps geopolitical risk (the first of the four factors above) that lead to supply risk. In Figure I, the hypothetical mineral A is subject to greater supply risk than mineral B.

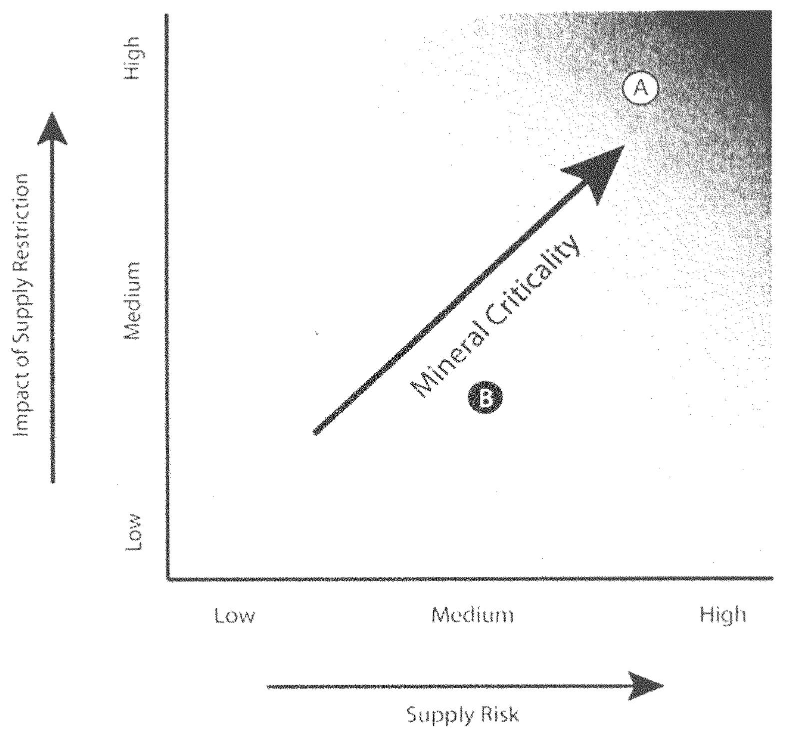


Figure I. The Criticality Matrix. Source: *Minerals, Critical Minerals, and the U.S. Economy* (National Academies Press, 2008).

The vertical axis represents the impact of a supply restriction, which increases from bottom to top. Broadly speaking, the impact of a restriction relates directly to the ease or difficulty of substituting away from the mineral in question. The more difficult substitution is, the greater the impact of a restriction (and vice versa). The impact of a supply restriction can take two possible forms: higher costs for users (and potentially lower profitability), or physical unavailability (and a "no-build" situation for users).[1]

The overall degree of criticality increases as one moves from the lower-left to the upper-right corner of the diagram. The hypothetical mineral A would be relatively more critical than mineral B.

Implementing the framework requires specifying a perspective and time frame. The perspective of a mineral-using company, for example, will likely be different than that of a national government. The degree of criticality in the short to medium term (one or a few years, up to a decade) depends on existing technologies and production facilities. Substituting one material for another in a product typically is difficult in the short term due to constraints imposed by existing product designs and production equipment. Short-term supply risks are a function of the nature and location of existing production. In contrast, over the longer term (a decade or more), the degree of criticality depends much more importantly on technological innovation

[1] When considering security of petroleum supplies, rather than minerals, the primary concern is costs and resulting impacts on the macroeconomy (the level of economic output). The mineral and mineral-using sectors, in contrast, are much smaller, and thus we are not concerned about macroeconomic effects of restricted mineral supplies. Rather the concern is both about higher input costs for mineral users and, in some cases, physical unavailability of an important input.

and investments in *new* technology and equipment on both the demand side (material substitution) and the supply side (mineral exploration, mining and mineral processing, and associated technologies).

Taking the perspective of the U.S. economy overall and in the short to medium term, the committee evaluated eleven minerals or mineral families. It did not assess the criticality of all important nonfuel minerals due to limits on time and resources. Figure 2 summarizes the committee's evaluations. Of the eleven minerals, those deemed most critical—that is, they plot in the upper-right portion of the diagram—are indium, manganese, niobium, platinum-group metals, and rare-earth elements.

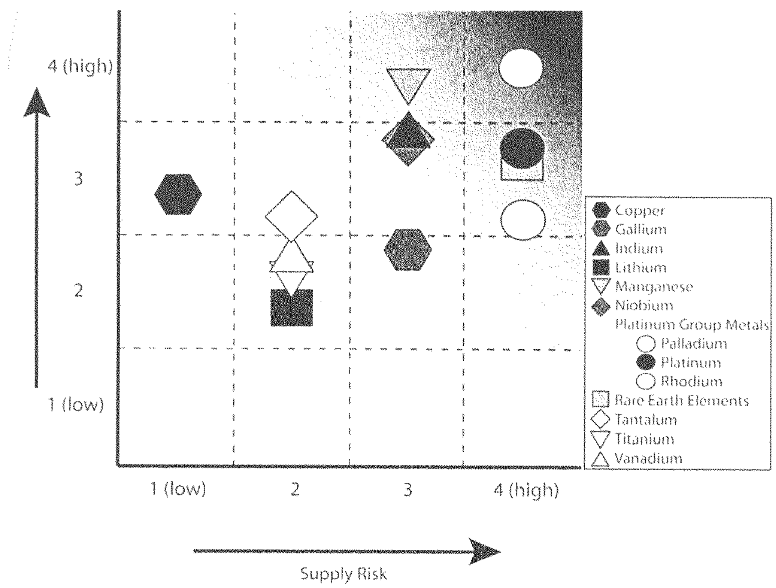


Figure 2. Criticality Evaluations for Selected Minerals or Mineral Families. Source: *Minerals, Critical Minerals, and the U.S. Economy* (National Academies Press, 2008).

A final point: criticality is dynamic. A critical mineral today may become less critical either because substitutes or new sources of supply are developed. Conversely, a less-critical mineral today may become more critical in the future because of a new use or a change in supply risk. Such could be the case with lithium, which the committee did not evaluate as one of the more-critical minerals in its analysis two years ago (Figure 2); if demand for lithium in batteries increases significantly and new sources of supply are in politically risky locations, then lithium could plot in the more-critical region of the figure in the future.

Recommendations

The committee made three recommendations, which I quote below:

1. The Federal Government should enhance the types of data and information it collects, disseminates, and analyzes on minerals and mineral products, especially as these data and information relate to minerals and mineral products that are or may become critical.
2. The Federal Government should continue to carry out the necessary function of collecting, disseminating, and analyzing mineral data and information. The USGS Minerals Information Team, or whatever Federal unit might later be assigned these responsibilities, should have greater authority and autonomy than at present. It also should have sufficient resources to carry out its mandate, which would be broader than the Minerals Information Team's current mandate if the committee's recommendations are adopted. It should establish formal mechanisms for communicating with users, government and nongovernmental organizations or institutes, and the private sector on the

types and quality of data and information it collects, disseminates, and analyzes. It should be organized to have the flexibility to collect, disseminate, and analyze additional, nonbasic data. and information, in consultation with users, as specific minerals and mineral products become relatively more critical over time (and vice versa).

3. Federal agencies, including the National Science Foundation, Department of the Interior (including the USGS), Department of Defense, Department of Energy, and Department of Commerce, should develop and fund activities, including basic science and policy research, to encourage U.S. innovation in the area of critical minerals and materials and to enhance understanding of global mineral availability and use.

Questions from the Subcommittee on Investigations and Oversight

What are the major gaps in current Federal policy for minerals and materials?

The committee report does not address this broad question. It does identify gaps in minerals information and recommends enhanced collection, dissemination and analysis of those parts of the mineral life cycle that are under-represented at present including: reserves and subeconomic resources, byproduct and coproduct primary production, stocks and flows of materials available for recycling, in-use stocks, material flows, and materials embodied in internationally traded goods. The committee report recommends periodic analysis of mineral criticality over a range of minerals.

Which aspects of research and development in minerals and materials require enhanced Federal support, and what form should this support take?

See Recommendation 3 above. As part of its detailed discussion of this recommendation, the committee report also recommends funding scientific, technical, and social-scientific research on the entire mineral life cycle. It recommends cooperative programs involving academic organizations, industry, and government to enhance education and applied research.

How should the Federal Government improve the collection of information on minerals and materials markets?

See Recommendation 2 above. As part of its more detailed discussion of this recommendation, the committee report suggests that the Federal Government consider the Energy Information Administration, which has status as a principal statistical agency, as a potential model for minerals information, dissemination, and analysis. Whatever agency or unit is responsible for minerals information, it needs greater autonomy and authority than at present.

Facing dynamic changes in supply and demand for particular minerals and materials in a global economy, what are the most useful contributions the Federal Government can employ to assist industry?

My personal opinion is that Federal. minerals and materials policy should focus on: (1) encouraging undistorted international trade, (2) ensuring that policies and procedures for domestic mineral development appropriately integrate commercial, environmental, and social considerations, (3) facilitating provision of information on which private and public decisions are made, and (4) facilitating research and development, including on recycling of specialty materials used in small quantities in emerging uses.

Thank you for the opportunity to testify today. I would be happy to address any questions the subcommittee may have.

BIOGRAPHY FOR STEPHEN FREIMAN

Dr. Freiman graduated from the Georgia Institute of Technology with a B. ChE. and a M. S. in Metallurgy. After receiving a Ph.D. in Materials Science and Engineering from the University of Florida in 1968, Dr. Freiman worked at the IIT Research Institute and the Naval Research Laboratory. He joined NIST (then NBS) in 1978. From 1992 to 2002 Dr. Freiman served as Chief of the Ceramics Division at NIST. Prior to his leaving NIST in 2006 to start a consulting business (Freiman Consulting Inc.), Dr. Stephen Freiman served for four years as Deputy Director of the Materials Science and Engineering.

Dr. Freiman has published over 200 scientific papers focusing primarily on the mechanical properties of brittle materials. He was the first Chairman of the ASTM

Subcommittee addressing brittle fracture and a past Chair of the Steering Committee of the Versailles Project for Advanced Materials and Standards. Dr. Freiman served as Treasurer, and President of the American Ceramic Society, and is a Fellow and Distinguished Life Member of the Society.

Chairman MILLER. Thank you, Dr. Freiman. Dr. Steven Duclos.

STATEMENT OF DR. STEVEN J. DUCLOS, CHIEF SCIENTIST AND MANAGER, MATERIAL SUSTAINABILITY, GENERAL ELECTRIC GLOBAL RESEARCH

Dr. DUCLOS. Chairman Miller, Ranking Member Broun, and Members of the Committee, it is my privilege to share with you GE's thoughts on how we manage shortages of materials critical to our manufacturing and what steps the government can take to help industry minimize the risk associated with these shortages.

This hearing addresses an issue that is critical to the future wellbeing of U.S. manufacturing. Without development of new supplies and focused research in materials and manufacturing, such supply challenges could undermine efforts to meet the Nation's future needs in defense, energy, health care and transportation.

I would like to share with you GE's strategy to address its material needs as well as outline a series of recommendations for how the government can strengthen its support of industry in this area.

GE uses 70 of the first 83 elements on the periodic table. As Chief Scientist and Manager of Material Sustainability at GE Global Research, is it my job to understand the latest trends in materials and to work with our businesses to manage our materials needs in a sustainable way.

To evaluate risks associated with material shortages, GE uses a modification of the assessment tool developed by the National Research Council in 2008. Risks are quantified by element in two categories, price and supply risk and impact of a restricted supply to GE. Those elements deemed to have high risk in both categories are identified as materials needing further study and a detailed plan to mitigate supply risks. For this assessment, we extensively used data from the U.S. Geological Survey's mineral information team as well as in-house knowledge of supply dynamics.

There is a broad spectrum of strategies that can be implemented to minimize the risk of those elements identified as being at high risk. These include, number one, improvements in the global supply chain, including the development of alternate sources, long-term supply agreements and development of inventory of materials. Number two, improvements of material utilization in manufacturing and reduction of manufacturing waste. Number three, development of recycling technologies that extract at-risk elements from both end-of-life products and manufacturing yield loss. This includes the design of products that are more easily recycled and service which improves materials service life. Number four, development of materials and systems technologies that either greatly reduce or even eliminate the need for the element altogether. Several examples of these are discussed in my written testimony where GE has successfully taken this approach. This includes the replacement of helium with boron in neutron detectors and the reduction by a factor of two in the use of rhenium content in superalloys for our jet engines, a development that leveraged past research programs supported by DARPA, the Air Force, the Navy and NASA.

And finally, number five, reassessment of the entire system. Often more than one technology can address a customer's need, and each will use a different subset of the periodic table. The solution to the materials constraint can involve using a new or alternate technology. An example is the development of energy-efficient LED lighting technologies as supported by the Department of Energy that offer a 70-times reduction in the use of rare earth elements for lighting.

Attention needs to be paid to all five of these solutions outlined above. The shorter term sourcing and manufacturing solutions are critical to buy time for the more optimal recycling and material substitution solutions. They tend to be longer term, higher risk and require risk mitigation strategies involving parallel paths. The government can help by enabling public/private collaborations that provide both materials understanding and resources that enable these material substitution approaches. Anticipated growth in the use of rare earths for efficient energy and transportation technologies mandates that we develop the full range of five solutions outlined above.

We make the following recommendations for the government to strengthen its support of efforts to minimize the increasing risk associated with material shortages.

Number one, appoint a lead agency with ownership of early risk assessment and authority to fund the five solutions. The government needs to enhance its ability to monitor, assess and coordinate a response to identified issue.

Number two, sustained funding for research focusing on material substitutions to lay the foundation upon which solutions are developed. Collaborative efforts between academia, government laboratories and industry will help ensure that manufacturing compatible solutions are available to industry in time to avert disruptions in U.S. manufacturing.

Number three, with global economic growth resulting in increased pressure on material stocks, it is imperative that there be a sustained support of the government to develop the full set of solutions outlined in this testimony, new material sources, recycling technologies, manufacturing efficiency, alternate materials and new system solutions.

In closing, we believe a more coordinated approach and sustained investment from the government in materials and manufacturing technologies is needed to provide industry with the flexibility that makes U.S. manufacturing less vulnerable to material shortages. Thank you for your time, and I look forward to answering your questions.

[The prepared statement of Dr. Duclos follows:]

PREPARED STATEMENT OF STEVEN J. DUCLOS

Introduction

Chairman Miller and members of the Committee, it is a privilege to share with you GE's thoughts on how we manage shortages of precious materials and commodities critical to our manufacturing operations and what steps the Federal Government can take to help industry minimize the risks and issues associated with these shortages.

Background

GE is a diversified global infrastructure, finance, and media company that provides a wide array of products to meet the world's essential needs. From energy and water to transportation and healthcare, we are driving advanced technology and product solutions in key industries central to providing a cleaner, more sustainable future for our nation and the world.

At the core of every GE product are the materials that make up that product. To put GE's material usage in perspective, we use at least 70 of the first 83 elements listed in the Periodic Table of Elements. In actual dollars, we spend $40 billion annually on materials. 10% of this is for the direct purchase of metals and alloys. In the specific case of the rare earth elements, we use these elements in our Healthcare, Lighting, Energy, Motors, and Transportation products.

Nowhere in the company is our understanding of materials more evident than at GE Global Research, the hub of technology development for all of GE's businesses. Located just outside of Albany NY, GE scientists and engineers have been responsible for major material breakthroughs throughout our 110-year history. One of GE's earliest research pioneers, William Coolidge, discovered a new filament material, based on ductile tungsten, in 1909, which enabled us to bring the light bulb to every home. Just four years later, he developed a safe x-ray tube design for medical imaging. In 1953, GE scientist Daniel Fox developed LEXAN plastic, which is used in today's CDs and DVDs. It was even used in the helmets that U.S. astronauts Neil Armstrong and Buzz Aldrin wore when they walked on the moon. More recently, GE scientists created a unique scintillator material, called Gemstone, which is the key component in GE Healthcare's newest High-Definition Computed Tomography (CT) medical imaging scanner that enables faster and higher resolution imaging.

Because materials are so fundamental to everything we do as a company, we are constantly watching, evaluating, and anticipating supply changes with respect to materials that are vital to GE's business interests. On the proactive side, we invest a great deal of time and resources to develop new materials and processes that help reduce our dependence on any given material and increase our flexibility in product design choices.

We have more than 35,000 scientists and engineers working for GE in the U.S. and around the globe, with extensive expertise in materials development, system design, and manufacturing. As Chief Scientist and Manager of Material Sustainability at GE Global Research, it's my job to understand the latest trends in materials and to help identify and support new R&D projects with our businesses to manage our needs in a sustainable way.

Chairman Miller, I commend you for convening this hearing to discuss an issue that is vital to the future well being of U.S. manufacturing. Without development of new supplies and more focused research in materials and manufacturing, such supply challenges could seriously undermine efforts to meet the nation's future needs in energy, healthcare, and transportation. What I would like to do now is share with you GE's strategy to address its materials needs, as well as outline a series of recommendations and indeed, a framework, for how the Federal Government can strengthen its support of academia, government, and industry in this area.

Comments and Recommendations

The process that GE uses to evaluate the risks associated with material shortages is a modification of an assessment tool developed by the National Research Council in 2008. Risks are quantified element by element in two categories: "Price and Supply Risk", and "Impact of a Restricted Supply on GE". Those elements deemed to have high risk in both categories are identified as materials needing further study and a detailed plan to mitigate supply risks. The "Price and Supply Risk" category includes an assessment of demand and supply dynamics, price volatility, geopolitics, and co-production. Here we extensively use data from the U.S. Geological Survey's Minerals Information Team, as well as in-house knowledge of supply dynamics and current and future uses of the element. The "Impact to GE" category includes an assessment of our volume of usage compared to the world supply, criticality to products, and impact on revenue of products containing the element. While we find this approach adequate at present, we are working with researchers at Yale University who are in the process of developing a more rigorous methodology for assessing the criticality of metals. Through these collaborations, we anticipate being able to predict with much greater confidence the level of criticality of particular elements for GE's uses.

Once an element is identified as high risk, a comprehensive strategy is developed to reduce this risk. Such a strategy can include improvements in the supply chain, improvements in manufacturing efficiency, as well as research and development into new materials and recycling opportunities. Often, a combination of several of these may need to be implemented.

Improvements in the global supply chain can involve the development of alternate sources, as well as the development of long-term supply agreements that allow suppliers a better understanding of our future needs. In addition, for elements that are environmentally stable, we can inventory materials in order to mitigate short-term supply issues.

Improvements in manufacturing technologies can also be developed. In many cases where a manufacturing process was designed during a time when the availability of a raw material was not a concern, alternate processes can be developed and implemented that greatly improve its material utilization. Development of near-net-shape manufacturing technologies and implementation of recycling programs to recover waste materials from a manufacturing line are two examples of improvements than can be made in material utilization.

An optimal solution is to develop technology that either greatly reduces the use of the at-risk element or eliminates the need for the element altogether. While there are cases where the properties imparted by the element are uniquely suitable to a particular application, I can cite many examples where GE has been able to invent alternate materials, or use already existing alternate materials to greatly minimize our risk. At times this may require a redesign of the system utilizing the material to compensate for the modified properties of the substitute material. Let's look at a few illustrative recent examples.

The first involves Helium-3, a gaseous isotope of Helium used by GE Energy's Reuter Stokes business in building neutron sensors for detecting special nuclear materials at the nation's ports and borders. The supply of Helium-3 has been diminishing since 2001 due to a simultaneous increase in need for neutron detection for security, and reduced availability as Helium-3 production has dwindled. GE has addressed this problem in two ways. The first was to develop the capability to recover, purify and reuse the Helium-3 from detectors removed from decommissioned equipment. The second was the accelerated development of Boron-10 based detectors that eliminate the need for Helium-3 in Radiation Portal Monitors. DNDO and the Pacific Northwest National Lab are currently evaluating these new detectors.

A second example involves Rhenium, an element used at several percent in super alloys for high efficiency aircraft engines and electricity generating turbines. Faced with a six-fold price increase during a three-year stretch from 2005 to 2008 and concerns that its supply would limit our ability to produce our engines, GE embarked on multi-year research programs to develop the capability of recycling manufacturing scrap and end-of-life components. A significant materials development effort was also undertaken to develop and certify new alloys that require only one-half the amount of Rhenium, as well as no Rhenium at all. This development leveraged past research and development programs supported by DARPA, the Air Force, the Navy, and NASA. The Department of Defense supported qualification of our reduced Rhenium engine components for their applications.

By developing alternate materials, we created greater design flexibility that can be critical to overcoming material availability constraints. But pursuing this path is not easy and presents significant challenges that need to be addressed. Because the materials development and certification process takes several years, executing these solutions requires advanced warning of impending problems. For this reason, having shorter term sourcing and manufacturing solutions is critical in order to "buy time" for the longer term solutions to come to fruition. In addition, such material development projects tend to be higher risk and require risk mitigation strategies and parallel paths. The Federal Government can help by enabling public-private collaborations that provide both the materials understanding and the resources to attempt higher risk approaches. Both are required to increase our chances of success in minimizing the use of a given element.

Another approach to minimizing the use of an element over the long term is to assure that as much life as possible is obtained from the parts and systems that contain these materials. Designing in serviceability of such parts reduces the need for additional material for replacement parts. The basic understanding of life-limiting materials degradation mechanisms can be critical to extending the useful life of parts, particularly those exposed to extreme conditions. It is these parts that tend to be made of the most sophisticated materials, often times containing scarce raw materials.

A complete solution often requires a reassessment of the entire system that uses a raw material that is at risk. Often, more than one technology can address a customer's need. Each of these technologies will use a certain subset of the periodic table—and the solution to the raw material constraint may involve using a new or alternate technology. Efficient lighting systems provide an excellent example of this type of approach. Linear fluorescent lamps use several rare earth elements. In fact, they are one of the largest consumers of Terbium, a rare earth element that along with Dysprosium is also used to improve the performance of high-strength permanent magnets. Light emitting diodes (LEDs), a new lighting technology whose development is being supported by the Department of Energy, uses roughly one-hundredth the amount of rare earth material per unit of luminosity, and no Terbium. Organic light emitting diodes (OLEDs), an even more advanced lighting technology, promises to use no rare earth elements at all. In order to "buy time" for the LED and OLED technologies to mature, optimization of rare earth usage in current fluorescent lamps can also be considered. This example shows how a systems approach can minimize the risk of raw materials constraints.

In addition to high efficiency lighting, GE uses rare earth elements in our medical imaging systems and in wind turbine generators. Rare earth permanent magnets are a key technology in high power density motors. These motors are vital to the nation's vision for the electrification of transportation, including automobiles, aircraft, locomotives, and large off-road vehicles. The anticipated growth in the use of permanent magnets and other rare earth based materials for efficient energy technologies mandates that we develop a broad base solution to possible raw material shortages. These solutions require the development of the sourcing, manufacturing efficiency, recycling, and material substitution approaches outlined above.

Based on our past experience I would like to emphasize the following aspects that are important to consider when addressing material constraints:

1) Early identification of the issue—technical development of a complete solution can be hampered by not having the time required to develop some of the longer term solutions.
2) Material understanding is critical—with a focus on those elements identified as being at risk, the understanding of materials and chemical sciences enable acceleration of the most complete solutions around substitution. Focused research on viable approaches to substitution and usage minimization greatly increases the suite of options from which solutions can be selected.
3) Each element is different and some problems are easier to solve than others—typically a unique solution will be needed for each element and each use of that element. While basic understanding provides a foundation from which solutions can be developed, it is important that each solution be compatible with real life manufacturing and system design. A specific elemental restriction can be easier to solve if it involves few applications and has a greater flexibility of supply. Future raw materials issues will likely have increased complexity as they become based on global shortages of minerals that are more broadly used throughout society.

Given increasing challenges around the sustainability of materials, it will be critical for the Federal Government to strengthen its support of efforts to minimize the risks and issues associated with material shortages. Based on the discussion above, we make the following recommendations for the Federal Government:

1) Appoint a lead agency with ownership of early assessment and authority to fund solutions—given the need for early identification of future issues, we recommend that the government enhance its ability to monitor and assess industrial materials supply, both short term and long term, as well as coordinate a response to identified issues. Collaborative efforts between academia, government laboratories, and industry will help ensure that manufacturing compatible solutions are available to industry in time to avert disruptions in U.S. manufacturing.
2) Sustained funding for research focusing on material substitutions—Federal Government support of materials research will be critical to laying the foundation upon which solutions are developed when materials supplies become strained. These complex problems will require collaborative involvement of academic and government laboratories with direct involvement of industry to ensure solutions are manufacturable.
3) With global economic growth resulting in increased pressure on material stocks, along with increased complexity of the needed resolutions, it is imperative that the solutions discussed in this testimony: recycling technologies, development of alternate materials, new systems solutions, and manufacturing efficiency have sustained support. This will require investment in long-term and high-risk research and development—and the Federal Government's support of these will be of increasing criticality as material usage grows globally.

Conclusion

In closing, we believe that a more coordinated approach and sustained level of investment from the Federal Government in materials science and manufacturing technologies is required to accelerate new material breakthroughs that provide businesses with more flexibility and make us less vulnerable to material shortages. Chairman Miller and Members of the Committee, thank you for your time and the opportunity to provide our comments and recommendations.

BIOGRAPHY FOR STEVEN J. DUCLOS

Steven Duclos is a Chief Scientist at the General Electric Global Research Center in Niskayuna, New York, and manages GE's Material Sustainability Initiative. The Material Sustainability initiative addresses GE's risks in the availability and sustainability of the company's raw material supply, by developing technologies that reduce the use, support the recycling, and enable substitution of lower-risk materials.

From 2000 to 2008 Dr. Duclos managed the Optical Materials Laboratory, also at GE GRC. The laboratory is responsible for development of advanced materials for a broad spectrum of GE businesses, including its Lighting and Healthcare businesses. From 1994 to 2004 Dr. Duclos served on the Executive Committee of the New York State Section of the American Physical Society. Prior to joining the GE Global Research Center in 1991 he was a post-doc at AT&T Bell Laboratories in Murray Hill, New Jersey.

Dr. Duclos received his B.S. degree in Physics in 1984 from Washington University in St. Louis, M.S. degree in Physics from Cornell University in Ithaca, New York in 1987, and Ph.D. in Physics from Cornell in 1990. He is the recipient of an AT&T Bell Laboratories Pre-doctoral Fellowship and the 1997 Albert W. Hull Award, GE Global Research's highest award for early career achievement.

Chairman MILLER. Thank you, Dr. Duclos. Dr. Gschneidner.

STATEMENT OF DR. KARL A. GSCHNEIDNER, JR., ANSON MARSTON DISTINGUISHED PROFESSOR, DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, IOWA STATE UNIVERSITY

Dr. GSCHNEIDNER. Good afternoon, Mr. Chairman, members of the Subcommittee, ladies and gentlemen. I am pleased to have this opportunity to present my views on the rare earth crisis and what can be done to alleviate this situation.

My brief responses to your questions are as follows. More detailed information will be found in my written statement.

The first question was, how has rare earth research at the Ames Laboratory changed over time? Rare earth science and technology at Ames Laboratory, the U.S. Department of Energy, had its beginning in World War II when Iowa State College assisted the war effort by supplying 1/3 of the uranium metal, two tons, necessary to make the first nuclear reactor go critical at the University of Chicago in 1942. By the end of the war, two million pounds of uranium and 600,000 pounds of thorium were produced for the Manhattan Project.

Work on rare earths was a natural outgrowth of the war effort. Initially there was a wide spectrum of research being carried out. This includes separation, analytical, solid state chemistry; process, physical and mechanical metallurgy; ceramics; and condensed matter physics. Many successes were achieved and technology was turned over to industry, but as science matured, programmatic changes occurred and a number of research areas were phased out. This included separation and—chemistry, process and mechanical metallurgy, and ceramics. The remaining areas are still strong, but the power person levels have diminished.

However, the establishment of the Materials Preparation Center, a DOE Basic Energy Scientist Specialized Research Center, has alleviated some of this degradation in process metallurgy.

I would like to mention a new and exciting development, the revolutionary method of preparing neodymium master alloy to make a neodymium-iron-boron permanent magnet. The cost of this master alloy is about half of that of neodymium. Furthermore, it is a very green technology with no byproducts compared to conventional processes which have byproducts which need to be disposed of in an environmentally safe manner.

I have in my hand the second neodymium-iron-boron magnet made which was just produced within the last month, and so they are working with that technology.

The second question, what would be required to conduct a robust program of basic research on rare earths? We are well-aware of the impact of Chinese activities in the rare earth market as noted by other invited speakers at this House hearing. In addition to forcing the United States and rare earth permanent magnet manufacturers out of business, the country now faces a shortage of trained scientists, engineers, technicians and a lack of innovations in a high-tech area which are critical to our country's future needs.

A research center which alleviates both of these problems is the best way to solve this rare earth crisis, an educational institute which has a long and strong tradition of carrying out research on all aspects of rare earth materials with a strong educational component would be an ideal situation. A National Research Center on Rare Earths and Energy should be established with Federal and state support, supplemented by U.S. industry as the rare earth industry revitalizes. The center would employ about 30 full-time employees. This research center would be a national resource for rare earth science technology and applications and would provide support of research activities at other institutions via subcontracts complementing the activities of the center.

The major emphasis of the center would be directed basic research; proprietary research paid by the organizations that request it, would also be a part of the center's mandate. The center would have an advisory board made up of representatives from the university, government, industry and the general public to oversee, guide and refocus as needed the research being conducted.

I would like to suggest to this House committee they consider a second national center on research on magnetic cooling. Cooling below room temperature accounts for 15 percent of the total energy consumed in the United States. Magnetic refrigeration is new, advanced, highly technical, energy efficient, green technology for cooling and climate control, for refrigerating and freezing. See Section 6.5 of my written response. It is about 20 percent more efficient as a green technology because it eliminates harmful gases and reduces energy consumption. If we were able to switch all cooling process to magnetic refrigeration at once, we would reduce the energy consumption by five percent. There are a lot of hurdles that need to be overcome, and the United States needs to put together a strong, cohesive effort to retain our disappearing leadership in this technology by assembling a National Center for Magnetic Cooling.

Europe and China are moving rapidly in this area. Denmark has assembled a Magnetic Refrigeration National Research Center at Riso, so far the only one in the world. This center should be structured similar to what has been posed for the National Research Center on Rare Earths and Energy. The question is, are we going to give up our lead position and be a second-rate country or will we lead the rest of the world? I hope and pray that our answer is that we are going to show the world that we are number one.

Question three, how can knowledge on rare earth be transferred to domestic companies? Knowledge is exported from research institutes, universities to industry through transfer of intellectual property and know-how. Research findings are disseminated as published articles in journals, presentations at conferences and electronic media and, if exciting enough, via news conferences, press releases, assuming the new results are not patentable. If research has some potential commercial value, this new information should be made available as soon as possible after filing a patent disclosure. However, before a patent disclosure is filed, one could disseminate the results to companies that might be interested by contacting them to say, one, if they are interested, two, if they would sign a nondisclosure agreement, and if they answer yes to both one and two, then the information could be disclosed to them.

The second highly effective route is the transfer of the skills and knowledge gained by university students to their industrial employers after graduation.

The fourth and last question is, how actively are U.S. scientists researching extraction, processing, substitution, recycling, and how is this compared to other countries? Rare earth research in the USA—and mineral extraction, rare earth separation, processing of oxides into metal, metallic alloys, and other useful forms, substitution, recycling is virtually zero. Today, some work is carried out at various DOE laboratories on rare earth and actinide separation chemistry directed toward treating waste nuclear products and environmental clean-up of radioactive minerals in the soils. This research may be beneficial to improving the rare earth separation processes on a commercial scale.

Some research at various universities might be considered to be useful in finding substitutes for a given rare earth metal in a high-tech application, but generally the particular rare earth properties are so unique it is difficult to find another substitute. And finally, the Chinese have two large research laboratories which have significant research and development activities that are devoted to the above topics. They are the General Research Institute for Nonferrous Metals in Beijing, and the Baotou Research Institute of Rare Earth in Baotou, Inner Mongolia. The former is a much larger organization than the Baotou group, but the rare earth activity is smaller. The Baotou Research Institute is the largest rare earth research group in the world. Baotou is located about 120 miles from the large rare earth deposit in Inner Mongolia.

Thank you for allowing me to participate in this House committee hearing this afternoon. Thank you.

[The prepared statement of Dr. Gschneidner follows:]

RARE EARTH MINERALS AND 21ST CENTURY INDUSTRY

Detailed Written Responses to Subcommittee's Questions

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QUESTION 1: RARE EARTH SCIENCE AND TECHNOLOGY AT THE AMES LABORATORY

PREPARED STATEMENT OF KARL A. GSCHNEIDNER, JR.

1. Introduction

The Ames Laboratory (AL) is the smallest of DOE's (Department of Energy) seventeen national laboratories. It is a single-program laboratory with about 78% of DOE's funding from the Office of Basic Energy Sciences (BES). Additional non-DOE income of about $7M is derived from contracts, grants, Cooperative Research and Development Agreements (CRADAs) and Work for Others (WFO) arrangements.

The AL is fully integrated with Iowa State University (ISU) and its buildings are right on the campus and several are directly connected with ISU buildings. All AL personnel are ISU employees, and many of the lead scientists (23) have joint appointments with various academic departments. There are about 140 scientists and engineers, 260 graduate and undergraduate students, another 240 visiting scientists, facility users, and associates, and 180 support personnel, for a total of about 440 employees (or about 300 full-time equivalent employees) and 410 associates (non-payroll). Of the scientific staff about 20% are directly involved in rare earth research and development activities, including materials science, condensed matter physics, and materials chemistry.

2. A Brief History—How Did Rare Earths get to Ames?

Many persons may wonder how the Mecca of rare earths [a] ever ended up on the picturesque ISU campus—an oasis amongst the corn and soy bean fields of central Iowa. The story begins in late 1930s when Frank H. Spedding was searching for a permanent academic position after receiving his Ph.D. from the University of California in 1929 under G.N. Lewis. His Ph.D. thesis dealt with the physical properties of rare earth materials at low temperature. He spent a number of years in temporary jobs, including two years in Europe, where he worked with several Nobel prize winners, including Niel Bohr. In 1937, while he was occupied at Cornell University working with a future Nobel prize winner, Hans Bethe, he was offered a permanent position at ISU [b] as an associate professor, and he remained at ISU until he retired in 1972. Frank Spedding was primarily a spectroscopist, but he had to separate and purify his rare earth samples from the other rare earth elements in order to carry out his optical measurements, which are very sensitive to the presence of other rare earth impurities. Based on his experience with rare earth (or 4*f*) chemistry he was asked by A.H. Compton of the University of Chicago to work with actinide (or 5*f*) materials to assist the team of physicists to build the first nuclear reactor under the stands of Stagg Field at the University of Chicago. Spedding was appointed the Director of Chemistry in the Chicago Project. One of the main goals of the Project was to purify uranium from its ores and then to convert the oxide to the metal—six tons were needed, which seemed like mission impossible since only a few grams of uranium metal had been produced before World War II. By late summer in 1942 the delivery of the uranium was behind schedule and Frank Spedding offered to use a different approach to make the metal via a metallothermic reduction of uranium tetrafluoride, UF_4. It was successful, and as an added bonus it was purer than the metal produced by other organizations. By November, the ISU team sent two tons of uranium cylinders (2″ diameter × 2″ long) to Chicago. The addition of these two tons to the four tons delivered previously allowed the reactor to go critical on December 2, 1942. This stellar contribution to the Manhattan Project was recognized when ISU and Spedding's team were awarded the "Army and Navy E for Effort with four stars" pennant on October 12, 1945; the only university (college) in the country to receive this prestigious honor. Since the Ames ingots were purer and less expensive to produce, the Manhattan District asked three companies to take over the Ames fluoride process and make large amounts of uranium for the Oak Ridge and Hanford reactors. But since it took time to get the facilities up and running the ISU group was asked to continue to produce uranium metal. More than two million pounds were produced by the end of World War H, and by December 1945 industry took over. The Ames process, albeit somewhat modified, is still in use today [1].

Soon thereafter, a new requirement arose in the war effort. Thorium metal was needed for another type of reactor, and Spedding and his co-workers were asked to develop a process for making thorium metal. Again they were successful and the Ames thorium process was turned over to industry. In the meanwhile, 600,000 pounds of thorium were produced [1].

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[a] Coined by Chemical and Engineering News in the 1970s.

[b] At that time ISU was known as Iowa State College, but I will use ISU in this presentation. The name change officially occurred in 1959.

During the late war years, research on developing methods of separating the rare earth elements was begun at several Manhattan District laboratories because some of the rare earth elements were among fission products which would absorb neutrons because of their high neutron capture cross-section and eventually would cause the reactor to shut down. Also the pure rare earth elements were needed to study their chemical and metallurgical behaviors to help actinide chemists and physicists understand the trans-uranium elements because of the expected similarities in the properties of the two series of elements. It was during these years that Spedding and co-workers developed the ion exchange method for separating rare earths, which was in commercial use for many years after World War H, until displaced by liquid-liquid extraction procedures. The ion exchange process is still in use today to obtain the very highest purity rare earth elements (99.9999% pure), which are primarily used in optical applications such as lasers and optical signal multipliers [1].

On May, 17, 1947 the Ames Laboratory became one of the Atomic Energy Commission (AEC) laboratories to promote the peaceful uses of atomic energy and to do research to increase our understanding and knowledge of the chemistry, physics, and nuclear behavior of the lesser known and uncommon elements, including the rare earths [1].

Additional information about the Ames Laboratory and Frank H. Spedding during World War II and the early post-World War II years can be found in several articles authored by I.E. Goldman [2,3,4] and papers by J.D. Corbett [5] and by S.R. Karsjen [6].

3. The Golden Age of Rare Earth Research

The time span of the 1950s through the 1970s was the golden age of rare earth research at the Ames Laboratory. At that time there was a very wide spectrum of research being carried out ranging from separation chemistry to analytical chemistry to process and physical metallurgy to solid state experimental physics to theoretical first principle calculations.

3.1 Separation Chemistry

The discovery of using ion exchange chromatography to separate and purify the rare earths was further refined and improved in the 1950s through the 1960s. A large pilot plant was set up to supply researchers at the Ames Laboratory and other organizations, including many of the AECs national laboratories, with high purity individual rare earths, to carry out fundamental and applied research on various chemical compounds and the pure metals (see §§ 3.3–3.6). In addition these ion exchange columns were used to separate the other rare earths from yttrium (also a rare earth element) which was to be used in the nuclear aircraft (see § 3.3).

3.2 Analytical Chemistry

In order to verify the chemical purity of the separated products new and more sensitive chemical and physico-chemical analytical methods were developed to detect impurities of both rare earth and other non-rare earth elements at the part per million level. This included wet chemistry, atomic emission and atomic absorption spectroscopy, laser ion mass spectrometry, vacuum and inert gas fusion, and combustion analysis. This research also led to the development of inductively coupled plasma (ICP)-atomic emission (AE) in the late 1970s, and ICP-mass spectrometry (MS), which occurred in the early 1980s. The ICP–MS technology was turned over to industry and today is still one of the most versatile and utilized analytical techniques, see § 5.

3.3 Process Metallurgy

This was one of the strengths of the Ames Laboratory in this time period. The pure rare earth elements, after separating them on the ion exchange columns, were converted to their respective rare earth oxides. The oxide was converted to the fluoride which was then reduced to the pure metal by calcium metal. These two processes were the critical steps for preparing high purity metals with low concentration of interstitial impurities, especially oxygen, carbon, nitrogen, and hydrogen. The reduced metals were further purified by a vacuum casting step and for the more volatile rare earth metals further purification was carried out by distillation or sublimation. Generally, kilogram (2.2 pounds) quantities were prepared at the Ames Laboratory. Industry adopted the Ames process with some minor modifications to prepare commercial grade rare earth metals, and it is still in use today. This method is still being carried out at the AL under the auspices of the Materials Preparation Center (MPC), see § 6.1.

In the late 1950s the AEC asked the Ames Laboratory to prepare pure yttrium metal for the proposed nuclear aircraft. A nuclear reactor would be used to heat gases to propel an airplane much like a jet engine. This aircraft would carry atomic weapons for months at a time without landing. The yttrium was to be hydride to form YH_2 which is used to absorb the neutrons produced by the fission of uranium protecting the crew from radiation. As part of this project the AL produced 65,000 pounds of YF_3 and 30,000 pounds of yttrium metal. The yttrium metal was cast into 85 pound, 6 inch diameter ingots to ship to the General Electric Co. facilities in Cincinnati, Ohio.

In the mid-1950s, Spalding and A.H. Daane and their colleagues developed a new technique for preparing high purity metals of the four highly volatility rare earths—samarium, europium, thulium, and ytterbium—by heating the respective oxides with lanthanum metal and collecting the metal vapors on a condenser. This process has also been turned over to industry and is used by AL's Materials Preparation Center today (§ 6.1).

3.4 Physical Metallurgy

Research in the physical metallurgy area encompassed: determining melting points, crystal structures, vapor pressures, low temperature heat capacities, elastic constants, and magnetic properties of the pure metals and various intermetallic compounds; and phase diagram and thermodynamic properties studies; crystal chemistry analyses; and alloying theory of rare earth-based materials. This was another strong focus area in the AL in the 1950s–70s era which is still active today but at reduced level.

Closely related, but not strictly physical metallurgy, was research on the mechanical behavior (tensile and yield strengths, ductility, and hardness) of the metals and some of their alloys, and also oxidation and corrosion studies, especially yttrium in conjunction with the nuclear aircraft project. From the information gained from the mechanical property measurements, processes were developed to fabricate the rare earth metals and their alloys at room and elevated temperature into a variety of shapes and forms, e.g. rolled sheets.

3.5 Materials and Solid State Chemistry, and Ceramics

The chemical activity, in addition to separation and analytical chemistry § 3.1 and § 3.2) was another area in which the AL was considered to be world class, even though the manpower levels were smaller than above noted areas of analytical chemistry, process and physical metallurgy. Research was focused on the sub-stoichiometric rare earth halides, and interstitial impurity stabilized compounds including the halides. X-ray crystallography was an important tool in this focus area to characterize these compounds. John D. Corbett was the lead scientist and is still active today.

Investigations of ceramic materials were important in many of the studies and advances in process and physical metallurgy, not only for their refractory properties, but also because of the need to contain the molten metals without contamination. Rare earth oxides and sulfides, because of their intrinsic stability, were candidate materials to contain the molten rare earths, uranium, thorium and other non-rare earth metals.

3.6 Condensed Matter Physics

The AL was very strong in this area from the very beginning and still is today. Research under the leadership of Sam Legvold was concentrated on the magnetic behavior of the metals and the intra-rare-earth alloys. This work was strongly coupled with neutron scattering studies at both the Ames Laboratory and Oak Ridge National Laboratory, and also with the theorists. The theoretical efforts included first principle calculations (Bruce Harmon) and phenomenological approaches (Sam Liu). Superconductivity was also another active topic of research, but most of the effort was concentrated on non-rare-earth compounds.

3.7 Interdisciplinary Research

Two of the main strengths of the Ames Laboratory are magnetism and X-ray crystallography of rare earth and related materials. In part this is due to cooperative research efforts that cut across the disciplines of physics, materials science, and chemistry. Frank Spedding was one of the leaders in this approach to scientific research, which was rare in the 1950s.

4. Interactions with Industry

As mentioned above in § 3 much of the research and development efforts were turned over to industry—the uranium and thorium metal production, the ion exchange separation processes, and the analytical techniques (especially ICP–MS). In addition, K.A. Gschneidner, Jr. established the Rare-earth Information Center (RIC) in 1966 with the initial support of the forerunner of BES, and later by industry (starting in 1968), which totaled about 100 companies world-wide in 1996. RIC's mission was to collect, store, evaluate and disseminate information about new scientific discoveries, industrial developments, new commercial products, conferences, books and other literature, honors received by rare earthers, and to answer information inquiries. RIC published two newsletters—a quarterly (available free) and a monthly (available to supporters of RIC), and occasional reports. In 1996 the directorship was turned over to R.W. (Bill) McCallum. But RIC ceased operation in August 2002—when industry support dwindled significantly as China forced many companies out of the rare earth markets with extreme price reductions and, simultaneously, a down-turn in the economy dried up state and Federal support.

Because of the expertise of individual AL scientists and/or some unique AL analytical or processing capability, many organizations, including industrial companies, asked the AL to perform applied research as Work for Others projects or CRADAs. Many of these non-DOE projects include the rare earths. One of these cases is discussed in more detail in § 6.5. In addition to these individual interactions, the AL established the Materials Preparation Center (MPC) in 1981 to provide unique metals, alloys and compounds to worldwide scientific and industrial communities; and to perform unusual processes for fabricating materials which could not be done elsewhere, see § 6.1. The functions carried out by the MPC over the nearly 30 years of its existence are an outstanding example of AL-industry interactions.

Over the years various industrial organizations have sent their staff scientists and engineers to work at Ames Laboratory getting firsthand experience on a particular technology. These arrangements may be part of CRADAs or Work for Others projects.

In 2009 ISU became a research member of the Rare Earth Industry and Technology Association (REITA) to implement rare earth technology and promote commercialization of the rare earths for military and civilian applications.

5. Technology Transfer and Patents

The Ames Laboratory (AL) has been awarded 300 patents, of which about 45 are concerned with rare earth materials. Ten patents deal with the rare earth-base permanent magnets and four with magnetic refrigeration materials. Before the passage of the Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96–480) and the Dayh-Dole Act of 1980 (P.L. 96–517) all patent rights were turned over to the U.S. Government. After the Acts became law, the AL (a GOCO—government owned, contractor operated laboratory) began to license the various technologies developed at the AL via the Iowa State University Research Foundation (ISURF).

The combination of inductive coupled plasma with atomic emission spectroscopy in 1975 and later with mass spectrometry in 1984 was a quantum jump in increasing the sensitivity for detecting and determining trace elements in various materials. The two analytical methods were developed at the AL to improve the speed and lower the limits of detecting various rare earth impurity elements in a given rare earth matrix. This technique was soon applied to other impurities in a variety of non-rare-earth materials, e.g. detection of poisons such as mercury and arsenic in drinking water. The ICP–MS and ICP–AE technologies were turned over to industry and are now a standard analytical tool in over 17,000 analytical laboratories worldwide. It is a rapid and accurate method for 80 elements, and in some cases allows the detection of an impurity down to the parts per trillion level. Today there are at least six companies that manufacture ICP–MS instruments.

In addition to the various technology transfers noted in the previous paragraph and in sections 2, 3.1–3.3, one of the more recent success stories is concerned with Terfenol. Terfenol is a magnetic iron-rare-earth (containing dysprosium-terbium) intermetallic compound which has excellent magnetostrictive properties. When a magnetic field is turned on Terfenol will expand and when the magnetic field is removed it relaxes to its original shape and size. There are many applications for this material including sonar devices for detecting submarines, oil well logging, vibration dampers, audio speakers, etc. The magnetostrictive properties were discovered in the early 1970s at the Naval Ordinance Laboratory in Maryland. Shortly thereafter the Navy contracted the AL to grow single crystals and Terfenol samples with preferred orientations. The AL was successful and designed a procedure for making the orientated material to maximize the amplitude of the magnetostrictive effect. Patents were issued and in the late 1980s ISURF licensed the processing technology to Etrema, a subsidiary of Edge Technologies, Inc. in Ames, Iowa. Today Etrema is a multimillion dollar business.

6. Where We are Today 1980–2010

With the Ames Laboratory's successes, some of the golden-age research was no longer deemed to be basic research and funding dried up. In addition key personnel started to retire. As a result of these two events a number of AL capabilities were phased out completely. These include: analytical chemistry, separation chemistry, process metallurgy, and ceramics. The excellent analytical capabilities were slowly reduced and completely lost by the 2000s, except for inert gas fusion and combustion analysis. The rare earth research activities in physical metallurgy and condensed matter physics areas have also suffered some downsizing to about half the level of what it was in the pre-1980 era, but what is left is still first class state-of-the-art basic research.

In the following sections important activities that are still ongoing are described. Other research that had been completed in the 1980s and may play in important role in the future activities of a new national rare earth research center, is also noted.

6.1 Materials Preparation Center

As an outgrowth of the Ames Laboratory's interactions with industry, other DOE laboratories, universities, other research organizations, the Materials Preparation Center (MPC) was established in 1981 to provide high purity metals (including the rare earths, uranium, thorium, vanadium, chromium); and intermetallics, refractory, and inorganic compounds, and specialty alloys; none of which are available commercially in the required purity or form/shape needed by the request or on a cost recovery basis. The MPC is a BES specialized research center with unique capabilities in the preparation, purification, processing, and fabrication of well-characterized materials for research and development. The Center is focused on establishing and maintaining materials synthesis and processing capabilities crucial for the discovery and development of a wide variety of use-inspired, energy-relevant materials in both single crystalline and polycrystalline forms, spanning a range of sizes with well-controlled microstructures. There are four functional sections within the MPC: (1) high purity rare earth metals and alloys; (2) general alloy preparation; (3) single crystal synthesis; and (4) metallic powder atomization. Each area is provided scientific and technical guidance by a Principal Investigator (PI) whose individual expertise is aligned with the function of each section. The original director was F. (Rick) A. Schmidt who retired in 1993 and turned over the directorship to Larry L. Jones.

In 2008 the MPC filled 183 external materials requests from 111 different scientists at 88 academic, national and industrial laboratories worldwide. Internally the Center provided materials, and services for 53 different research projects that totaled 1092 individual requests.

6.2 $Nd_2Fe_{14}B$ Permanent Magnets

The announcement of the simultaneous discovery of the high strength permanent magnet materials based on $Nd_2Fe_{14}B$ by scientists at General Motors in the USA and at Sumitomo Special Metals. Co., Ltd. in Japan in November of 1983 set off a flurry of activities everywhere. The lead scientist at General Motors was John Croat (an ISU graduate), who was Frank Spedding's last graduate student. DOE/BES funding for research on these materials at the AL started in 1986 and lasted through 1998. U.S. Department of Commerce (DOC) funding for gas atomization processing work on $Nd_2Fe_{14}B$ alloys, through the ISU Center for Applied Research and Technology, was received from 1988 through 1993. Funding was renewed at the AL in 2001 under the auspices of DOE/EERE's Vehicle Technology (formerly FreedomCar) program.

Notable achievements in the BES funded project included: (1) demonstrating that the $Nd_2Fe_{14}B$ compound can be prepared by a thermite reduction process that is competitive with other methods of the permanent magnet material; (2) developing methods for controlling the solidification microstructure of melt spun $Nd_2Fe_{14}B$ which leads to large energy products (the larger the energy product the better the permanent magnet properties); (3) proposing a model for the rapid solidification of a peritectic compound to explain the solidification microstructure of melt spun $Nd_2Fe_{14}B$; and (4) developing a model for hysteresis in exchange coupled nanostructure magnets. In 1996 the AL team headed by R.W. (Bill) McCallum[c] received the DOE Materials Science Award for "Significant Implications for DOE Related Technologies, Metallurgy and Ceramics" (items 2 and 3 above). A year later this same team won an R&D–100 Award for Nanocrystalline Composite Coercive Magnet Powder (see § 7.1). In the DOC funded project, an alternative rapid solidification process, gas atomization, was developed for making fine spherical $Nd_2Fe_{14}B$ powders, for which the AL (Iver Anderson and Barbara Lograsso) received an R&D–100 award in 1991 (see § 7.1). They also received the Federal Laboratory Consortium Award for Excellence in Technology Transfer for gas atomization processing of $Nd_2Fe_{14}B$ to enable improved molding of bonded magnets. The AL thermite reduction process (item 1), which was developed by F. (Rick) A. Schmidt, J.T. Wheelock and Dave T. Peterson under MPC research, was selected for one of the 1990 IR–100 (changed to "R&D 100" in 1991) Awards for new innovative research for potential commercialization.

The Vehicle Technology research funded by SERE is on-going and includes design of improved $Nd_2Fe_{14}B$ permanent magnets which can operate at high temperature, enabling more powerful and more efficient motors. This project also is developing further the high temperature RE magnet alloys for powder processing, intended for injection molded bonded magnets for mass production of hybrid and electrical vehicles. Based on initial success with both aspects of the RE magnet project, in 2009 SERE expanded their support into the high risk task of identifying non-rare-earth magnet alloys with sufficient strength for vehicle traction motors.

6.3 $Nd_2Fe_{14}B$ Scrap Recovery

As manufacturers began to make the $Nd_2Fe_{14}B$ material, it soon became apparent there was a great deal of waste magnet material being generated because grinding, melting and polishing the magnets into a final form/shape. Much of the magnet material is mixed with oils and other liquids used in these operations—this material is known as "swarf". The team of scientists at AL headed by F. (Rick) A. Schmidt developed two different processes to recover the neodymium metal: a liquid metal extraction process to treat the solid materials; and an aqueous method for treating the swarf. Both processes were patented, but the patents have since expired.

6.4 High Temperature Ceramic Oxide Superconductors

In the mid-1980s another major discovery occurred and had an enormous impact on the rare earths as well as science and technology in general—the discovery of the oxide superconductor with transition temperatures greater than that of liquid nitrogen 77 K (~195° C). One of the key superconductors was $YBa_2Cu_3O_7$, also known as "1:2:3". It is utilized today in electrical transmission lines, electrical leads in low temperature high magnetic field apparati and other superconducting applications. The AL had a strong tradition in superconducting research well before this discovery, and when they learned of it the condensed matter physicists and materials scientists immediately began research on these ceramic oxide superconductors. A National Superconducting Basic Information Center was established at AL in 1987 with financial support from DOE's BES. It was headed by John R. Clem, a theorist who continues to consult with American Superconductor. The experimentalists worked diligently on various aspects of the 1:2:3 and other oxide superconductors to understand the processes by which they are formed and to prepare high purity well characterized materials for physical property studies, which would assist the theorists to understand the fundamental nature of these superconductors. This work laid the ground work for the development of a method of fabricating the rare earth 1:2:3 materials into filaments and flexible wires. Most of the research on these oxide superconductors at AL has stopped and most of the know-how has been turned over to industry. However, AL scientists are still at the forefront of the field studying the new high temperature superconductors: the rare-earth-arsenic-iron-oxide-fluoride and the MgB_2 materials.

6.5 Magnetic Cooling

Magnetic cooling is new, advanced, highly technical, energy efficient, green technology for cooling and climate control of buildings (large and homes), refrigerating and freezing food (supermarket chillers, food processing plants, home refrigerator/freezers). The AL team headed by K.A. Gschneidner, Jr. and V.K. Pecharsky has been involved with magnetic cooling since 1990, when Astronautics Corporation of

[c] Other team members were K. Dennis, M. Kramer and Dan Branagan, who moved to DOE's INEEL laboratory.

America (ACA) asked Gschneidner to develop a new magnetic refrigerant material to replace the expensive GdPd refrigerant they were using for hydrogen gas liquefaction (a DOE sponsored research effort). The AL team was successful and showed that a $(Dy_{0.5}Er_{0.5})Al_2$ alloy was about 1000 times cheaper and 20% more efficient than GdPd. A patent was issued for this new magnetic refrigerant material. This work was recognized as the best research paper presented at the 1993 Cyrogenic Engineering Conference. A few years later AL teamed up with ACA and designed, constructed and tested a near room temperature magnetic refrigerator. In 1997 they demonstrated that near room temperature magnetic refrigeration is competitive with conventional gas compression cooling technology and is about 10% more efficient, and is a much greener technology because it does not employ ozone depleting, or greenhouse, or hazardous gases [7]. This work was funded by BES's Advanced Energy Project program. Additional research on magnetocaloric materials was supported by BES after the Advanced Energy Project ended in 1998. But in 2005 BES funding for this research was terminated because they thought it was no longer basic research, i.e. it was too applied. Since then some work has continued on magnetocaloric materials under a work for others subcontract with ACA who has a Navy contract to build shipboard cooling machines, and a few SBIRs which are being funded by EERE.

This research on magnetic cooling is a good example of AL's response to a problem encountered by industry which was successfully solved, and then later, this work led to a whole new cooperative AL-industry project on near room temperature magnetic refrigeration.

6.6 Neutron Scattering

Neutron scattering is a powerful tool in determining magnetic structures of magnetic materials and it compliments magnetic property measurements made by standard magnetometers. The rare earth research at AL has benefited from interactions with the neutron scatterers. In the early 1950s Frank Spedding and Sam Legvold of the AL had a close relationship with the neutron scattering group headed by Wally Koeller at Oak Ridge National Laboratory neutron scattering facility and furnished single crystals of the rare earth metals. Recognition and demand for neutron scattering resulted in a 5MW reactor being constructed locally for Ames Laboratory. Scientists used this reactor for extensive measurements of the electronic interactions in rare earth and other magnetic materials. Because of a large jump in the cost of operating and fueling this reactor, it was shut down in 1978. The relationship with the neutron scattering effort at Oak Ridge was enhanced and continued for many years up to about 1980, shortly before the death of the three scientists in 1983–84. To this day a dedicated neutron scattering facility, run by AL scientists, operates at the Oak Ridge High Flux Isotope Reactor (HFIR). It is still of great benefit to AL scientists studying rare earth materials.

6.7 X-ray Magnetic Scattering

X-ray magnetic scattering is a fairly new tool, which was developed in the early 1990s, to study magnetic structures. It is fortunate that this new tool became available because a few of the rare earth elements, especially gadolinium, readily absorb neutrons and neutron scattering measurements are very difficult if impossible to make. Thus, X-ray magnetic scattering has been especially useful in determining the magnetic structures of gadolinium compounds.

In more recent years scientists have improved the X-ray magnetic scattering technique, which is called X-ray magnetic circular dischroism (XMCD). The AL scientists have been on the forefront by applying the latest experiments and theoretical tools to help elucidate complex electronic interactions underlying bulk magnetic properties. The AL team, led by Alan Goldman (experiment) and Bruce Hannon (theory), has been pioneers in the development and application of XMCD on rare earth materials. This tool gives valuable and direct information about the itinerant electrons responsible for coupling the individual localized magnetic moments of each rare earth atom in a solid. The stronger the microscopic coupling the stronger the bulk magnet, and the more useful it can be in applications. Such experiments and powerful computers are essential for helping AL scientists in their latest "materials discovery" initiative to accelerate the discovery of new magnetic materials for industry.

6.8 Emerging Technologies

One of the new and exciting, ongoing developments at Ames Laboratory is a revolutionary method of preparing rare earth-based master alloys for energy and other applications. In addition to lowering costs of the starting material, the processing technique also reduces energy consumption by 40 to 50% and is a very green technology. The work on preparing $Nd_2Fe_{14}B$ magnet material began about a year ago with financial support from AL patent royalties, and it has been reduced to practice—we have prepared a state-of-the-art permanent magnet on February 5, 2010, see attached figure. It is a one step process going from the neodymium oxide to the neodymium master alloy, and since the end-products are completely utilized, there are no waste materials to dispose of. The conventional process also starts with the neodymium oxide but takes two steps to obtain the neodymium metal, and there are waste products associated with both steps which need to be disposed of in an environmentally friendly manner. The step to prepare the $Nd_2Fe_{14}B$ magnet material is essentially the same in either case. This processing technique was invented by F. (Rick) A. Schmidt and K.A. Gschneidner, Jr. A provisional patent has been filed.

A modification of this process should enable us to prepare a lanthanum master alloy to prepare lanthanum nickel metal hydride batteries, which are used in hybrid and electrical vehicles. Likewise, we believe this process can be used to make magnetic rare earth refrigerant alloys (see § 6.5).

7. Kudos

The Ames Laboratory scientific achievements and their science/engineering leaders have been recognized by several organizations including DOE.

7.1 R&D–100 Awards (former IR–100 Awards)

Industrial Research magazine annually identifies the nation's top 100 technological innovations, called the ER–100 Awards before 1991 and now are called the R&D–100 Awards. These awards are also known as the "Oscars of Science". Over the past 25 years AL has received 17 R&D–100 Awards. Of these three are involved with rare earths, in particular the $Nd_2Fe_{14}B$ permanent magnet materials. These are listed below.

1990: "Thermite Reduction Process to Make Rare-earth Iron Alloys" F. (Rick) A. Schmidt, John T. Wheelock and Dave T. Peterson

1991: "HPGA (High Pressure Gas Atomization)" Iver Anderson and Barbara Lograsso

1997: "Nanocrystalline Composite Coercive Magnet Powder" R.W. (Bill) McCallum, Kevin Dennis, Matt Kramer, and Dan Branagan

FIGURE CAPTION: The first and second $Nd_2Fe_{14}B$ bonded permanent magnet prepared using the new process for making the neodymium master alloy.

Left: Our KAA–1–34 composition. 60/40 by vol. $Nd_2Fe_{14}B$/PPS (poly(phenylene sulfide). Hot pressed at 300° C and magnetized with a 2T electromagnet. The second bonded permanent magnet prepared.

Center: Practice magnet of similar composition. The surface is boron nitride coating from the die used to compact the $Nd_2Fe_{14}B$ particles in the polymer.

Right: First Bond permanent magnet. 30/70 by vol. $Nd_2Fe_{14}B$/diallyl phthalate sample mounting material. Hot pressed and sealed with thin layer of epoxy.

7.2 National Academies Members

Six Ames Laboratory scientists have been named to the National Academy of Sciences and the National Academy of Engineering. Frank H. Spedding was elected in 1952 and John D. Corbett in 1992 to the National Academy of Sciences. The four National Academy of Engineering members are: Donald O. Thompson—1991, Dan Schechtman—2000, R. Bruce Thompson—2003, and Karl A. Gschneidner, Jr.—2007. Of the six three (Spedding, Corbett and Gschneidner) were heavily involved in the rare earth science and technology of rare earths during their careers. Corbett and Gschneidner are still actively engaged in research and development activities. Spedding died in 1984 but was still active until shortly before his passing.

7.3 Department of Energy Awards

Scientists at AL have won several DOE, (mostly from BES) awards for their scientific achievements. These are listed below.

1982 K.A. Gschneidner, Jr. and K. Ikeda for quenching of spin fluctuations

1991 I.E. Anderson and B.K. Lograsso received the Federal Laboratory Consortium Award for Excellence in Technology Transfer for high pressure gas atomization of rare earth permanent magnet alloys

1994 B.J. Beaudry for thermoelectric materials characterization from DOE's Radioisotope Power Systems Division

1995 J.D. Corbett for sustained outstanding research in materials chemistry

1995 A.I. Goldman, M.J. Kramer, T.A. Lograsso, and R.W. McCallum for sustained outstanding research in solid state physics

1996 D. Branagan, K.W. Dennis, M.J. Kramer, R.W. McCallum for studies on the solidification of rare earth permanent magnets

1997 K.A. Gschneidner, Jr. and V.K. Pecharsky for contributions to the advancement of magnetic refrigeration

2001 K.A. Gschneidner, Jr. and V.K. Pecharsky received the "Energy 100 Award" for research on magnetic refrigeration as one of the 100 discoveries between 1997 and 2000 that resulted in improvements for American consumers.

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QUESTION 2: BASIC RESEARCH PROGRAM

In the 1990s the Chinese flooded the marketplace with low priced raw rare earth products (mixed and separated rare earth oxides) and as a result, not only did the primary rare earth producers in the United States and the rest of the world shut down, but technical personnel with expertise in rare earth mining, refining, extraction, etc. found employment in other industries. Soon thereafter the Chinese began manufacturing higher value rare earth products, including rare earth permanent magnet materials, and in time, all of the $Nd_2Fe_{14}B$ magnet manufacturers in the United States also went out of business. This also resulted in a brain drain of scientists and engineers in this field, and also in all high-tech areas involving other rare earth products, such as high energy product permanent magnet materials, metallic hydrogen storage and rechargeable battery materials. Some of these experts have moved on to other industries, others have retired, and others have died, basically leaving behind an intellectual vacuum.

In the late 2000s the Chinese game plan changed, and they have started to exercise export controls on a variety of rare earth products, and signaled that they intend to consume all the rare earths mined in China internally in the next three to five years. This change will allow the rare earth producers and manufacturers to supply the needed products, but this presents several problems which have been cited by others at this House Committee hearing. One of these is the shortage of trained scientists, engineers, and technicians. Another need is innovations in the high tech areas which are critical to our country's future energy needs. A research center which alleviates both of these problems is the best way to work our way through the rare earth crisis facing the USA. An educational institution which has a long and strong tradition in carrying out research on all aspects of rare earth materials—from mining and purification to basic discovery and applications over a number of disciplines (i.e. chemistry, materials, physics, and engineering) with a strong educational component (undergraduate, graduate and post doctoral students) would be the ideal solution. A National Research Center on Rare Earths and Energy should be established at such an institution initially with Federal and, possibly, state support, and as the U.S. rare earth industry matures in five to ten years, supplemented by industrial financial support. The center would employ about 30 full time employees—group leaders; associate and assistant scientists and engineers; post docs, graduate and undergraduate students; and technicians plus support staff. This research center will be a national resource for the rare earth science, technology and applications, and therefore, it would also provide broad support of research activities at other institutions (universities, national laboratories, non-profit research centers, and industry) who would supply intellectual expertise via subcontracts to complement the activities at the center.

The major emphasis of the center would be goal oriented basic research, but proprietary research directly paid by the organizations that request it would also be part of the center's mandate. The center would have an advisory board to oversee, guide and refocus as needed the research being conducted. The advisory board would be made up of representatives from the university, government, industry and the general public.

I would like to suggest to this House subcommittee that they consider .a second national center, the National Research Center for Magnetic Cooling. Cooling below room temperature accounts for 15% of the total energy consumed in the USA. As noted in my response to the first question, magnetic refrigeration is a new advanced, highly technical, energy efficient green technology for cooling and climate control of buildings,-ships, aircraft, and refrigerating and freezing (§ 6.5). We have shown that magnetic cooling is a refrigeration technology competitive with conventional gas compression cooling. Magnetic cooling is 10 to 20% more efficient, and it is a very green technology because it eliminates hazardous and greenhouse gases, and reduces energy consumption. If we were able to switch all of the cooling processes to magnetic refrigeration at once we would reduce the nation's energy consumption by 5%. But there are a lot of hurdles that need to be overcome and the USA needs to put together a strong, cohesive effort to retain our disappearing leadership in this technology, by assembling a National Research Center for Magnetic Cooling. Europe and China are moving rapidly in this area, and Denmark has assembled a magnetic refrigeration national research center at Riso—so far the only one in the world. The U.S. Center should be structured similar to what has been proposed in the above paragraphs for the National Research Center on Rare Earth and Energy. The question is, are we going to give up our lead position and be a second rate country, or will we be leading the rest of the world? I hope and pray that the answer is, we are going to show the world that we are number one.

QUESTION 3: KNOWLEDGE TRANSFER

Knowledge is transferred from a research organization to industry through two primary routes. The first is the transfer of intellectual property. Research findings carried out at universities, colleges, non-profit organizations, and DOE and other Federal laboratories are disseminated as published articles in peer-reviewed journals and in trade journals, presentations at national and international conferences, electronic media, or their organization's web site, and if exciting enough, via news conferences and press releases assuming the new results are not patentable. If, however, the research has some potential commercial value, this new information/data should be made available as soon as feasibly possible after filing a patent disclosure. However, before the patent is filed one could disseminate the results to companies that might be interested by contacting them directly to see: (1) if they are interested, (2) if they would sign a non-disclosure agreement, and (3) if they answer yes to both (1) and (2) then the information could be disclosed to them. However, all the companies must be treated equally and fairly.

The second route is highly effective when the research organization is connected with a university. This is exemplified by Ames Laboratory and Iowa State University. AL employs a significant number of ISU students in part time positions either as graduate research assistants or undergraduate research helpers. These science and engineering students, particularly at the bachelors and masters levels, transfer the skills and process the knowledge gained in working in the laboratory to their employers after they graduate.

QUESTION 4: U.S. RESEARCH ON RARE EARTH MINERALS

Rare earth research in the USA on mineral extraction, rare earth separation, processing of the oxides into metallic alloys and other useful forms (i.e. chlorides, carbonates, ferrites), substitution, and recycling is virtually zero. As is well-known, research primarily follows money; but prestige and accolades are other drivers; or when someone serendipitously comes up with an exciting idea for a research project. The lack of money and excitement accounts for the low level of research on the above topics.

Today some work on rare earth and actinide separation chemistry is directed toward treating waste nuclear products and environmental clean-up of radioactive materials in soils is being carried out at various DOE laboratories. This research may be beneficial to improving rare earth separation processes on a commercial scale.

Some research at various universities might be considered to be useful in finding substitutes for a given rare earth element in a high tech application. But generally the particular rare earth's. properties are so unique it is difficult to find another element (rare earth or non-rare earth) as a substitute.

The Chinese have two large research laboratories which have significant research and development activities devoted to the above topics. They are the General Research Institute for Nonferrous Metals (GRINM) in Beijing, and the Baotou Research Institute of Rare Earths (BRIRE) in Baotou, Inner Mongolia. GRINM is a much larger organization than the Baotou group, but the rare earths activity is smaller than what is carried out at BRIRE. The Baotou Research Institute of Rare Earths is the largest rare earth research group in the world. Baotou is located about 120 miles from the large rare earth deposit in Inner Mongolia and is the closest large city to the mine. This is the reason why BRIRE is located in Baotou.

BIOGRAPHY FOR KARL A. GSCHNEIDNER, JR.

Karl A. Gschneidner, Jr. was born on November 16, 1930 in Detroit, Michigan, and received his early education at St. Margaret Mary grade school and St. Bernard high school. He attended the University of Detroit, 1948–1952 and graduated with B.S. in Chemistry. He went to graduate school at Iowa State College (became Iowa State University in 1959) and in 1957 obtained a Ph.D. degree in Physical Chemistry studying under Distinguished Professor Frank H. Spedding and Professor Adrian H. Daane. He then worked in the plutonium research group at the Los Alamos Scientific Laboratory from 1957 through 1963. In 1963 he joined the Department of Metallurgy as an Associate Professor, and jointly as a group leader at the Ames Laboratory of Iowa State University. He was promoted to a full professor in 1967, and named a Distinguished Professor in 1979. In 1966 he founded the Rare-earth Information Center and served as its Director for 30 years. He was also the Program Director for Metallurgy and Ceramics at the Ames Laboratory from 1974 to 1979. He taught mostly graduate level courses, including x-ray crystallography, the physical metallurgy of rare earths, and alloying theory.

Gschneidner, sometimes known as "Mr. Rare Earths", is one of the world's foremost authorities in the physical metallurgy, and the thermal, magnetic and electrical behaviors of rare earth materials, a group of chemically similar metals naturally occurring in the earth's crust. His work lately has taken him into the field of magnetic refrigeration, a developing technology that has the potential for significant energy savings with fewer environmental problems than existing refrigeration systems.

Gschneidner has over 450 refereed journal publications and nearly 300 presentations to leading scientific gatherings worldwide to his credit. Holder of more than a dozen patents, he has been honored with numerous awards by governmental, professional, and industrial bodies, including recognition for his Ames Lab team's research in magnetic refrigeration by the U.S. Department of Energy in 1997 and with an Innovative Housing Technology Award in 2003.

In addition to the National Academy of Engineering, Gschneidner is also a Fellow of the American Society for Materials-International, The Minerals, Metals and Materials Society, and the American Physical Society. In 2005, he was honored for 53 years of outstanding contributions to his field with a symposium at Iowa State that was attended by some of the world's leading experts in rare earth materials, many of them his former students or collaborators. He maintains an active research program with Ames Laboratory.

Chairman MILLER. Thank you, Dr. Gschneidner. Mr. Smith for five minutes.

STATEMENT OF MR. MARK A. SMITH, CHIEF EXECUTIVE OFFICER, MOLYCORP MINERALS, LLC

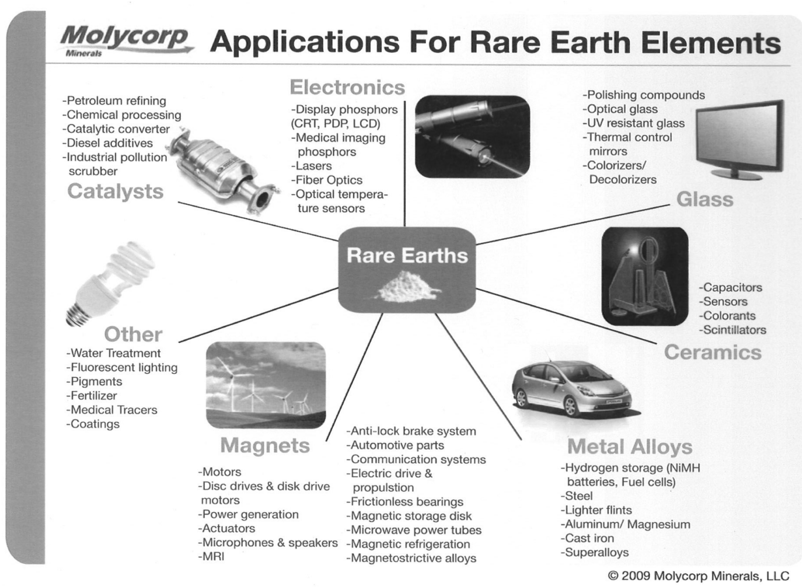
Mr. SMITH. Thank you. Chairman Miller, Ranking Member Broun, other distinguished Members of the Subcommittee. I would like to thank you for the opportunity to be here today.

This is the first committee to hold a hearing specifically on this issue, and I want to commend you for your leadership in this regard.

It has been remarkable, in my 25 years in this business, to see the use of rare earths literally explode in front of our eyes. However, while rare earth-based technologies have become more and more essential and more and more a part of our everyday lives, the United States—as well as the rest of the world—has become almost completely dependent on China for access to the rare earth resources and the metals, alloys and magnets that derive from them.

A combination of three factors should make this situation one of urgent concern to policymakers: first, the indispensability of rare earths in clean energy and defense technologies; two, the almost complete dominance of rare earth production by China; and three, China's accelerating consumption of their own rare earth resources.

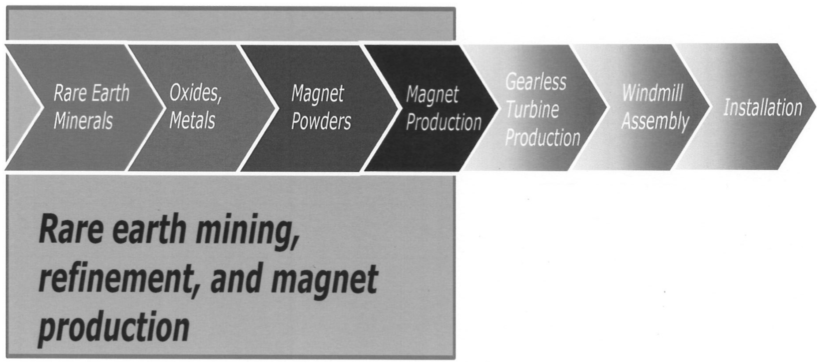
[The information follows:]



On the screen in front of you is a slide that just touches the surface of some of the uses of rare earths in the world today. On the clean energy side, rare earths are used in the advanced nickel hydride batteries for hybrid cars as well as the rare earth permanent magnets that power the highly efficient next generation of wind turbines and the electric and hybrid vehicle motors and generators. Rare earth phosphors are what illuminate compact fluorescent light bulbs which are currently mandated in the European Union.

On the defense side, missile guidance systems, electronics, communications and surveillance equipment, just to name a few applications, all require rare earths. None, let me repeat, none of these technologies will work without rare earths, and yet each is tied directly to some of the Nation's highest national priorities today.

[The information follows:]



On the screen in front of you now I have provided a simplified version of a wind turbine supply chain from a rare earth perspective. With the exception of our historic rare earth mineral production at the very start, none of the capabilities in the green box really exist in the United States today. The result is a supply chain capability gap in the United States that has the potential to become a very serious strategic and economic disadvantage. Today, China actually produces over 97 percent of the world's rare earth oxides. They produce almost 100 percent of the associated metals and 80 percent of the rare earth magnets. For the last 15 years, China's production has been able to satisfy their own internal needs as well as those of the rest of the world. However, it is predicted that rapid Chinese demand growth, coupled with lower and lower Chinese government-controlled export quotas, will continue to decrease the amount of rare earths available to the rest of the world, thereby creating a serious supply gap. Forecasts conclude that this shortage could occur by 2012, and with China's recently announced commitment to be the world's largest producer of wind energy and electric vehicles, this will certainly not help that timeframe.

In order to truly break our near-total dependence on China, Molycorp has developed its mining-to-magnet strategy. Molycorp has 57 years of experience in the rare earth industry and has a world-class ore deposit at its rare earth facility in Mountain Pass. We have invested over $20 million in process technology improvements in advance of our restart project, and the resulting efficiencies will drastically improve our overall cost competitiveness, as well as our environmental stewardship.

We also believe that our mine-to-magnets project could create an estimated 900 new direct jobs as well as 700 temporary construction jobs in the United States, not to mention the multiplier effect this will have in both green and defense technological industries in this country.

Molycorp is the only rare earth company outside of China that stands shovel-ready. We are uniquely well-positioned to rebuild the rare earth supply chain from mining to magnets, and we can do it in the shortest timeframe possible.

The Federal Government clearly has a role to play. As you consider legislation, there are four areas I think you can have the greatest impact on. The first is Federal loan guarantees. We applied for the DOE's loan guarantee program in the fall of 2009, and our application was recently rejected as ineligible. The DOE contends that this project goes too far upstream and that their program was not intended to cover projects that go all the way back to mining. Congress will need to provide legislative direction or new legislative language clarifying the use of loan guarantees for strategically vital supply chain projects.

Second, the Federal Government and this committee in particular can play a pivotal role in reestablishing our world class rare earth knowledge and expertise the way it used to be.

Number three, as noted earlier, the White House OSTP is working with the Departments of Commerce, Defense and State to lead a collaborative interagency effort on this issue. We are very encouraged by this effort, but the imminent global supply and demand challenge clearly necessitates more urgency by the Administration right now.

And finally, Federal funding support for competitive grants specifically directed at the rare earth research and technology industry, including recycling, will certainly help to further expand the United States' capabilities in the rare earth world.

Thank you, Mr. Chairman, for this time today, and I would be happy to answer any questions later.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF MARK A. SMITH

Introduction

Chairman Miller, Ranking Member Broun, and Members of the Subcommittee, I want to thank you for the opportunity to share my observations, experiences, and insights on the subject of rare earths, the critical role they play in the technologies that will shape our future, the looming supply challenges that are ahead of us, and the work we are doing at our facility at Mountain Pass, California. This is the first Committee to hold a hearing specifically on this important topic, and I want to commend you for your leadership and forethought.

I'm the CEO of rare earths technology company Molycorp Minerals, LLC. Molycorp owns the rare earth mine and processing facility at Mountain Pass, California, one of the richest rare earth deposits in the world, and we are the only active producer of rare earths in the Western Hemisphere. I have worked with Molycorp and its former parent companies, Unocal and Chevron, for over 25 years, and have watched closely the evolution of this industry over the past decade. It has been remarkable to watch the applications for rare earths explode. However, as rare earth-based technologies have become more and more essential, the U.S., which invented rare earth processing and manufacturing technology, has become almost completely dependent on China for access to rare earths and, more' specifically, the metals, alloys and magnets that derive from them.

On its face it may not seem any more disconcerting than any other material dependency. However, it is the combination of three key factors that make this situation one of urgent concern to policymakers: 1) the indispensability of rare earths in key clean energy and defense technologies; 2) the dominance of rare earth production by one country, China, and 3) China's accelerating consumption of their own rare earth resources, leaving the rest of the world without a viable alternative source.

The development of clean energy technology is a top national priority, as these innovations are key to our broader national objectives of greater energy security and independence, reduced carbon emissions, long term economic competitiveness, and robust job creation. Yet all of these crucial national objectives become less achievable if we lack access to rare earth resources.

Our company has produced rare earths for 57 years, and we are in the process of restarting active mining and down-stream processing at Mountain Pass. We are redeveloping our facilities to dramatically increase our production, and we are executing a strategy to rebuild the rare earth metal and magnet manufacturing capabilities that our country has lost in the past decade. This effort will help to address rare earth access concerns and may help to catalyze clean tech manufacturing, but the lingering question is how quickly we can make this happen, as the looming supply concerns seem to accelerate every day.

Below I offer my perspective on rare earths and their applications, America's rare earth capability gap, the global supply concerns and their implications, our work at Molycorp to expand our domestic rare earth access, and the role the Federal Government can play to help address the looming supply concerns.

Rare Earth Elements and Key Applications

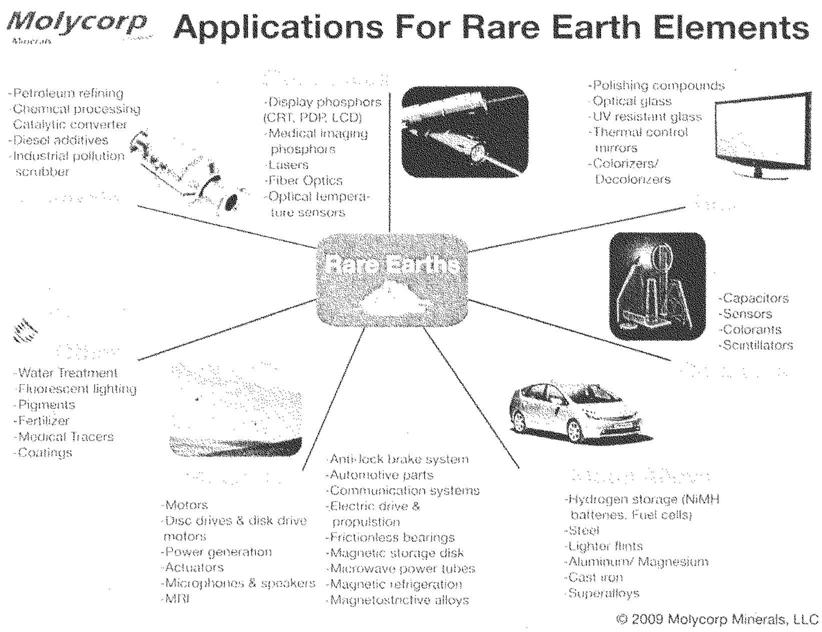
Rare earths are a group of 17 elements (atomic numbers 57–71 along with Sc and Y) whose unique properties make them indispensable in a wide variety of advanced technologies. One rare earth in particular—neodymium (Nd)—is used to create the very high powered but lightweight magnets that have enabled miniaturization of a long list of consumer electronics, such as hard disk drives and cell phones. While high-tech applications such as these have dominated the usage of rare earths over the past decade, it is their application in clean energy technologies and defense systems that has brought heightened attention to rare earths.

Rare earths are indispensable in a wide variety of clean energy technologies. Rare earth metals are used in the advanced nickel-metal hydride (NiMH) batteries that are found in most current model hybrids; powerful rare earth magnets enable next generation wind turbines, electric vehicle motors, and hybrid vehicle motors and generators; and rare earth phosphors are what illuminate compact fluorescent light bulbs. On the defense side, missile guidance systems, military electronics, communications and surveillance equipment all require rare earths. None of these technologies will work without rare earths, and yet each of these technologies is tied closely to some of the nation's highest national priorities, our energy and national security.

The list of rare earth applications is long and varied, but there are additional applications that are worth noting specifically. The automotive sector is a big user of rare earths. Cerium is used to polish glass and provides protection from UV rays. In the 1970s, rare earths replaced palladium for use in catalytic converters, and if palladium were still used today, cars would be significantly more expensive. They are also used in petroleum refining and as diesel additives.

At Molycorp, we have also found a use for cerium in water filtration. We have developed proprietary water filtration technology that has applications in industrial wastewater treatment, clean water production in the developing world, and the recreation and backpacking market.

The diagram below offers a broader view of rare earths' applications:

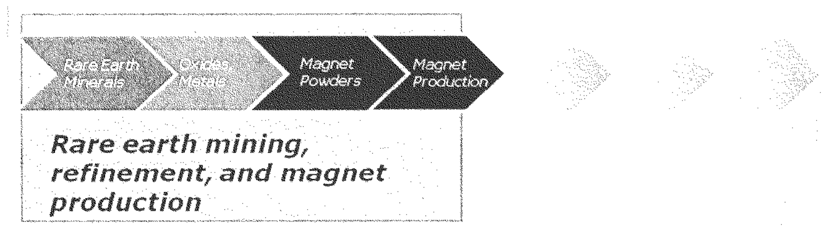


Despite their name, rare earths are not rare. If you were to go outside right now and grab a handful of dirt from the ground, it would contain rare earths. However, it is far more difficult to find rare earths in a concentration high enough to be mined and separated economically. When rare earths are extracted from the ground, the ore contains all of the rare earths, and it is through highly complex separation processes that each individual rare earth oxide can be produced. It is this separation process that largely drives the cost of rare earth production. Ore bodies that contain rare earths at percentages in the low single digits cannot be mined economically under current prices for rare earths.

Thus, today, there are only 3 known and verified locations where a sufficiently high concentration of rare earths exists: Baotou, China; Mountain Pass, California, where Molycorp's mine is located; and Mt. Weld, Australia, which has a rich ore deposit but none of the infrastructure necessary to begin extraction, separation, and distribution to market. Given these circumstances, Molycorp's mine at Mountain Pass is clearly one of the only rare earth resources in the world that is immediately minable, economically viable, and can provide a near-term source of rare earth materials. With supply concerns becoming increasingly imminent, the greatest challenge facing Molycorp is the speed at which we can bring these needed resources online. I will discuss this in further detail later in this testimony.

Industrial Supply Chain and America's Capability Gap

One of the biggest challenges in raising awareness and understanding about rare earths is that they are found so early in the industrial supply chain that it is difficult to contemplate their usage in products that we see every day. To illustrate this point, consider the example of the new generation of wind turbines, which employ rare earth-based permanent magnet generators with reliability and efficiency improvements of 70% over the current industry standard. Below is a simplified supply chain:



Once the rare earths are mined, they are separated and converted to oxides and then converted into metals. The metals are then manufactured into alloys and magnet powders. The powders are then bonded or. sintered to form the magnets required for turbine production. The turbine, in turn, is included in the windmill assembly, and the final product is installed. All of the functions within the green box are necessary to be able to produce the magnets required for this clean energy technology and so many others. However, other than the rare earth mineral extraction and conversion to oxides, the other manufacturing capabilities in the green box no longer exist in the United States. The U.S. did at one time possess all of these capabilities, and in fact, these technologies largely originated here. However, over the past decade as American manufacturing has steadily eroded, the U.S. has ceded this technological ground to competitors in China, Japan and Germany.

China has become particularly dominant, and some would contend that it has been by design. In the early 1990s, China's Deng Xiaoping was quoted as saying, "There is oil in the Middle East; there is rare earth in China." [1] China realized that it had a significant natural resource advantage, and through the development of new applications in an ever-expanding number of advanced technologies, China helped to grow the market for rare earths from 40,000 tons in the early 1990s to roughly 125,000 tons in 2008. It is over that same period that, due to a variety of factors, the U.S. ceased active mining of rare earths.

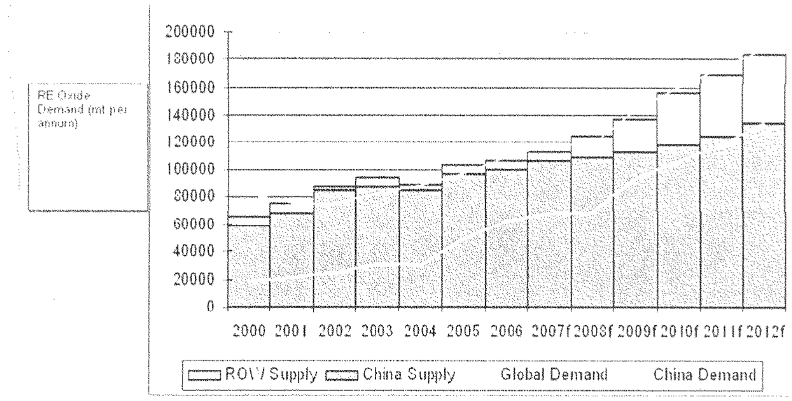
While the U.S. still possesses the technical expertise, we have lost the necessary infrastructure to manufacture the rare earth metals and magnets that fuel next generation technologies. The last rare earth magnet manufacturer in the U.S. was a company called Magnaquench, formerly located in Valparaiso, Indiana, and owned by General Motors. Magnaquench and all of its U.S. assets were sold to a Chinese company in the early 2000s in an effort to help GM gain access to the Chinese market.[2] Two domestic companies can produce small quantities of rare earth based alloys but none can convert the rare earth oxides to metal. The result is a significant rare earth "capability gap" in the U.S. that has the potential to quickly become a major strategic and economic disadvantage.

Global Supply Concerns and Implications for the U.S.

Today, the production of rare earths, and the metals and magnets that derive from them, is overwhelmingly dominated by China. 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. Complicating this picture even further, China's national consumption of rare earth resources is growing at an intense pace, consistent with their meteoric GDP growth, and it is leaving the rest of the world with less of these critical materials just as the clean energy economy is beginning to gain momentum. As the chart below from rare earths research firm, the Industrial Minerals Company of Australia (IMCOA) demonstrates, China's massive production has been able to satisfy both their own internal needs and those of the rest of the world. However, as the blue line indicates Chinese demand for its own rare earths will soon match, if not eclipse, its own internal supply, and with global demand (in yellow) growing at a parallel pace, there is a significant production gap—around 60,000 tons—that must be filled in a very short timeframe.

[1] Cox, Clint. (2006, October 10). *Rare earth may be China's checkmate.* Retrieved from the Anchor House web site on February 5, 2010 at *http://www.theanchorsite.com/2006/10/*.

[2] Moberg, David. (2004, January 23). *Magnet Consolidation Threatens Both U.S. Jabs and Security.* Retrieved from the In These Times web site on February 5, 2010 at *http://www.inthesetimes.com/article/685/*.



Source: Industrial Minerals Company of Australia, 2008

IMCOA's previous forecasts concluded that this critical shortage for the rest of the world outside of China would occur by 2012, but China has recently said that it intends to be the world's largest producer of wind energy and electric vehicles and has committed $150 billion and $29 billion to these two respective clean technology sectors (by comparison, the entire amount of stimulus funding under the American Recovery and Reinvestment Act directed at all areas of clean energy deployment was $60 billion). The new, more efficient wind turbines that use rare earth permanent magnet generators require around 2 tons of rare earth magnets per windmill. The rare earth industry has never seen this level of demand. To date, rare earth producers like Molycorp have filled orders by the pound or kilogram, not by the ton. If China's commitment holds true, this will vastly accelerate their consumption of rare earths and speed up the date when the rest of the world will find its access to rare earths severely limited.

Around the same time that China was outlining its clean energy investments, it also began to consider steps to reduce the availability of its rare earths to the rest of the world. As if the demand forecasts weren't disconcerting enough, China heightened international supply concerns last fall when its Interior Ministry signaled that it would further restrict its exports of rare earth resources. China has been steadily decreasing its exports by an average of 6% per year since 2002, but these new restrictions portend a more aggressive effort to use its own resources domestically. This critical issue was featured on the front page of the New York Time's business section on August 31, 2009, and I've included the article for the Committee's record.

Finally, in late December, China announced that it will begin to stockpile rare earths. It is our estimation that if they are announcing it officially to the rest of the world, it is highly likely that the stockpiling has been occurring for some time. Regardless, it will have a further depressive effect on global supply.

Energy Security and Global Competitiveness

Disruption in the global supply of rare earths poses a significant concern for America's energy security and clean energy objectives, its future defense needs, and its long-term global competitiveness. Rare earths may not be familiar to most people, hidden deep in the industrial supply chain, but they are absolutely indispensable for so many of the advanced technologies that will allow us to achieve critical national objectives.

Efforts to decrease U.S. dependence on foreign oil and develop a clean energy economy, as well as the jobs that come with it, have received broad bipartisan support, and few would disagree that the U.S. must diversify its sources of energy and slow the demand for fossil fuels. Wind power and electric vehicles (EVs) have emerged as technologies that will play important roles in these efforts, and the U.S. has indicated it intends to be a leader in both. As noted above, the most efficient wind turbines require multiple tons of rare earths, and as the U.S. moves to increase the percentage of power that comes from wind, there will be a commensurate increase in domestic demand for rare earths. The American automotive industry is expanding the number of hybrid, plug-in hybrid (PHEV), and full electric vehicle (EV) models in an effort to produce far more fuel efficient products, and yet many of the advanced batteries that power hybrids and PHEVs utilize several kilograms of rare earth metals in each unit. The motors and generators in these new vehicles also use several kilograms of rare earth permanent magnets. Similar implications exist for our national defense capabilities. From military communications equipment to missile guidance systems, rare earths enable a long list of advanced defense technologies. We have had extensive discussions with the Department of Defense (DOD), and they are paying far greater attention to this concern. In fact, the FY 2011 DOD Authorization signed into law last October included a provision requiring the Department to submit a report to Congress no later than April 1, 2010, assessing the usage of rare earth materials in DOD's supply chain, looking at projected availability for use by DOD, the extent to which the DOD is dependent on rare earth materials, steps that the Department is taking to address any risks to national security, and recommendations for further action.

Access to rare earths is obviously essential, but without rebuilding the manufacturing capacity to produce rare earth metals and magnets, the U.S. could find itself dependent on China for key technological building blocks. But even this scenario presumes that the U.S. has the manufacturing capabilities to put Chinese rare earth materials to use in final products. Right now, given the current state of U.S. manufacturing, it is unfortunately more likely that we would become a raw material supplier to Chinese manufacturers.

Viewed through this lens, the domestic development of rare earth resources and manufacturing capabilities is not only a strategic necessity but also a potential catalyst for job growth in the clean energy and advanced technology manufacturing sectors. If these resources and capabilities were built up domestically, it could have a multiplier effect on downstream, value added manufacturing. Consider China's experience. It has to create 10–15 million jobs a year just to accommodate new entrants into its job market, and it has viewed the rare earths industry as a "magnet" for jobs. China repeatedly attracted high-tech manufacturers to move to its shores in exchange for access to rare earths among other enticements. The U.S. could experience a similar jobs boost by making a concerted effort to rebuild the clean energy supply chain, beginning with rare earths, within its borders.

Molycorp Minerals' Mining to Magnets Strategy

Molycorp Minerals has been in the rare earths business for 57 years, and while the company and its facilities have changed ownership over the years, it has remained one of the world's only viable sources of rare earth minerals. On October 1, 2008, a group of U.S. based investors, including myself, formed Molycorp Minerals, LLC, and we acquired from Chevron its rare earth assets at Mountain Pass, which the U.S. Geological Survey has deemed "the greatest concentration of rare earth minerals now known." From the outset, we have sought to combine this world-class rare earth deposit with a "mining to magnets" strategy. Our redevelopment of Mountain Pass is the starting point of a broader effort to reestablish domestic manufacturing of the rare earth metals, alloys and magnets that enable and are indispensable to the clean energy economy and advanced technology manufacturing.

Our work at Mountain Pass provides a timely, well-planned, and economically viable means to address the rare earth access challenges on the shortest timeline possible. While Molycorp has been processing existing rare earth stockpiles since 2007, it has invested $20 million to begin the restart of active mining. Our team matches this remarkable natural resource with 57 years of rare earth mining, milling, and processing experience. We have obtained the necessary 30-year mine plan permit, and the Environmental Impact Report for the mining-to-oxides portion of the redevelopment has been reviewed and approved by all applicable Federal, state, and local agencies. Molycorp's footprint will be limited to its privately-held land, using state-of-the-art technologies for water treatment and mineral recovery. Through new advances in our production processes, Molycorp will produce 20,000 tons, or 40,000,000 pounds, of rare earth oxides per year, and our increased production and capabilities can potentially create 900 new jobs for the hard hit San Bernardino-Riverside and Henderson-Las Vegas regions of California and Nevada. Molycorp is the only domestic rare earth provider that stands "shovel-ready" to create jobs and commence the mining-to-magnets work required to meet multiple customer-specific product demands.

Access to the raw, rare earth minerals is obviously essential, but as noted earlier, it resolves only part of the challenge. As part of our mining to magnets development, we will build out the metals, alloying and magnet powder manufacturing capabilities. We would also establish the production of rare earth permanent magnets, all here in the United States. Our company is uniquely well-positioned to rebuild these early steps in the clean energy supply chain and fully extend the value and capabilities of the rare earth resources at Mountain Pass.

Environmental Stewardship as a Source of Cost-Competitiveness

Many industry observers question how a U.S. producer of rare earths can ever compete with the Chinese, when the possibility always lingers that the Chinese could flood the market and dramatically depress rare earth prices, a practice they have demonstrated previously. We have spent the better part of the past 8 years developing the answer to this question. We changed the orientation of our thinking and discovered that by focusing principally on energy and resource efficiency, we could make major improvements in our cost competitiveness while at the same time advance our environmental stewardship.

We will incorporate a wide variety of manufacturing processes that are new to the rare earth industry, which will increase resource efficiency, improve environmental performance, and reduce carbon emissions. Specifically:

- Our overall processing improvements will almost cut in half the amount of raw ore needed to produce the same amount of rare earth oxides that we have produced historically. This effectively doubles the life of the ore body and further minimizes the mine's footprint;
- Our extraction improvements will increase the processing facility's rare earth recovery rates to 95% (up from 60–65%) and decrease the amount of reagents needed by over 30%;
- Our reagent recycling, through proprietary technology that Molycorp has developed, could lead to even greater decreases in reagent use;
- Our new water recycling and treatment processes reduce the mine's fresh water usage from 850 gallons per minute (gpm) to 30 gpm a 96% reduction;
- Finally, the construction of a Combined Heat and Power (CHP) plant—fueled by natural gas—will eliminate usage of fuel oil and propane. This will significantly reduce the facility's carbon emissions, reduce electricity costs by 50%, and improve electricity reliability.

These process improvements fundamentally reverse the conventional wisdom that superior environmental stewardship increases production costs. At the same time, we significantly distinguish ourselves from the Chinese rare earth industry that has been plagued by a history of significant environmental degradation, one that it is just beginning to recognize and rectify.

Need for Federal Leadership

Over the past year, I have spent a significant amount of time in Washington meeting with Members of Congress and their staffs as well as officials in a variety of Federal agencies to direct greater attention to this issue. I'm pleased to report, just over one year since we began our efforts, that the Federal Government is beginning to take meaningful steps toward understanding and addressing our rare earth vulnerabilities. The question remains, however, if it will be able to make its assessments, determine the required actions, and execute them within a timeline that seems to be accelerating daily.

In each of these meetings, and as this Committee has also inquired, I am asked what role the Federal Government should play in tackling this pressing concern, and I believe that there are 4 areas where it can have the greatest near- and long-term in impact: 1) federally based financing and/or loan guarantee support for highly capital intensive projects like ours; 2) assistance rebuilding America's rare earth knowledge infrastructure (university-based rare earth research, development of academic curricula and fields of study, training and exposure to the chemical and physical science related to rare earths, etc.); 3) increased interagency collaboration at the highest levels on the impact of rare earth accessibility on major national objectives; and 4) funding competitive grants for public and private sector rare earth research. I'll explore each in greater depth below:

- **Financing support:** Given the size, scale, ambition, and necessity of Molycorp's redevelopment efforts, we submitted an application for the Department of Energy's Loan Guarantee Program (LGP). We believed that the program was well-suited for our project, particularly given that the project's substantial implications closely match the program's paramount objectives. Traditional bank financing in the current climate—with very short repayment periods and interest rates near double digits—is not economically feasible. The LGP offers longer term financing and lower interest rates and would allow

Molycorp to accelerate development in the near-term while ensuring rare earth resource availability in the long term. However, the DOE summarily rejected our application in December, saying that the project did not qualify as a "New or Significantly Improved Technology." We reviewed the relevant portion of the Rule, Section 609.2, and our project meets every one of the stated criteria. We requested further discussion with the DOE to understand how it came to its conclusion and how Molycorp might proceed. After almost two months, the DOE finally responded to our request. During the meeting, the DOE contended that this project goes "too far upstream" and that the program was not intended to cover mining projects. We have yet to find the legislative or regulatory language that provides such a limitation. However, it appears we may need to ask Congress for legislative direction or possibly new legislative language specifically authorizing the use of loan guarantees for strategically important projects like this. Our frustrations with the loan guarantee notwithstanding, I still believe that this kind of financing support is exactly what a project like ours needs. We will be in a very strong position to both raise our portion of the capital to execute the project and repay the loan well-within the required timeline. We will continue to pursue this financing support despite the DOE's current position.

- **Rebuilding the rare earth knowledge infrastructure:** The United States used to be the world's preeminent source of rare earth information and expertise, but it has ceded that advantage over the past decade, as its position in the industry has become subordinate to China and other countries in East Asia. The Federal Government, and the House Science and Technology Committee in particular, can play a pivotal role in reestablishing that institutional knowledge and expertise and sharing it with a wider audience of researchers, scholars, and practitioners here in the U.S. and abroad. At Molycorp, we are fortunate to have a team of 17 rare earth researchers and technologists who are second to none in the world, but almost all of them had no previous expertise in rare earths prior to joining Molycorp. It will be difficult for the U.S. to reestablish its preeminence without a concerted effort to attract the brightest scientists and researchers to the field of rare earths. Rebuilding the knowledge infrastructure and the research support will go a long way toward that goal. Dr. Gschneidner, who I'm honored to testify with today, is regarded as the father of rare earths, and his work at Ames Laboratory and Iowa State University as well as the great work being done by Dr. Eggert and his colleagues at the Colorado School of Mines can serve as the foundation on which to expand America's rare earth expertise. As a reminder of the rest of the world's interests and actions in this regard, the Korea Times recently reported that Korea is developing rare earth metals for industrial use at a government-funded research center.
- **Interagency Cooperation:** Over the past several months, we have been very pleased to learn about efforts within many Federal agencies to direct specific attention to rare earth issues. We have been in direct contact with the Departments of Defense, Commerce, and State, and each is examining this issue within the unique context of their agencies' work. It is also worth noting that the Commerce Department convened a group of stakeholders from both the government and the private sector in December, 2009, which included representatives from DOD, GAO, USTR, and OSTP. We have also had multiple discussions with the Office of Science and Technology Policy directly and have been very appreciative of their engagement on this issue. In fact, OSTP, along with Commerce, is facilitating interagency collaboration going forward. While we are encouraged by these recent efforts, it is our hope that the agencies and the White House recognize that the global supply-demand challenges are approaching at an increasingly rapid pace and that their efforts should reflect the requisite urgency.
- **Funding support for rare earth research:** Part of China's success in growing and dominating the market for rare earths can be attributed to their efforts to find and commercialize new applications for rare earth materials. Federal funding support for competitive grants specifically directed at, rare earth research will help to expand the U.S.'s ability to do the same. This has the potential to broaden the economic impact of rare earths, and contribute to the goal mentioned above of reestablishing America's superior expertise in rare earth research.

Conclusion

The global rare earth supply concerns facing the U.S. and all other countries outside China are obviously disconcerting, but they are not insurmountable. A combination of geologic good fortune and an accelerated effort to ramp up domestic production and rebuild lost manufacturing capabilities could provide a solution for the U.S. and ensure that our leading national objectives are not jeopardized. At Molycorp, our "mining to magnets" strategy is far more than an approach to a new business, it is a cause with far reaching implications. If executed effectively, it could prove to be catalytic for our development of a clean energy economy and the resurgence of domestic manufacturing. This project will have meaningful and significant impact on leading national priorities, and as such, we stand ready to work with Congress and the Administration to find ways to accelerate our work at Mountain Pass and bring these needed capabilities online as soon as possible.

Thank you once again for the opportunity to share my perspective on rare earths, and I look forward to working with the Committee in the weeks and months to come as it continues to examine this important topic and determine potential actions.

The New York Times
September 1, 2009; pp. B1, B4

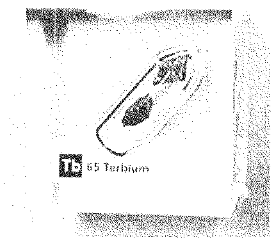
Business

China Tightens Grip on Rare Minerals

By KEITH BRADSHER

HONG KONG - China is set to tighten its hammerlock on the market for some of the world's most obscure but valuable minerals.

China currently accounts for 93 percent of production of so-called rare earth elements - and more than 99 percent of the output for two of these elements, dysprosium and terbium, vital for a wide range of green energy technologies and military applications like missiles.



Deng Xiaoping once observed that the Mideast had oil, but China had rare earth elements. As the Organization of the Petroleum Exporting Countries has done with oil, China is now starting to flex its muscle.

Even tighter limits on production and exports, part of a plan from the Ministry of Industry and Information Technology, would ensure China has the supply for its own technological and economic needs, and force more manufacturers to make their wares here in order to have access to the minerals.

In each of the last three years, China has reduced the amount of rare earths that can be exported. This year's export quotas are on track to be the smallest yet. But what is really starting to alarm Western governments and multinationals alike is the possibility that exports will be further restricted.

Chinese officials will almost certainly be pressed to address the issue at a conference Thursday in Beijing. What they say could influence whether Australian regulators next week approve a deal by a Chinese company to acquire a majority stake in Australia's main rare-earth mine.

The detention of executives from the British-Australian mining giant Rio Tinto has already increased tensions.

They sell for up to $300 a kilogram, or up to about $150 a pound for material like terbium, which is in particularly short supply. Dysprosium is $110 a kilo, or about $50 a pound. Less scare rare earth like neodymium sells for only a fraction of that.

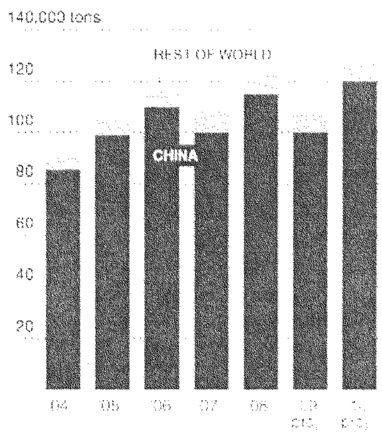
(They are considerably less expensive than precious metals because despite the names, they are found in much higher quantities and much greater concentrations than precious metal.)

China's Ministry of Industry and Information Technology has drafted a six-year plan for rare earth production and submitted it to the State Council, the equivalent of the cabinet, according to four mining industry officials who have discussed the plan with Chinese officials. A few, often contradictory, details of the plan have leaked out, but it appears to suggest tighter restrictions on exports, and strict curbs on environmentally damaging mines.

Rare Wealth

China accounts for the vast majority of the world's production of rare earths — 17 elements — which are used in a wide array of products.

RARE EARTH MINERAL PRODUCTION



Source: Dudley J. Kingsnorth (production)

RARE EARTHS	ATOMIC NO.	COMMERICAL USE
Scandium	21	Stadium lights
Yttrium	39	Lasers
Lanthanum	57	Electric car batteries
Cerium	58	Lens polishes
Praseodymium	59	Searchlights, aircraft parts
Neodymium	60	High-strength magnets
Promethium	61	Portable X-ray units
Samarium	62	Glass
Europium	63	Compact fluorescent bulbs
Gadolinium	64	Neutron radiography
Terbium	65	High-strength magnets
Dysprosium	66	High-strength magnets
Holmium	67	Glass tint
Erbium	68	Metal alloys
Thulium	69	Lasers
Ytterbium	70	Stainless steel
Lutetium	71	None

Beijing officials are forcing global manufacturers to move factories to China by limiting the availability of rare earths outside China. "Rare earth usage in China will be increasingly greater than exports," said Zhang Peichen, the deputy director of the government-linked Baotou Rare Earth Research Institute.

Some of the minerals crucial to green technologies are extracted in China using methods that inflict serious damage on the local environment. China dominates global rare earth production partly because of its willingness until now to tolerate highly polluting, low-cost mining.

The ministry did not respond to repeated requests for comment in the last eight days. Jia Yinsong, a director general at the ministry, is to speak about China's intentions Thursday at the Minor Metals and Rare Earths 2009 conference in Beijing.

Until spring, it seemed that China's stranglehold on production of rare earths might weaken in the next three years - two Australian mines are opening with combined production equal to a quarter of global output.

But both companies developing mines - Lynas Corporation and smaller rival, Arafura Resources - lost their financing last winter because of the global financial crisis. Buyers deserted Lynas's planned bond issue and Arafura's initial public offering.

Mining companies wholly owned by the Chinese government swooped in last spring with the cash needed to finish the construction of both companies' mines and ore processing factories. The Chinese companies reached agreements to buy 51.7 percent of Lynas and 25 percent of Arafura.

The Arafura deal has already been approved by Australian regulators and is subject to final approval by shareholders on Sept. 17. The regulators have postponed twice a decision on Lynas, and now face a deadline of next Monday to act.

Matthew James, an executive vice president of Lynas, said that the company's would-be acquirer had agreed not to direct the day-to-day operations of the company, but would have four seats on an eight-member board.

Expectations of tightening Chinese restrictions have produced a surge in the last two weeks in the share prices of the few non-Chinese producers that are publicly traded. In addition to the two Australian mines, Avalon Rare Metals of Toronto is trying to open a mine in northwest Canada, and Molycorp Minerals is trying to reopen a mine in Mountain Pass, Calif.

Unocal used to own the Mountain Pass mine, which suspended mining in 2002 because of weak demand and a delay in an environmental review. State-owned CNOOC of China almost acquired the mine in 2005 with its unsuccessful bid for Unocal, which was bought instead by Chevron; Chinese buyers tried to persuade Chevron to sell the mine to them in 2007, but Chevron sold it to Molycorp Minerals, a private American group.

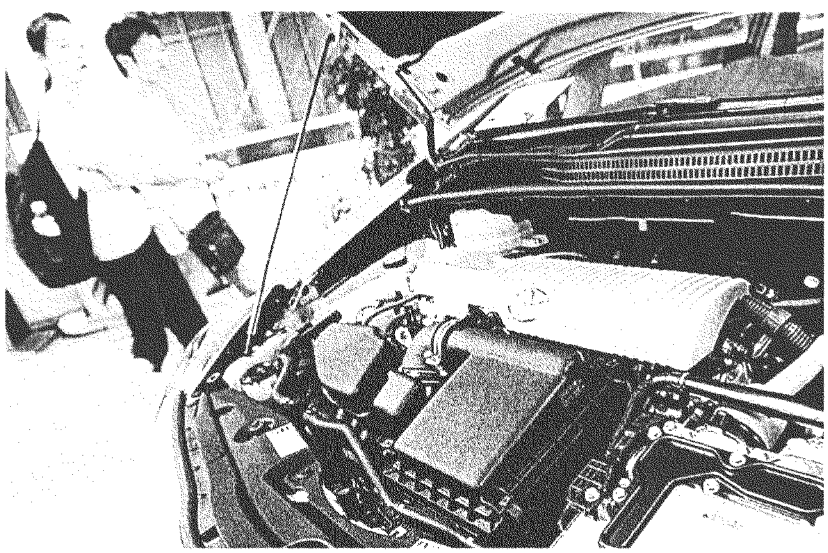
A single mine in Baotou, in China's Inner Mongolia, produces half of the world's rare earths. Much of the rest - particularly some of the rarest elements most needed for products from wind turbines to Prius cars - comes from small, often unlicensed mines in southern China.

China produces over 99 percent of dysprosium and terbium and 95 percent of neodymium. These are vital to many green energy technologies, including high-strength, lightweight magnets used in wind turbines, as well as military applications.

To get at the materials, powerful acid is pumped down bore holes. There it dissolves some of the rare earths, and the slurry is then pumped into leaky artificial ponds with earthen dams, according to mining specialists.

The Ministry of Industry and Information Technology has cut the country's target output from rare earth mines by 8.1 percent this year and is forcing mergers of mining companies in a bid to improve technical standards, according to the government-controlled China Mining Association, a government-led trade group.

General Motors and the United States Air Force played leading roles in the development of rare-earth magnets. The magnets are still used in the electric motors that control the guidance vanes on the sides of missiles, said Jack Lifton, a chemist who helped develop some of the early magnets.



But demand is surging now because of wind turbines and hybrid vehicles.

The electric motor in a Prius requires 2 to 4 pounds of neodymium, said Dudley Kingsnorth, a consultant in Perth, Australia, whose compilations of rare earth mining and trade are the industry's benchmark.

Mr. Lifton said that Toyota officials had expressed strong worry to him on Sunday about the availability of rare earths.

Toyota and General Motors, which plans to introduce the Chevrolet Volt next year with an electric motor that uses rare earths, both declined on Monday to comment.

Rick A. Lowden, a senior materials analyst at the Defense Department, told a Congressional subcommittee in July that his office was reviewing a growing number of questions about the availability of rare earths.

China is increasingly manufacturing high-performance electric motors, not just the magnets.

"The people who are making these products outside China are at a huge disadvantage, and that is why more and more of that manufacturing is moving to China," Mr. Kingsnorth said.

Correction: September 4, 2009

An article on Tuesday about China's tightening control over the production of rare earth minerals misidentified the country in which Avalon Rare Metals, a non-Chinese producer, was trying to open a new mine. It is Canada, in the northwest area, not Australia.

BIOGRAPHY FOR MARK A. SMITH

Mark A. Smith is Chief Executive Officer, member of the Board of Directors and a shareholder of Molycorp Minerals, LLC. Prior to Molycorp Minerals, Mr. Smith was the president and chief executive officer of Chevron Mining Inc. a wholly-owned subsidiary of Chevron Corporation. Mr. Smith was appointed President and Chief Executive Officer in April 2006. Chevron Mining Inc. operated five mines one of which was the Mountain Pass, CA Rare Earth mine.

Prior to this appointment, Mr. Smith was a vice president for Unocal Corporation, where he was responsible for managing the real estate, remediation and mining divisions. Mr. Smith worked for Unocal for over 22 years.

Mr. Smith received his Bachelor of Science degree in agricultural engineering from Colorado State University in 1981 and his Juris Doctor, *cum laude,* from Western State University, College of Law, in 1990. He is a registered professional engineer and an active member of the State Bar of California and Colorado. Mr. Smith and his wife live in Denver, Colorado.

Chairman MILLER. Thank you, Mr. Smith. Dr. Broun and I are worried what percentage of rare earths the Chinese will control by——

Mr. SMITH. It is growing every day.

Chairman MILLER. —the end of the hearing.

Mr. SMITH. 97.3 to be precise.

Chairman MILLER. Mr. Stewart for five minutes.

STATEMENT OF MR. TERENCE STEWART, ESQ., MANAGING PARTNER, STEWART AND STEWART

Mr. STEWART. Mr. Chairman, members of the Subcommittee, good afternoon. China's policy on rare earth minerals is similar to that nation's actions on a large number of other raw materials. The general goals seem to be reducing availability of supply for global customers as well as making foreign purchases more expensive through the imposition of export duties, export licenses and other trade-impeding measures. China's policy encourages foreign investors to move production and investment to China and ensures low price supplies for targeted rapid-growth sectors within China.

Last year the United States filed a WTO case against China's export restraints on numerous raw materials critical to U.S. manufacturers and workers. The raw materials subject to export restraints are used in some of the key industries identified in China's industrial policies such as steel, aluminum and chemicals. China's most recent 5-year plan, which goes through 2010, continues to focus development in certain strategic sectors and to ensure a leading role for state-owned enterprises in many of those sectors.

Recently the European Chamber in China reviewed the massive problems of overcapacity in a number of important industries in China including steel, aluminum, cement, chemicals, oil refining, wind power equipment, shipbuilding, flat glass and photovoltaics. This overcapacity, coupled with export restraints on key raw materials, effectively shifts the burden of adjusting global excess capacity from China to trading partners by limiting access to affordably priced key raw materials. Moreover, limiting access to key raw materials can be used to force investment within China.

According to the 2009 U.S.-China Economic and Security Review Commission in an annual report to Congress, China is targeting rare earth dependent components of key strategic industries for production within China including many of the green technologies reviewed earlier. China is attempting to make significant cuts to rare earth exports through a combination of export duties and export quotas. These actions are intended to raise prices outside of China, and in an indication that commissions reach the common number, they found that China currently produces 93 percent of rare earth minerals, somewhere between 90 and 97——

Chairman MILLER. The trend is heading in the right direction now.

Mr. STEWART. China's export restraints have understandably caused concern in many countries, including our own.

So what can be done? First and foremost, the United States and its trading partners should bring a second trade action against China on the range of export restraints being imposed on rare earth minerals. Such restraints are in clear violation of obligations that China undertook to become a member of the World Trade Organization in 2001. At that time, China agreed to limit the use of export taxes to 84 product categories, none of which included rare earth minerals. In 2010, China is imposing export taxes not on 84 products, but on 329 product categories including 23 rare earth mineral categories, a plain violation of their commitments.

On the domestic front, it is my understanding that both the government and the private sector are taking actions to understand the nature of the potential problems as well as looking for alternative sources of supply. For example, the National Defense Authorization Act for Fiscal Year 2010[7] requires the Comptroller General to deliver a report by this April 1st on rare earth materials in the defense supply chain.[8] Obviously, understanding the national security implications of Chinese rare earth policies is critical.

The Chairman and Members of this Subcommittee might want to advocate creation of a similar report for the civilian sector to help Members of Congress understand the challenges facing the American economy from the current reliance on China's supply and what legislative approaches might be pursued to safeguard our commercial as well as our military interests.

A positive trend in recent years has been renewed interest in developing rare earth mineral resources outside of China including in North America, obviously the Molycorp example being one of the key elements. Reports are encouraging, although cost structures with environmental needs versus China remain important challenges. The Government through the Committee on Foreign Investment in the United States must help ensure that mines in the United States are not purchased by foreign interests whose governments have limited supply to U.S. users and that any new mines receive priority attention in terms of various government licenses and reviews.

Finally, the USGS indicates that for most rare earth minerals there are substitute products available, although known substitutes are less effective currently than the rare earth minerals themselves. The United States Government can support efforts to develop alternative solutions to current rare earth needs, both through publicly financed research and through tax policies and other actions to support private sector research.

Thank you very much.

[The prepared statement of Mr. Stewart follows:]

PREPARED STATEMENT OF TERENCE STEWART

Mr. Chairman and members of the Subcommittee. Good afternoon. I am pleased to appear this afternoon as part of your hearing on rare earth minerals and 21st century industry to try to address three questions that I understand are of interest to the Subcommittee:

1. How do Chinese actions in the rare earths sector fit into China's policies on strategic industries and economic development?
2. Are there policies that the Federal Government can adopt, or strategies that the U.S. private sector can adopt, that can help assure a consistent and sustainable domestic supply of economically and militarily critical materials such as rare earths?
3. Are there policies that the Federal Government can adopt, or strategies that the U.S. private sector can adopt, that would support firms dependent on rare earth elements to retain their manufacturing capacity in the U.S.?

Let me start with some acknowledgments on my limitations as a witness on rare earth minerals. First, my background and expertise is on international trade law matters, including the World Trade Organization, and manufacturing competitiveness issues. Others on the panel today are the experts on minerals in general or rare earth minerals policies.

[7] Public Law 118–84; enacted October 28, 2009. The study was authorized in Section 843.
[8] See GAO Report GAO–10–617R (April 14, 2010).

Our firm, over the years, has looked at many aspects of the U.S.-China relationship and has prepared for the U.S.-China Economic and Security Review Commission various studies looking at the trade and manufacturing impacts of China's practices. For example, on March 24, 2009 I testified at a hearing before the Commission on "China's Industrial Policy and its Impact on U.S. Companies, Workers and the American Economy."

Rare earths are not part of the current WTO challenges brought by the U.S., the EU and Mexico of China's export restraints on various materials. (see WT/DS394/1, China—Measures Related to the Exportation of Various Raw Materials, request for consultations by the United States) Purchasers of rare earths are concerned about similar types of restraints imposed by China on rare earth minerals and that there have been discussions by the U.S. with key allies about a possible future case. *Inside U.S.-China Trade,* October 21, 2009, "U.S. and Allies Discuss Rare Earth Metals Action at WTO."

Now let me turn to the questions of interest to the Subcommittee.

China's Actions on Rare Earth Minerals

What China is doing on rare earth minerals mirrors what it is doing on a large number of other raw materials: reducing availability of supply for global customers and/or making purchases more expensive through the imposition of export duties, export licenses, etc. The objective can be to encourage foreign investors to move investment to China to produce downstream products in the Middle Kingdom versus overseas, or to ensure low priced supplies for sectors in China targeted for rapid industrial growth.

China's most recent five-year plan (covering 2006–10) continues to focus development in certain sectors and to ensure a leading role for state-owned enterprises ("SOEs") in certain sectors.

Specific guidance regarding SOEs was provided in December 2006 by the National Development and Reform Commission (NDRC) when it issued a guiding opinion on state-owned assets restructuring. The opinion states that SASAC's state-owned assets should concentrate on "important industries and key areas" (i.e., strategic industries). The opinion then explained that the "important industry and key areas" shall "mainly include industries that involve national security, large and important infrastructures, important mineral resources, important public utilities and public services, and key enterprises in the pillar industries and high-tech industries."

Seven important industries and key areas were identified: defense, electric power and grid, petroleum and petrochemical, telecommunications, coal, civil aviation, and shipping. Basic and pillar industries where the state would also maintain an important role included equipment manufacturing, auto, information technology, construction, iron and steel, non-ferrous metals, chemicals, and surveying and design.

The counterpart to rapid development of key industries is maintaining low prices and ready availability of key raw materials. Not surprisingly, the cases filed by the US, the EU and Mexico against Chinese export restraints on certain raw materials involve raw materials used in some of the key industries identified in China's industrial policies—steel, aluminum and chemicals. As the USTR press release of November 28, 2009, announcing the panel request against China indicated, "The materials at issue are: bauxite, coke, fluorspar, magnesium, manganese, silicon metal, silicon carbide, yellow phosphorus and zinc, key inputs for numerous downstream products in the steel, aluminum and chemical sectors across the globe."

A corollary to keeping prices at home low is the ability to force trading partners to shutter capacity in downstream industries. For example, a study came out in December 2009, published by the European Chamber, entitled "Overcapacity in China: Causes, Impacts and Recommendations." *http://www.europeanchamber.com.cn/view/static/?sid=6388.* The European Chamber in China reviewed the massive problems of overcapacity in a number of important industries including steel, aluminum, cement, chemicals, refining, wind power equipment, ship building, flat glass, and photovoltaics. While the causes of overcapacity in China are varied as reviewed in the study, when coupled with export restraints on key raw materials, China can apply pressure on trading partners to make the adjustments for excess capacity created in China by limiting access at affordable prices to key raw materials or preempting development of key new technologies in the U.S. and elsewhere.

And control of key raw materials can be used to attract foreign investment by limiting access to such materials to those with a local presence. As discussed on one Web site, China is apparently offering to give ample supplies of rare earth minerals to companies that invest in China, even as China moves to limit or eliminate availability of product for export.

> Chinese officials have made it very clear: If foreign manufacturing companies move their facilities to China, they will be guaranteed a steady supply of rare earths. Many technology companies are reluctant to do this because they want to protect their intellectual property, but will the temptation of an endless REE supply be too much? Companies continue to move operations to China, but the tension still exists.

Clint Cox, The Anchor House, Inc. (Research on Rare Earth Elements), December 17, 2009, *http://theanchorhouse.com* (page 5).

When one looks at China, one sees all of the effects and/or purposes behind the wide ranging export restraints applied to rare earths and other materials. A series of articles in the last four months of 2009 reflects a range of concerns and purposes behind the draft "2009–2015 Rare Earth Industry Development Plan" from the Ministry of Industry and Information Technology:

> [A]s early as 1998, China has started to limit the export quantities of rare earth products, and implemented the differentiating principle of "forbid, encourage, and restrict:" forbid the export of rare earth raw materials; restrict oxides and metals by using export quota; encourage downstream rare earth products, such as high value-added products like magnetic materials and fluorescent powder.

However, under the increasing global demand and China's increasingly reduced number of eligible export companies and export quotas, some companies with large quotas started to sell their quotas illegally. In addition, some developed countries' companies started to invest and establish factories in tungsten, antimony, and other rare earth reserves areas, bought large quantities of raw materials, processed them simply before shipping them overseas for further processing or storage, thereby effectively evaded China's export control. From 1990 to 2008, China's rare earth export grew almost 10 times, but the average export price has lowered to about 60% of the original price.

All these demonstrate that China's rare earth industry has three serious problems: overcapacity, disorderly competition, and cheap export on a large scale. It is of great urgency that we protect our rare earth resources and establish our reserve system.

MIIT's 2009–2015 Plan aims to macro-manage the rare earth industry, strengthen the control of strategic resources, and strictly control production capacity, by both administrative and market means. In the next six years, no new rare earth mining penult will be approved, separation of newly formed rare earth smelting companies will be strictly reviewed, and existing rare earth companies will be eliminated [by judging their performance] in the three areas of technology and equipment, environmental protection, and management.

At the same time, industry access standards will be higher, elimination of outdated capacity will be accelerated through "shut down, pause, merger, transfer." Promote merger and reorganization of companies, strengthen and enlarge rare earth industry, form leading rare earth companies, establish a "China Rare Earth OPEC," form companies with absolute dominating power in the market so that China can be the leader in controlling international market price.

Of course, to accomplish this, merely depending on controlling resources and export is not enough. More importantly, we must grasp rare earth core technology patents, rare earth application market, rare earth products standards. Therefore, we must start from the technology innovation, invest more in technology, and at the same time value intellectual property, implement IP strategies, and seize the commanding ground of technology. Break out of the technology restrictions of foreign-invested enterprises, and establish our own rare earth "high-way" industry chain.

"2009–15 Rare Earth Industry Development Plan" Has Been Passed, Hardware Business Web site (an electronic business Web site formed by Wenzhou Shengqi Internet Technology, Co., Ltd.), November 6, 2009 (unofficial translation).

China is attempting to make significant cuts to both rare earth exports. China has implemented its program to limit foreign availability of rare earths through a combination of both export duties and export quotas. These actions will raise prices outside of China by curtailing supplies and by raising import prices (with all relevant taxes or duties).

> The quota for rare earth materials was 31,300 MTs in 2009, down 8.33% from 2008. This is the fifth year since China started decreasing its rare earth export.
>
> As a corresponding policy to the annual 35,000 MTs quota from 2009 to 2015 proposed by MIIT, China will restrict its mineral annual production to 130,000 to 170,000 MTs and its rare earth smelting products' production to 120,000 to 150,000 MTs from 2009 to 2015.

"2009–15 Rare Earth Industry Development Plan," China Suppliers' Web site (under the guidance of State Council Information Office, Internet Promotion Division; MOFCOM Department of Market Operation Regulation; National Development and Reform Commission, International Cooperation Center), September 4, 2009 (unofficial translation).

For 2010, the Chinese export duty and quota programs are reviewed in a series of documents issued in late 2009.

Included as Exhibit 1 to this testimony is an unofficial translation of the export duty rate chart for 2010, which is an attachment to a notice titled "State Council Customs Tariff Commission's Notice on the Implementation of the 2010 Tariff Schedule," Customs Tariff Commission Pub. [2009] No. 28, December 8, 2009. The exhibit shows export duties being assessed on 329 products in 2010 including many rare earth items (e.g., items 47, 89–92, 122–139 (export duties of 10–25%)).

Exhibit 2 to this testimony is an unofficial translation to the Ministry of Commerce of the People's Republic of China (MOFCOM) Trade Letter [2009] No. 147, December 29, 2009, "2010 1st Batch Export Quota Distribution for Rare-Earth Materials in General Trade." The total quota for the "1st batch" is 16,304 MT, with allocations given to twenty-two companies. A month and a half earlier, MOFCOM had published "Notice on Application Criteria and Procedures for 2010 Rare-Earth Materials Export Quota." MOFCOM Pub. [2009] No. 94, November 6, 2009. An unofficial translation is included as Exhibit 3.

The U.S.-China Economic and Security Review Commission (USCC) has done great work summarizing the general problem of export restrictions found in China as well as the USCC's understanding of how this problem plays out with rare earths. I have quoted the USCC at length because nobody has synthesized this data better. A complete excerpt of the USCC's views from its 2009 Report to Congress is available in Exhibit 4.

Regarding China's general export restrictions, the USCC states in its 2009 Report to Congress,

> Export restrictions or export quotas, especially on energy and raw materials, have two general effects: First, they suppress prices in the domestic market for these goods, which lowers production costs for industries that use the export-restricted materials; and second, these restrictions increase the world price for the raw materials that are affected by limiting the world supply, thereby raising production costs in competing countries.

U.S.-China Economic and Security Review Commission (USCC) 2009 Report to Congress, at 62. Available at *http://www.uscc.gov/annual_report/2009/annual_report_full 09.pdf.*

While specifically addressing China's restrictions on the export of rare earth minerals, the USCC notes,

> China appears to be tightening its control over the supply of rare earth elements, valuable minerals that are used prominently in the production of such high-technology goods as flat panel screens and cell phones, and crucial green technologies such as hybrid car batteries and the special magnets used in wind turbines. USCC 2009 Report to Congress, at 63.

This reduction in supply by China is problematic because, according to the USCC, "China accounts for the vast majority—93 percent—of the world's production of rare earth minerals, and for the last three years it has been reducing the amount that can be exported." 2009 Report to Congress, at 63. China admits that rare earth elements are "the most important resource for Inner Mongolia," which contains 75 percent of China's deposits. *Id.* Accordingly, the USCC cautions that by limiting exports and controlling production, the Chinese government is attempting to "consolidate its rare earths industry, with the aim of creating a consortium of miners and processors in Inner Mongolia." *Id.* And according to the USCC, these tighter limits on exports of rare earths will place foreign manufacturers at a disadvantage compared to the domestic producers, whose access will not be so restricted. *Id.*

Policies and Solutions for Government and Private Sector Consideration

First and foremost, the U.S. and its trading partners should be considering a second trade action against China on the range of export restraints being imposed on rare earths (and possibly other products). The U.S. and others were concerned about China's use of export restrictions during China's negotiations for accession to the World Trade Organization. China agreed to limit the use of export taxes to 84 product categories (none of which included rare earth items) at rates no higher than included in Annex 6 of the Protocol of Accession. The fact that in 2010 China has imposed export taxes on 329 product categories, including twenty-three rare earth categories, creates a strong case of violation by China on the export taxes alone. Other violations from the use of export quotas are likely as well. Hopefully, Congressional interest will help move the Administration towards a second case on an expedited basis.

On the domestic front, it is my understanding that both the government and the private sector are taking actions to understand the nature of the potential problems as well as looking for alternative sources of supply.

For example, it is my understanding that the National Defense Authorization Act for Fiscal Year 2010, Public Law 111–84, requires the Comptroller General to deliver a report to the House and Senate Committees on Armed Services by April 1st this year on "rare earth materials in the defense supply chain." Section 843, 50 USC app. 2093 note. The nature of the report suggests that it is likely to provide important options that should be considered by the Government to safeguard the military needs of the country moving forward in this area. Section 843(b) is reprinted below:

> (b) Matters Addressed.—The report required by subsection (a) shall address at a minimum, the following:
>
> (1) An analysis of the current and projected domestic and worldwide availability of rare earths for use in defense systems, including an analysis of projected availability of these materials in the export market.
>
> (2) An analysis of actions or events outside the control of the Government of the United States that could restrict the access of the Department of Defense to rare earth materials, such as past procurements and attempted procurements of rare earth mines and mineral rights.
>
> (3) A determination as to which defense systems are currently dependent on, or projected to become dependent on, rare earth materials, particularly neodymium iron boron magnets, whose supply could be restricted
>
> (A) by actions or events identified pursuant to paragraph (2); or
>
> (B) by other actions or events outside the control of the Government of the United States.
>
> (4) The risk to national security, if any, of the dependencies (current or projected) identified pursuant to paragraph (3).
>
> (5) Any steps that the Department of Defense has taken or is planning to take to address any such risk to national security.
>
> (6) Such recommendations for further action to address the matters covered by the report as the Comptroller General considers appropriate.

Historically, the U.S. maintained a strategic stockpile of critical materials for national defense. Presumably, one of the issues that will be addressed in the report is the extent to which stockpiling rare earth materials is appropriate or feasible.

The Chairman and Members of this Subcommittee might want to advocate creation of a similar report for the civilian sector. Such a report would obviously be helpful to Members of Congress in understanding the challenges facing the American economy from the current reliance on China as the source of supply and what legislative approaches might be pursued to safeguard our commercial and military interests.

Press accounts suggest that in recent years there has been renewed interest in developing rare earth mineral resources outside of China and that several mines are in the process of being reactivated or developed. See, e.g., "New USGS Rare Earth Report Includes Thorium Energy, Inc.," Earth Times, Oct. 8, 2009; *http://www.earthtimes.org/articles/show/new-usgs-rare-earth-report-includes-thorium-energy-inc,991131.shtml;* "Canadian firms set up search for rare-earth metals," New York Times, Sept. 9, 2009, *http://www.nytimes.com/2009/09/10/business/global/10mineral.html?r=1&scp=10&sq=br*

Possible American sources of rare-earths include a separation plant at Mount Pass, CA. Bastnasite concentrates and other rare-earth intermediates and refined products continue to be sold from mine stocks at Mountain Pass. Exploration for rare earths continued in 2009; however, global economic conditions were not as favorable as in early 2008. Economic assessments continued at Bear Lodge in Wyoming; Diamond Creek in Idaho; Elk Creek in Nebraska; and Lemhi Pass in Idaho-Montana.

Thus, government and the private sector may have additional sources of supply of rare earths beyond China, although the challenge may be overall cost of supply, particularly in countries like the U.S. or Canada where environmental needs are more likely to be addressed at present than in China.

Presumably, the government, under CFIUS, can help ensure that mines in the U.S. are not purchased by foreign interests whose governments have limited supply to U.S. users and that new mines receive priority attention in terms of various government licenses and reviews.

I note that the Senate Committee on Energy and Natural Resources held a hearing last summer on mining law reform. The hearing had a number of witnesses who talked about the ability to improve the U.S. ability to supply more of its rare earth mineral needs and what challenges they faced based on various pending bills. Mining Law Reform, S. Hrg. 111–116, 111th Cong., 1st Sess. (July 14, 2009)(S. 796; S. 140). Certainly, the Congress will want to be sure that any legislation balances our needs for access to critical raw materials with the other concerns prompting legislative modifications.

Finally, the USGS indicates that for most rare earth minerals there are substitute products available, although known substitutes are less effective than the rare earth minerals. The U.S. government can support research efforts into the development of alternative solutions to current rare earth needs both directly through basic and applied research and through tax policies and other actions to support private sector research.

Thank you for the opportunity to appear today. I would be pleased to respond to any questions.

Biography for Terence Stewart

Terry Stewart is the Managing Partner of Stewart and Stewart. Mr. Stewart's practice focuses on international trade matters (litigation, negotiations, policy) and customs law. He has worked with various U.S. industries and labor unions to solve trade matters in the U.S. and abroad, including representing agricultural, industrial and services groups. He is a currently a member of the Advisory Council to the U.S. Court of Appeals for the Federal Circuit and a member of the Steering Group of the International Trade Committee of the American Bar Association's International Law Section. Mr. Stewart is one of America's leading academic experts on the WTO system and has advised several governments on their WTO accession processes.

In recent years, Mr. Stewart has written extensively on trade relations with the People's Republic of China, including volumes on the WTO accession commitments undertaken and progress made in meeting those commitments over time, a review of intellectual property protection within China and steps being taken to address problems in enforcement, and reports on subsidies provided to major sectors of the Chinese economy.

Mr. Stewart is the editor of the 2009 book, *Opportunities and Obligations: New Perspectives on Global and U.S. Trade Policy;* and author and editor of numerous other publications. Previously, he was best known for editing a four-volume treatise on *The GATT Uruguay Round: A Negotiating History (1986–92)(Vols. I–III); and The End Game (Vol. IV)* published in July 1996 by the American Bar Association.

Mr. Stewart is an adjunct professor at Georgetown University Law Center where he currently teaches a graduate seminar on the WTO. He received his law degree from Georgetown University, his masters in Business Administration from Harvard University, and his bachelors from the College of the Holy Cross.

Chairman Miller. Thank you, Mr. Stewart. At this point we will begin our first round of questions. Typically I would recognize myself, but I would be happy to recognize—well, I will do what is typical then. I will recognize myself for five minutes.

Early Warning for Material Supply Problems

The questions are probably somewhat redundant to your oral testimony, but we did pass a law 30 years ago that called upon the President to establish early warning systems for material supply problems. That didn't work. That is why we are having this hearing today. What would have been needed to warn us about the problems that we have with rare earth, with the Chinese controlling 90, 93, 95, 97, way too much of the earth's supply, at least commercially available rare earths? And how do we keep everyone interested in the materials issues when there ceases to be a crisis? That is sort of a problem with Congress. There is either complete inactivity or frenzy, with little in between. How can we keep our attention on the need for the necessary supply of rare earths? Any of you may begin. Mr. Smith?

Mr. SMITH. Thank you, Mr. Chairman. I think that the answer rests in the ability to look at things from a full supply chain concept. It is very difficult to talk to people about rare earths in the world today. We go and talk to defense contractors that work for the Department of Defense, and sometimes we have to go down nine different tiers before we find the party that actually purchases the rare earths. So I don't think that anybody has done anything intentionally here, but these things are very ubiquitous, they only use very, very small quantities, and I think we have to continue to look at things on a full supply chain basis, not on an element-by-element basis.

Chairman MILLER. Dr. Freiman?

Dr. FREIMAN. We argued, in the report that I spoke to, that one of the things that was needed—and I spoke to it when you saw the diagram—that what is needed is up-to-date data that we can rely on. As you hear, technology moves quickly and changes in availability move quickly as well. And we felt that what was needed was an agency which had the autonomy and the authority to collect the necessary data, rapidly, and to disperse that to the people who need it so that you could keep up-to-date on what was really the situation with respect to not just rare earths but, in our case, many of the critical minerals.

Chairman MILLER. Dr. Duclos?

Dr. DUCLOS. I would certainly agree with that, and as I said in my verbal testimony, you know, appointing a lead agency that is able to do that assessment is absolutely critical—but recognize that the assessment itself is just a very start and represents a relatively small part of actually solving the problem, which will involve bringing in the research into the various areas that I describe in my verbal testimony.

The issue with the rare earths came on very gradually through the '90s, systematically but gradually, and I think without an agency assessing these things quantitatively over time, you won't see these gradual increases in the crisis level unless you do that.

Chairman MILLER. Anyone else? Dr. Gschneidner?

Dr. GSCHNEIDNER. I would just sort of like to recite a little bit of history concerning Magnequench—which was established by General Motors, of course, to make motors for the magnets and so forth. Eventually, the Chinese bought a good percentage of that, and they didn't think too much about it. Then as they got a higher percentage of it, the union in Anderson, Indiana, said that they were opposed to this thing. The Chinese said, well, we won't move the factory out of Anderson for five years. Well, when the fifth year came up, right at the end of the time, they moved everything, lock, stock and barrel, out of Anderson, Indiana. So we lost lots of jobs. And the reason why I know that is a number of my students and post-docs have worked there at Magnequench. And so we know what happened to that, and I think the government probably should have interfered and said, no, we are not going to allow you to sell the whole thing. But again, it is the same thing as the other gentleman made. How do you get the warning signal out to the government to stop this sort of action?

HOW TO COMPETE WITH CHINA

Chairman MILLER. Thank you, Dr. Gschneidner. Mr. Smith, Molycorp has to compete in a market economy. China doesn't play by those rules and are quite willing to subsidize, provide funds, to develop, to mine, to make commercially available rare earth minerals to gain a strategic advantage. Is being in a subsidy war the only response that we have to the way China plays?

Mr. SMITH. Absolutely not, Mr. Chairman. I think our best attack is actually technology. Molycorp sat for about ten years when the Chinese came in and flooded the United States' rare earth markets with lots of product and low prices. We sat there for about ten years and whined and cried about the low wages that the Chinese had to pay, et cetera. We finally got over that, and we used our own American ingenuity to figure out process technologies that drastically cut our costs in producing these materials, and we feel that with these new technologies, we can in fact be the lowest-cost producer in the world. But we do need help in that regard. I have 17 scientists and engineers that are competing with over 6,000 Chinese scientists, and I can't find any students from any university in the United States that have any rare earth experience or curricula today.

Chairman MILLER. My time is expired, and I recognize Dr. Broun for five minutes.

PRIORITIZING RESPONSES TO SHORTAGE

Mr. BROUN. Thank you, Mr. Chairman. Today's testimony highlighted several themes for rare earth research and development. We have heard about the need to reconstitute our Nation's rare earth knowledge base and infrastructure. Witnesses have highlighted the need to find new applications and uses for rare earths as well as identifying efficiencies in its production.

We have also heard of the need to find substitutes and technologies that greatly reduce the use of rare earths. We probably won't all agree on how to prioritize these topics as I doubt Mr. Smith will want to focus on eliminating the need for a product that his company has invested hundreds of millions of dollars in developing. Understanding that you may disagree, how would you prioritize these topics and are there any additional areas of focus you would suggest? We will start here and go down. Dr. Freiman?

Dr. FREIMAN. Well, I think prioritizing is quite difficult, and I won't attempt to do that. But one of the main outcomes of our committee was a recognition that what we can do in helping not just rare earth but other critical minerals is, as I mentioned earlier, is to know well in advance what the change in the availability will be, and I think that is a critical point.

We also emphasized the need for more research and development and more coordination between agencies in what is going on so we understand what each other is doing. As most of you know, there was this coordination present, certainly I know in the materials area, for many years and it sort of has disappeared at the OSTP level. And putting that back together again and developing that kind of agency coordination in research and development, certainly in rare earths, and we hear that that is starting to go on now, but in other critical minerals I think is an important factor.

Dr. DUCLOS. I would like to point out that there are 17 rare earths in the periodic table, and each one of its applications is different. And the solution will be different for each one of the 17. And with that in mind, that is why we recommend the five solutions, going from certainly developing new sources, all the way to developing technologies that eliminate the use. It will be different, and we have seen within GE on materials not necessarily dealing with rare earths but other rare elements.

They have to take a number of the solutions in order to make it all work. So I don't think there is a single answer to the question except that all five of these areas of work are absolutely needed.

Mr. BROUN. Anybody else? Mr. Smith?

Mr. SMITH. Thank you. I would concur with Dr. Duclos. I think that we have to balance the many needs of the rare earth world, and we are not adverse to finding substitutes for rare earths, either, contrary to what may seem quite obvious.

But on the other hand, I can use the rare earth magnets as an example. The permanent rare earth magnets, the neodymium-iron-boron type, have been around for well over 20, close to 30 years now. We have been researching for this entire time for a substitute for those magnets, and we haven't found one yet. But that doesn't mean that we should stop. The problem we have in between is that we have got about a two- or three-year window here before a major supply gap occurs between what China can supply to the rest of the world and what the rest of the world needs for their own needs. And we need to prioritize that right now as an immediate need that we have to address because the research will take a lot of time. But we certainly advocate research on all aspects, including replacement.

Mr. BROUN. Mr. Stewart, quickly. I have about run out of time. I have another question or two I want to ask.

Mr. STEWART. Just very quickly, while I support those positions, the WTO process is about a two-year process and should get started immediately to get our trading partners to honor the commitments that they have made as well.

ROLE OF FEDERAL AGENCIES

Mr. BROUN. OK. Thank you so much. Dr. Freiman pointed out in his testimony that the Federal Government should enhance the types of data and information it collects, disseminates, and analyzes on minerals and on mineral products. His committee also suggested the Energy Information Administration as a model. What agency or office should be tasked with that responsibility, Dr. Freiman?

Dr. FREIMAN. I would point out we chose not to select an agency. We didn't feel that was our business.

Mr. BROUN. No recommendation whatsoever?

Dr. FREIMAN. No. No. We pointed out that whoever was chosen, they need to have enough authority to be able to demand that they could collect the kind of data and information they need in a timely manner.

Mr. BROUN. Anybody else want to suggest an agency?

Dr. GSCHNEIDNER. I would suggest the United States Geological Service. They have done an outstanding job for the last 20 years of pointing out this problem, with rare earths in particular, and I think what we need to do is to figure out how to communicate their results better amongst all the parties.

Mr. BROUN. Thank you. Mr. Chairman, my time is expired. I yield back.

Chairman MILLER. And now the regular order, the Full Committee Chairman, Mr. Gordon, for five minutes.

Mr. GORDON. Thank you, Mr. Miller. You know, it is somewhat rare also that Mr. Miller and Dr. Broun can be in such strong agreement, so I think that we are onto something here and I want to thank the committee for being here. As Mr. Smith pointed out, this is the first of these type of hearings, and hopefully this will pull back the curtain.

Now, in this committee, we don't have jurisdiction on WTO and some tax benefits and that sort of thing. So I want to try to bring this discussion back to what we can do here, and listening to you, it seems that we should appoint or anoint a lead agency to try to collect and assess data. We need to have some type of research. Although you didn't say it, I would say also workforce in terms of potentially through the National Science Foundation having fellowships and grants for those students that would go into the rare research area.

And so I want to get your suggestions on what else within our sort of jurisdiction, which is the research and deployment, what public/private role should be played, and when it comes to research, is a research center adequate or do you have more than one for more different elements or do we parcel this around to various universities? How should we approach that? And I will open it up for the field.

Dr. DUCLOS. One area that this agency could do is actually collect sensitive information. I think you can imagine, for a corporation that has challenges in these areas, it is not exactly something that we talk about publicly, and therefore the data collection can be done, for example, by an agency in confidence and then can use that data to help prioritize the materials that need immediate attention. And so long as that can lead to—as I said, the assessing of the situation is just the first part.

Mr. GORDON. Well, it seems to me if you are collecting data and trying to determine what is immediate need, you are ten years behind.

Dr. DUCLOS. You know, what you can do, and in fact this is what we do, we use this criticality diagram matrix that Dr. Freiman discussed to quantify where the elements are on this table, and then we do that annually, OK? So we can see them moving around. We can tell generally which direction the elements are going and have some hope of seeing it a little bit in advance what the——

IMPROVING RESEARCH INFRASTRUCTURE

Mr. GORDON. Let me go back in terms of research. Would we want a single research center? Is there already something at NIST or elsewhere that we would build upon? Do we need to have multiple? Do we need to make this university based and what is the private/public sector partnerships? What should there be there?

Dr. GSCHNEIDNER. I would like to address that question. First of all, I don't think you want to spread it out too far because things you have criticality as far as people, groups, and so forth and I think advocate a strong center which can then tie together research that is being carried out at other places and so forth, and I think a university is a good place to start because you can be training students which will go into industry eventually and help them out.

I think one thing you don't want to do is divide the rare earth, the 17 elements, into 17 research centers. Even though they may be somewhat different, there is a lot of commonality in there which can be used. I mentioned earlier today that neodymium-iron-boron magnet here using a new process which is very energy efficient in green technology. We have also just made last week, made the measurements on a lanthanum-nickel hydride battery material which is very competitive with what you can get from industry. So what we learned there applies to some of the other elements.

So I think a strong center, and it should be well-funded because if you underfund it, it is not going to do the job you want it to do.

Mr. GORDON. And is there an existing place? Is there an existing Federal agency again like NIST or a national lab that would be a lead agency here?

Dr. GSCHNEIDNER. Well, one possibility of course is the Department of Energy because they have already funding—and that is a critical need in this country, and possibly the military would be another place to fund such a center.

Mr. GORDON. Thank you. I am sorry. We have got a vote on again.

Chairman MILLER. OK. In our regular order, Ms. Dahlkemper is recognized for five minutes.

FUNDING FOR RARE EARTH RESEARCH

Ms. DAHLKEMPER. Thank you, Mr. Chairman, and thank you to the witnesses for being here today. A very interesting topic of discussion.

I want to just kind of go on with the Chairman's discussion here, Dr. Gschneidner. Right now your laboratory is being funded by the DOE. Where else is the DOE funding this kind of research in this country?

Dr. GSCHNEIDNER. Well, a smattering of things at Oak Ridge, at Los Alamos. There is some up in Hanford up in there. There is also Argonne. You know, there are specialized areas or research where people are doing this. But there is really—I mean, we are the most coherent laboratory devoted to rare earth materials, but there is a lot of research being carried out. And also they fund a number of universities. But it is usually one or two groups at a university. It is very small. It is not critical——

Ms. DAHLKEMPER. So of the percentage of their dollars going to this, how much of it would be going to your lab, do you think? Do you have any idea? Coming out of DOE.

Dr. GSCHNEIDNER. From all of DOE? Well, I will talk from basically——

Ms. DAHLKEMPER. You said you are the most concentrated.

Dr. GSCHNEIDNER. Well, our laboratory gets about $16 million. Maybe 25 percent of that might go into rare earth materials, different people in the laboratory, something like that.

Ms. DAHLKEMPER. Do you think the research is adequate for what we need to do in terms of energy and——

Dr. GSCHNEIDNER. No.

Ms. DAHLKEMPER. Can you give me any idea by how much more we would need? Do you have any——

Dr. GSCHNEIDNER. Well, I think a research center is something like I mentioned in here of about 30 people, full-time equivalence. You probably should be funding that center alone by about $5 million per year, something like this with a 5-year lead time to show that they can produce what they claim they want to do.

Ms. DAHLKEMPER. Dr. Freiman, you wanted to say something?

Dr. FREIMAN. Yes, briefly I was going to say one of the things I think we don't know is what research has been carried out over the past few years or even numbers of years in this area of rare earths. It is scattered about, National Science Foundation, Department of Energy, et cetera, and one of the things that would be nice to know right now is, you know, what has been done and therefore what could be done now or in the future in this area.

Ms. DAHLKEMPER. So again, having a central lead agency that can collect all that data and bring that together?

Dr. FREIMAN. Right.

Ms. DAHLKEMPER. Dr. Duclos, did you want to say something?

Dr. DUCLOS. Yeah, I just wanted to give you an idea of this sort of funding that it takes to solve some of these. These are very challenging problems. But generally, in our experience, and we have been through a number of challenges here in terms of materials, you are probably talking something between $5 and $50 million per element per application for a solution.

Ms. DAHLKEMPER. And obviously we have huge budget concerns here. What would be the ramifications if we were not able to fund at the level you think we need to fund?

Dr. DUCLOS. Well, what you do is you go through those five solutions. You take the shorter term ones, the quicker ones, and then you know, basically challenge yourself to ensure that you have a supply and work the best you can without doing the longer term, more expensive work that is the cleaner solution.

DOMESTIC SOURCES OF RARE EARTHS

Ms. DAHLKEMPER. Mr. Smith, a question for you. Mountain Pass Mine. If you go back in, if you have domestic production, can you get all 17 rare earth minerals out of your locations that you have and how soon to supply the American, you know, the U.S. needs?

Mr. SMITH. Understood. Thank you. We have all 15 of the lanthanide rare earths in our ore body. We can recover nine of those economically at today's prices, and we can start doing that as early as 2012.

Ms. DAHLKEMPER. And the others?

Mr. SMITH. Prices will have to go up before they are economic to recover.

Ms. DAHLKEMPER. And then there are two that you do not have supplies?

Mr. SMITH. Right, yttrium and scandium.

Ms. DAHLKEMPER. OK. And those are only found in?

Mr. SMITH. They are found in various places, China being one, Canada has some yttrium.

Ms. DAHLKEMPER. OK. So they are found in other countries besides China?

Mr. SMITH. Correct, although not in the quantities and the concentrations that they are found in China.

EXPANDING U.S. WORKFORCE

Ms. DAHLKEMPER. I did want to ask you just one more question. I have just a few seconds left here, but if I am back talking to students in my district, because you talked about having an issue with not being able to find the educated people that you need to work in your industry; what should I tell them to do?

Mr. SMITH. Tell them to go into rare earths and that we would like to hire them as interns as soon as possible. We can use all the people that we can get that have rare earth experience. We found none when we went out to hire, and we went ahead and took a risk, hired people with zero experience and about three-and-a-half years later, they became very productive in our organization.

Ms. DAHLKEMPER. And are there programs out there in different educational institutions——

Mr. SMITH. No, they will have to be established.

Ms. DAHLKEMPER. OK. Thank you very much.

Mr. SMITH. Thank you.

Chairman MILLER. Thank you. Mr. Coffman is now recognized for five minutes.

DEPENDENCE ON FOREIGN PRODUCTS

Mr. COFFMAN. Thank you, Mr. Chairman. Mr. Smith, I come to the rest of the panel, so I come to this committee via being on the Armed Services Committee where I became alarmed about the need and the supply for rare earth elements for advanced weapons systems.

The one question that I have, Mr. Smith, to ask you a question, even if the Mountain Pass Mine is reopened, will the United States still be dependent upon foreign rare earth products? I think you mentioned there are two that we would still be dependent on.

Mr. SMITH. Yttrium and scandium, yes. And we would still be dependent on other countries like China for portions of our supply needs. For instance, dysprosium is a very critical rare earth element needed for neodymium-iron-boron magnets. It is part of the alloy, and it allows the magnet to be used in a higher temperature application. Mountain Pass can produce a quantity of that material, but it will likely not be enough to suit the full needs of the United States relative to the hybrid vehicle industry.

Mr. COFFMAN. OK. Because I read an analysis where at full production that your mine could produce 20,000 tons of rare earth metals or elements. Is that figure correct?

Mr. SMITH. That is correct. That is our design capacity right now, and we can, with existing permits in hand, we can actually double that production to 40,000 tons per year.

Mr. COFFMAN. How long would it take you to get to full production?

Mr. SMITH. We think it would take us until about the middle of 2012 to reach our full, 20,000 ton, design capacity right now.

Mr. COFFMAN. But I understand, if I hear some of the testimony from today is that China, its demand will meet its supply in the vicinity of 2012 and that we will have to drastically curb exports. Am I correct in that?

Mr. SMITH. That is very, very accurate. The problem will be, they will produce enough for themselves, and it will be the rest of the world that has to find their alternative supply.

Mr. COFFMAN. Anybody else on the panel? Yes?

Dr. GSCHNEIDNER. I would like to address this product of, you know, yttrium and scandium, for example. The Canadians have several mines up there which are rich, and of course, the disposing point that Mark pointed out, but they are a little bit behind Molycorp in getting their products up. So I mean, as far as I am concerned, maybe the Canadians will like it. They are almost another state of the United States. Actually, there is no problem getting materials from them.

Australia has some mines. We have a representative right back here from the Australian group, and they have several good mines with materials and they are probably about a year or two behind Molycorp, so these materials are coming.

Scandium is a little bit rarer but a lot of it comes from Russia. China has some, too, but I don't think it is a real critical problem, but it could be in the future. We don't have much scandium. There aren't very good ore sources of scandium. That is the problem, I think.

MAINTAINING A COMPLETE SUPPLY CHAIN

Mr. COFFMAN. It would seem that the first phase of that supply chain in terms of mining, it seems that Molycorp may be able to bridge the gap in terms of China. But I also have a concern about the other levels of the supply chain in terms of the processing, and it seems that we have a real deficit in that area, and I think Dr. Gschneidner, I think you had mentioned the plant in Indiana that was moved to China. And so, can somebody speak to where we are in terms of that next step in the supply chain in terms of processing? Mr. Smith, would you like to address that first?

Mr. SMITH. Thank you, Congressman Coffman. To my knowledge, there are not a whole lot of activities in that regard, other than Molycorp's mining-to-magnets strategy where we will put in the conversion capabilities to go from oxides to metals. We will have the capability of taking the metals and alloying them, and we will have the capability of producing neodymium-iron-boron magnets here in the United States.

Mr. COFFMAN. That is great. Yes?

Dr. GSCHNEIDNER. Well, as I told you, we were preparing these neodymium-iron-boron magnet material, and that was one of the things we had come up with—a new process for making these metals. And Molycorp, of course, is quite interested and wants to obtain licenses for our technology but will also bring in a battery. So we are already solving part of that problem, but we are training people, too, at the same time. So this will help the supply train down the road. But again, it takes four years to get a Ph.D. out and two years for a Master's, so you just can't hit a light switch button and they pop up. But there are people out there that are reasonably well-trained and could move in pretty fast.

Mr. COFFMAN. Mr. Chairman, I am afraid I am out of time. I yield back.

KEEPING MANUFACTURING IN THE U.S.

Chairman MILLER. Thank you, Mr. Coffman. I will now recognize myself for a second round of questions. I agree with Mr. Coffman. I am worried about sophisticated weapons systems that may need rare earth minerals, but I am also concerned about manufacturing jobs. My part of North Carolina has seen the loss of a great many manufacturing jobs that were less-skilled, cut-and-sew jobs in the apparel industry, but our hope has been to replace those jobs with highly skilled jobs in very sophisticated, innovative industries.

China seems to be using the leverage of their rare earths to say if you need these minerals, these rare earth minerals in your products, come build your plant here. Mr. Stewart, you are nodding. This is the area you work in. What can we do to respond to that?

Mr. STEWART. Well, it is unusual for a country that has joined the WTO to take on specific obligations in the export arena because most countries do not maintain these types of restrictions or impediments. So just as the United States has brought the first case dealing with, I think, eight or nine raw materials that are used in steel and aluminum and chemicals, the most direct approach is to take a second case, at least on rare earth products, to the WTO. It is a process that could take two years to resolve, but the resolution of that should be a very clear finding that China is not permitted to close its markets. It is doing this in a whole range of products. There was an article in the *New York Times* yesterday talking about how China is taking advantage of the rules in the WTO and the rules in the IMF to maximize their advantage.[9] Well, that is what countries should do. They should be looking after their own interests. As a commercial power, we should be looking after our interest which is to see that China is not allowed to violate the commitments they have made without their being a cost, and the cost is to bring them in line, which would require them to take the taxes off, take the quotas off, and in fact make the products available to the highest bidders globally as most raw materials are done.

[9] Keith Bradsher. "China Uses Rules on Global Trade to Its Advantage." *New York Times,* March 15, 2010: pp. A1, A10.

BALANCING PRIVATE AND PUBLIC NEEDS

Chairman MILLER. Industry's need seems to be more of a short-term solution how to get production started again. Government seems to be more focused on what the long-term risk is of not having these minerals available. How can we kind of allocate our time and energy between industry and government to address both? Dr. Duclos.

Dr. DUCLOS. Well, actually, I would say that industry's interest is both short and long term. To the point earlier, I think an answer is technology, technology in developing systems and materials technologies that reduce the use of the material, technologies that involve recycling because, as I think everyone has seen, even if we develop all the sources of the rare earths that we—and it depends a little bit, rare earth by rare earth. But even if we develop all the sources of rare earths that we see around the world today, we are still not going to have enough in the sort of 5- to 10-year timeframe.

The solution is to minimize the use of these materials and develop those technologies. That is the long-term solution. The short-term solution is to certainly develop these sources which we absolutely need, but the long term is to do the technology development, recycling materials development.

Chairman MILLER. I will yield back my remaining 40 seconds. Mr. Coffman, do you have an additional round?

CHINESE INDUSTRIAL STRATEGY

Mr. COFFMAN. Thank you, Mr. Chairman. Just to any Member of the Committee, this strategy which China has deployed to secure really what is a strategic resource for its domestic industry, is this in any way calculated to rare earth metals that is different than any other commodity that China seeks to control for its own industrial base, in your view? Yes, Mr. Stewart.

Mr. STEWART. Well, it is similar to some of the strategies they have employed on other products where they have a dominant share of global supply, but there are specific documents that have come out at the provincial and central government level, both laying out their strategy to be dominant players in these products and the downstream use of those products and to force investment through these kinds of strategies. So while it is similar to what they have been trying to do in some others because these are perceived as high-growth sectors, obviously is the reason that it is of such great concern to us and many other countries.

Mr. COFFMAN. Very well. Anybody else? Mr. Smith?

Mr. SMITH. I guess it wouldn't be a full rare earth hearing if we didn't hear this quote, but there was a Chinese premier back in the 1980s that said the Middle East has oil and China has rare earths.

Mr. COFFMAN. Anybody else? Thank you so much for your testimony today. Mr. Chairman, I yield back the balance of my time.

FUNDING MODELS FOR MATERIALS RESEARCH

Chairman MILLER. Thank you. Mr. Smith, when you said there was a Chinese from here, I thought you were starting a limerick.

I will now recognize myself for five minutes, although I will not use five minutes. With other technologies we need to develop, we feel some urgency about developing high-speed computing and nanotechnology. We do instruct OMB to publish, to make budget requests for all agencies contributing to the programs as a whole and publish an explanation with the President's request to Congress. Is that a model that we should follow for materials research for rare earths? Any of you? Not a topic you have thought a lot about. OK.

Then I think, Mr. Coffman, unless you want another round of questioning?

TIMEFRAME FOR RE-STARTING DOMESTIC PRODUCTION

Mr. COFFMAN. Mr. Chairman, yes, I have a question for Mr. Smith. I understand so we are talking full production in your California mine by 2012?

Mr. SMITH. Correct, the middle of 2012.

Mr. COFFMAN. And obviously you seem to be the only game in town in the United States. Am I correct in that?

Mr. SMITH. So far that is correct.

Mr. COFFMAN. Now, is there anything that, I mean, unforeseen—not necessarily unforeseen. You can't control that. But is there anything that would in fact inhibit you or delay that capability of bringing that mine on line at that 20,000 ton capability?

Mr. SMITH. There is only one thing that the company needs right now, Congressman Coffman, and that is the capital to put the project into play, and that is what we are working on very hard as we speak.

Mr. COFFMAN. How hard is that? I mean, in your view, how hard is that?

Mr. SMITH. I think that there will be challenges just because of the current climate in the banking industry where project financing is a very difficult way to finance things right now. If you can get the money at all, it is going to be at very high interest rates and it is going to be at very short terms, and that is where the DOE loan guarantee program comes in to help the problem because they do offer lower interest rates and longer payback periods, and that is a much more attractive form of capital to use.

Mr. COFFMAN. So in your view, that would seal the deal in terms of your ability to go forward?

Mr. SMITH. There is no doubt in my mind.

Mr. COFFMAN. Give me a timeframe because it seems to me that we have a problem here in the sense that if in fact these timeframes are right where China, its demand catches up with the supply in 2012, and I have heard that from a variety of sources.

Mr. SMITH. Right.

Mr. COFFMAN. Your mine needs to come on line in the vicinity of 2012, and you think you could have full production of 20,000 tons which meets the U.S. demand for the rare earth elements that you would produce out of your mine. If in fact those things don't occur, it would seem to me that that would be an extraordinary escalation of price in these rare earth elements because where in fact would we get them from at that time?

Mr. SMITH. There would only be one place, although there are other mines that are certainly trying to open right now in other countries. But we are the only game in the United States right now. It is absolutely imperative that we get this operation up and running by 2012. The one thing I have learned in my 28 years in this business is that forecasters are never accurate in what they forecast, so is it precisely 2012 or is it 2013, 2014, I don't know. But I think that we can meet the window given the trends that we see today, but we do need to get going on our project and get going on it immediately.

Mr. COFFMAN. Mr. Smith, according to your business plan, when do you have to have your financing in place in order to be in full production in the vicinity of 2012?

Mr. SMITH. It would have to be in place this summer in order to have the full production on line and running by the middle of 2012. Every day we do not have the financing in place, it will be another day or so delay on the other end.

Mr. COFFMAN. OK. Thank you, Mr. Chairman. I yield back the balance of my time.

Chairman MILLER. Thank you, Mr. Coffman. I think that is a fine note to end on, Mr. Coffman's call for a more active role for government in the economy. And before we bring the hearing to a close, I want to thank our witnesses for testifying before the Subcommittee today. Under the rules of the committee, the record will remain open for two weeks for additional statements from the members and for answers to any follow-up questions the Subcommittee may have for the witnesses and for the submission of extraneous materials. The witnesses are excused, and the hearing is now adjourned.

[Whereupon, at 3:25 p.m., the Subcommittee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Stephen Freiman, President, Freiman Consulting, Inc.

Questions submitted by Chairman Brad Miller

Q1. In developing the "criticality matrix," and in applying it to the test cases discussed in the report, your committee appears to have gone through many of the steps that an "early warning" organization would take. If that's true, what should Congress learn from your experience that it can apply in setting up similar capabilities within the Government?

A1. To use the matrix as a tool in an early-warning system, the evaluation method must be become more quantitative. That is, it will be important to base the placement of minerals within the matrix on more quantitative indicators of supply risk and impact of a supply disruption than the committee was able to do in its testing of the matrix (e.g., to employ and adapt the matrix in a manner similar to the approach used by General Electric). As I noted in my testimony, the matrix is only as good as the input data. The Federal Government's access to data and information about some of the rarer minerals and metals will need to improve because at present many of these markets are not very transparent (e.g., rare earths, antimony, indium, etc.). As the committee noted in its recommendations, whatever agency is tasked with collecting mineral data, it must have the authority to require such submissions, as occurs with Principal Statistical Agencies such as the Energy Information Agency.

Q2. If the "early warning systems for material supply problems" required under the National Materials and Minerals Policy Act of 1980 are finally established, which Federal agencies should play a role in them, and what roles should they play?

A2. The 1980 Act calls out the Departments of the Interior, Commerce, and Defense as having principal roles. I would add the Department of Energy and the National Science Foundation(?), and possibly the Department of Transportation, since a number of applications of critical minerals relate to automobiles, etc. The roles of each of the agencies will differ, e.g. Interior (USGS) would be expected to play the lead role in collecting and analyzing mineral data, Commerce would have a dual role, through NIST in measurement and fundamental data and through Commerce's role in analyzing international trade. An important aspect in implementing the 1980 Act would be to reestablish a coordination of activities of the agencies through OSTP.

Q3. As the former deputy director of the National Institute of Standards and Technology's Materials Science and Engineering Laboratory, how would you say the Laboratory can contribute to a national research program for rare earth minerals?

A3. The mission of the NIST laboratories is to conduct research that advances the nation's technology infrastructure. As such, within the Materials Science and Engineering Laboratory there are ongoing efforts in developing and maintaining databases on crystal structure and phase diagrams, both of which will be important in any research program on rare earths.

In addition, the *Technology Innovation Program* provides cost-shared awards to industry, universities, and consortia for research on potentially revolutionary technologies that address critical national and societal needs.

Q4. Given your knowledge of Federal capabilities in materials research, which agencies would you see as able to contribute to the development and execution of a research program as called for by the 1980 Act (30 U.S.C. 1603 (2))?

A4. As the committee noted in its recommendations, and included in my testimony, a number of Federal agencies, including the National Science Foundation, Departments of the Interior, Defense, Energy, and Commerce should develop and fund activities to encourage U.S. innovation in the area of critical minerals. These same agencies should coordinate such programs as noted in number (2) above.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Steven J. Duclos, Chief Scientist and Manager, Material Sustainability, General Electric Global Research

Questions submitted by Chairman Brad Miller

Q1. What information does the Government need, and what information should government and users of minerals be sharing, in order to maximize the lead times it will have for deciding which of the strategies you described at the hearing should be pursued in a particular case?

A1. From a manufacturing perspective the sourcing, recycling, manufacturing efficiency, materials substitution, and systems strategies outlined in my testimony will only be carried out on materials that the U.S. considers both critical to the country's defense and manufacturing base and at risk from a supply and demand perspective. To assess which materials fall into this category an assessment could be done that is similar to the one proposed by the National Research Council in Minerals, Critical Minerals, and the US. Economy in 2008. The government would need to update and expand the list of elements considered by the NRC panel, but the assessment metrics used by this panel remain viable. Collection in confidence of anticipated future use of materials by industry in the three to five year timeframe, as well as augmenting current supply information collected by USGS with anticipated future supplies, would greatly improve the accuracy of evaluation of future supply and demand risks. For those materials deemed to be at greatest risk the government could then solicit business and technology solutions along the strategies outlined in my testimony. Government support of the longer term, higher risk solutions would enable industry to pursue a greater breadth of solutions that would minimize the risk of disruption to U.S. manufacturing. By completing this assessment annually the government would better understand the progression of elements along the criticality diagram, which could lead to an early warning on future risks.

Q2. If GE were interested in partnering with an academic institution or a government facility to develop a substitute material (or find a replacement) for something like Rhenium, what would it be looking for in that partner and what resources would that partner bring to the collaboration?

A2. Pre-competitive information, such as materials property databases, material property testing capability, and basic understanding of material behavior in systems is important to accelerate the insertion of new and substitute materials into OEM systems. Specific details of resources that a partner could bring to such a collaboration would depend greatly on the material to be reduced since each substitution effort tends to be unique to both the element and the application.

Q3. Would General Electric's materials scientists be interested in collaborating with the type of Centers proposed by Dr. Gschneidner?

A3. Since GE uses permanent magnets in a wide array of products the company would welcome the opportunity to participate in the type of Center that Dr. Gschneidner has proposed. In addition to providing material science know-how, the company would provide a critical role in ensuring that the properties, cost, and reliability of developed substitute materials and processes are compatible with the systems in which they would be used.

Q4. As you serve as the "early warning system" for General Electric, what advice would you give a counterpart in the Federal Government trying to provide the same service for the Nation?

A4. The assessment of risks related to supply and demand should be made as quantitatively as possible. National and international data is available on both the supply and demand sides of the equation, and development of a quantitative risk rating, similar to that discussed in the invited contribution to this hearing Operationalizing the Concept of Criticality by Dr. Thomas Graedel of Yale University, would aid building the risk assessment. Such an assessment should include a specific recent elemental challenge, perhaps one from among the rare earths. Comparison of the position on the criticality diagram of this recent elemental risk would provide a useful relative level of risk of the other elements assessed. In addition, future material supply scenarios, akin to those built for economies, could be built for those elements and materials indicated to be at high risk on the criticality diagram. Such scenario building may help elucidate which of the risk reduction processes are most likely to lead to a solution. Finally, since the assessment is only the start of the process it needs to be done expeditiously, to allow time for new sources, recycling, efficient manufacturing, and material research on substitutions to be developed.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Karl A. Gschneidner, Jr., Anson Marston Distinguished Professor, Department of Materials Science and Engineering, Iowa State University

Questions submitted by Chairman Brad Miller

Q1. What level of funding would you consider necessary to support the two Centers you proposed in your testimony?

NATIONAL RESEARCH CENTER ON RARE EARTHS AND ENERGY

A1. The National Research Center on Rare Earths and Energy (NRCREE) should be composed of five research groups covering the following five areas of greatest need:

1. Process Metallurgy and Scrap Recovery
2. Permanent Magnet Materials
3. Battery and Electronic Materials
4. Catalytic Materials
5. Materials for Nano Science and Nano Technology

A typical research group would consist of a group leader; staff scientist(s); post-doctoral, graduate and undergraduate students; technical and secretarial support.

The NRCREE would also have critical in-house analytical chemistry and characterization expertise (x-ray diffraction, and optical, electron, atomic force and magnetic force microscopy) as a support group shared by all research groups.

NRCREE would also initiate and support projects in important areas, not covered by the five research groups at other universities, non-profit research groups, national laboratories, and industry. Some potential topics may be separation science, optical and photonic research, organometallic chemistry, analytical chemistry.

NRCREE would have a full-time director and a part-time associate director (probably one of the group leaders), an advisory board made up of representatives of the university, government, industry and general public.

The cost would be $10M per year. The Center should be funded for five years and reviewed in its fourth year for extension for an additional five year term.

The NRCREE would need a new building for offices and laboratories. There would be some special space requirements for the Process Metallurgy and Scrap Recovery Group because it would be involved in scaling up metallurgy production from laboratory size to bench scale to a full pilot plant scale. In addition a special handling facility would be needed for hydrofluoration process, which uses hazardous HF (hydrogen fluoride) gas, to prepare the fluorides which are later reduced to the metals. The cost of this building is $60M.

NATIONAL RESEARCH CENTER FOR MAGNETIC COOLING

The National Research Center for Magnetic Cooling (NRCMC) would be a fully integrated center devoted to bringing the energy efficient magnetic cooling (air conditioning/climate control, refrigeration and freezing) from the exploratory stage to commercial products. Today there are about 30 individual (a few persons at the most) laboratories scattered around the world (including about 5 in the USA) working on various aspects related to magnetic refrigeration but there is only one group (Denmark) which is concerned with the complete technology. The NRCMC would consist of five research groups devoted to the following areas:

1. Modeling and Theory
2. Magnetocaloric Materials
3. Regenerator Design and Fabrication
4. Magnetic Arrays
5. Cooling Machines

A typical group would consist of a group leader; staff scientist(s); post-doctoral, graduate and undergraduate students; technical and secretarial support.

The NRCMC would also have a key characterization capabilities (x-ray diffraction; optical, electron, atomic force and magnetic force microscopy; and magnetic property and thermal transport measurements) support group.

NRCMC would also initiate and support projects in important areas not covered by the five research groups at other universities, non-profit research groups, national laboratories, and industry. Some topics might be exploratory research on special fabrication techniques and unusual magnetocaloric materials.

NRCMC would have a full-time director and a part-time associate director (probably one of the group leaders), an advisory board made up of representatives of the university, government, industry and general public.

The cost would be $9M per year. The Center should be funded for five years and reviewed in its fourth year for extension for an additional five year term.

The NRCMC would need a new building for offices and laboratories. Some special facilities would need to be considered, for example fabrication equipment for fabrication of regenerators, and machine shops for prototyping cooling machines. The cost of this building is $50M.

SPECIAL COMMENTS

The above estimates were made on the assumption that the two Centers would not be co-located. If, however, they were located on the same campus, they should be combined into one building which would result in some cost savings. For example, the operating expenses would be reduced because the NRCREE and NRCMC could share the characterization support group personnel and facilities, also the administrative cost could be reduced, i.e. instead of a sum of $19M per year, the operating costs for the two Centers it could be reduced to $18M per year. Also the cost of the buildings, one instead of two, the combined building would be $95M (compared to $110M for separate buildings).

There are also additional advantages because persons carrying out research and development activities on permanent magnets in the NRCREE would have access to the NRCMC scientists and engineers designing permanent magnet arrays and vice versa, this would be an important synergism. There may be some other indirect interactions, but there is essentially no overlap between the missions of the two Centers.

Q2. Which Federal Agencies, other than the Department of Energy, could contribute to the research programs you would contemplate for the proposed Centers?

A2. The Department of Defense (DOD) and National Institute for Science and Technology (NIST) are logical choices of Federal agencies which could contribute to the research programs of NRCREE and NRCMC. For example, at the present time the Office of Naval Research (DOE) is funding a project for cooling electronic hardware on seafaring vessels, and the U.S. Air Force has funded a few (at least one) SBIR for magnetic cooling below about 200° C. As far as I am aware NIST has one internal (quite small) project on magnetic cooling. All three of these projects would complement research carried out at the NRCMC.

Q3. Given your knowledge of Federal capabilities in rare earths research, which agencies do you regard as able to contribute to the development and execution of a research program as called for by Section 1603(2) of the National Materials and Minerals Policy Act of 1980?

A3. The best Federal agency to develop and execute a research program called for by Section 1603(2) of the National Materials and Minerals Policy Act of 1980 would have been the U.S. Bureau of Mines, Department of Interior, but unfortunately all of the research laboratories were closed down in 1995 when the Bureau of Mines went out of existence. Today there is no Federal agency that could easily undertake the tasks required in Section 1603(2). But with some realignment and priority changes one of the following Federal agencies should be able to accomplish the goals of this act: DOE, DOD, NIST and NSF.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mark Smith, Chief Executive Officer, Molycorp Minerals, LLC

Questions submitted by Chairman Brad Miller

Q1. As you are planning to operate throughout the rare earths supply chain, can you tell us what processes in your production chain need immediate increases in R&D support?

A1. Re-establishing for America a domestic "mining-to-magnets" supply chain, on which Molycorp is focused virtually round-the-clock, involves deploying five fundamental steps of production: 1) rare earth mining and milling; 2) oxide production; 3) oxide-to-metals production; 4) metal alloying; and 5) magnet manufacture. All of these steps are integrally linked to one another, and failure at any one step will prevent the U.S. from building a full domestic supply chain. Molycorp is investing significant capital and research and development across all five steps of production. The new technologies and processes that we are developing and seeking to deploy at each step of production are contributing to lowering production costs and improving environmental performance. In other words, we are finding that investment in "green" process technologies at each step of production is a key driver to lowering costs and will help the U.S. become the low-cost producer of rare earth materials and products. This is why investment is needed across the entire production chain, as opposed to any single step.

Q2. Would you be interested in collaborating with the type of Center Dr. Gschneidner proposed at the hearing?

A2. Absolutely. As I testified, virtually all analyses show that the U.S. and the world will need both to increase production of rare earth materials and products as well as find economic paths to rare earth recycling and substitution technologies.

Questions submitted by Representative Kathleen Dahlkemper

Q1. If you are successful in developing the new magnet production capability, how likely are we to see a repeat of the Magnaquench episode, where the Defense Department and General Motors set up a domestic magnet producer only to see its facilities shipped off to China?

A1. Molycorp is committed to establishing and operating the entire rare earth magnet supply chain on U.S. soil. If we are successful in establishing this supply chain, and if we are able to compete successfully in the global market—as we are confident of doing—the odds of another Magnaquench happening as a result of investment in our project are practically zero. That is because we, as a company, believe very strongly that America's national and economic security demand that the entire rare earth magnet supply chain be established and maintained here in America. This is our goal and our commitment.

Q2. What will guarantee that the benefits that come from investing in your project will be captured for and kept in the U.S. domestic economy?

A2. If Molycorp is successful in re-establishing a domestic mining-to-magnets supply chain on U.S. soil, then the benefits of that supply chain will clearly flow to the U.S. economy, including re-establishing a manufacturing base for many end-use products using rare earth elements. Moreover, studies have clearly shown that research and development activities closely follow industrial bases. Hence, our establishment of the entire supply chain will actually foster research related activities relating to rare earths. Perhaps more importantly, the U.S. will reap substantial long-term benefits from a reduction of our dependence on foreign countries for these strategic materials.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Terence Stewart, Esq., Managing Partner, Stewart and Stewart

Questions submitted by Chairman Brad Miller

Q1. What are the leading trade considerations that should shape a U.S. national policy for minerals and materials?

A1. Any new U.S. policy on minerals and materials would presumably be focused on tracking (1) use and anticipated growth in demand, (2) availability, (3) development of additional sources, (4) development of alternative products and (5) risks to availability.

WTO rules already in place should reflect the types of trade considerations of importance to the U.S. and any policy it has or develops on minerals and materials to increase availability (Item 2). These rules could be bolstered by ongoing negotiations within the WTO (Doha negotiations) and in bilateral and plurilateral talks with major trading partners.

As a general matter, international trade rules and ongoing negotiations look to open markets and limit restrictions on access to materials and to limit distortions flowing from government largesse. While there are exceptions that can be important from a national security perspective, the key element of a proactive policy is the need to eliminate discrimination in availability of products or access to markets or raw materials.

More specifically, Article I of GATT 1994 deals with most favored nation treatment of goods on a market access perspective (this means no discrimination between WTO members); Article III of GATT 1994 requires the provision of national treatment (requiring governments to treat foreign goods the same as domestic goods once imported) and Article XI of GATT 1994 seeks to eliminate limitations on both imports and exports outside of duties, taxes and other charges. Moreover, some countries in their accession protocols have undertaken specific commitments not to apply export taxes or duties. This includes China as it pertains to rare earth minerals, as my testimony at the hearing reviewed.

Hopefully, the current U.S. challenge to China's export duties, quotas and licensing requirements on certain raw materials that are not rare earth minerals will confirm the vitality of these considerations vis-a-vis China within the WTO. If China fairly implements any adverse determination, that may eliminate at least one source of trade concern for the U.S. on minerals and materials.

Probably it will be necessary for the U.S. to bring a second WTO case against China dealing with rare earth minerals, to provide additional pressure on China, and to provide a path forward to a positive resolution of the rare earths dilemma faced by the United States.

There are trade considerations as well for subsidies which can, of course, be used to develop capacity, new uses and alternative materials (issues (1), (3) and (4) above). Trade considerations prohibit export subsidies for most countries and subsidies which are "contingent, whether solely or as one of several other conditions, upon the use of domestic over imported goods." Article 3.1(b) of the Agreement on Subsidies and Countervailing Measures. At the same time, domestic subsidies for mineral and materials production and development are permitted where such subsidies are either general in reach or not causing injury to foreign producers (serious prejudice; nullification or impairment of benefits; injury to the domestic industry of another member). The U.S. should be vigilant in pursuing trade actions against trading partners who engage in the use of prohibited subsidies or use domestic subsidies in a manner harmful to U.S. manufacturing. This is particularly true for minerals and materials.

Q2. Which elements of the nation's trade apparatus should participate in or contribute to the development of the "early warning system" for materials and minerals bottlenecks discussed at the hearing?

A2. The U.S. Trade Representative's office prepares annually a National Trade Estimate in cooperation with input from other government agencies and our embassies and consulates overseas and information from the business community reviewing barriers to U.S. exports. Actions and policies by many of our trading partners are reviewed annually. This report could be modified to have a section within the overall report as well as a section in every country that looks at actions by foreign governments that affect any of the five policy issues on minerals and materials.

In addition, the U.S. Department of Commerce and the U.S. Trade Representative put out an annual report on subsidy practices of our trading partners. In the past, the report has focused on particular industries where there was Congressional interest. Requiring a section in this report that examines the subsidy practices of trading partners on minerals and metals would be an important step to take.

Finally, historically there has been a so-called "special 301" provision in law to address annually concerns on intellectual property laws and protections amongst our trading partners. Through a statutory change, a special 301 provision could require an annual evaluation of government policies affecting availability, non-discrimination, national treatment, development and subsidy issues and require consultations with nations viewed as creating artificial barriers to minerals and materials.

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