Testimony

Critical Materials and U.S. Import Reliance

Recent Developments and Recommended Actions

Richard Silberglitt

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Critical Materials and U.S. Import Reliance: Recent Developments and Recommended Actions

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Before the Committee on Natural Resources
Subcommittee on Energy and Mineral Resources
United States House of Representatives

December 12, 2017

Thank you Chairman Gosar, Ranking Member Lowenthal, and distinguished members of the Subcommittee for inviting me to testify today. My testimony is based on the results of a 2013 study conducted by the RAND Corporation at the request of the National Intelligence Council,[3] taking into account relevant developments and data since the publication of that report. I have divided my comments into four sections. The first defines what I mean by a critical material. The second explores the concentration of global production of these materials, focusing on China. The third uses a case study of tungsten, updated with current data, to illustrate problems faced by U.S. manufacturers. The final section summarizes the current supply situation and suggests possible actions for U.S. federal policymakers to increase resiliency to supply disruptions and market distortions as well as to provide early warning for problems concerning critical material production.

Critical Materials

While the United States has extensive mineral resources and is a leading global materials producer, it is dependent on imports for many materials that are critical to manufacturing. The most well-known examples are metals of the rare earth family, which are essential to many technologies that we rely on for both civilian and defense applications, such as chemical

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[2] The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest.

[3] The final report of that study was published as Richard Silberglitt, James T. Bartis, Brian G. Chow, David L. An, and Kyle Brady, *Critical Materials: Present Danger to U.S. Manufacturing*, Santa Monica, Calif.: RAND Corporation, RR-133-NIC, 2013.

catalysts, lasers, high-power magnets, batteries, LEDs, night-vision goggles, and computer hard drives.[4] However, U.S. import dependence is not limited to rare earth metals. In 2016, the United States was reliant on imports for 80 non-fuel mineral commodities. It was fully dependent on imports for 20 of these commodities and more than 50 percent dependent on imports for another 30 commodities.[5] These mineral commodities included semiconductors, such as indium, gallium, and germanium; metals used in high-temperature alloys, such as vanadium and rhenium; antimony, which is a critical component of flame-retardant plastics and textiles; and tungsten, a critical component in materials for drilling, cutting, and machining. Tungsten is used in mining and construction; oil and gas exploration; tools and dies; and the cutting of wood, plastics, and metals. It is these materials—critical inputs to manufacturing—which I address in this testimony.

Dependence on imports is not necessarily a problem, as long as manufacturers have access to a global supply chain with fair market prices. Concerns arise when supply chains are dominated by countries that have weak governance or exercise control over their materials production sector. In such cases, U.S. manufacturers are vulnerable to export restrictions that limit their access. This can result in lower prices for manufacturers in the producing country, thereby hindering the international competitiveness of U.S. manufacturers and creating pressure to move manufacturing away from the United States and into the producing country.

RAND examined these issues through a focus on materials that met the following three criteria:

- The dominant producer is outside the United States
- The United States has appreciable net imports
- The dominant producer has shortfalls in its quality of governance, as measured by the Worldwide Governance Indicators (WGI) published by the World Bank.[6]

Concentration of Production

To measure the concentration of production of critical materials, the RAND study used the most common measure of the concentration of commodity markets: the Herfindahl-Hirschman Index (HHI), which is computed as the sum of the squares of the market shares of the 50 largest producers. The U.S. Department of Justice and the Federal Trade Commission use the HHI to examine antitrust issues involving corporate mergers. According to the Horizontal Merger Guidelines established by these two agencies, markets in which the HHI is between 1,500 and 2,500 are moderately concentrated, and those in which the HHI is greater than 2,500 are highly

[4] Definitions of the rare earth family of metals vary slightly. Here we adopt the definitions used by K.A. Geshneider, Jr., "The Rare Earth Crisis—The Supply/Demand Situation for 2010-2015," *Material Matters*, Vol. 6, No. 2, 2012, pp. 32–37. Geshneider defines rare earth metals as lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, and yttrium.

[5] U.S. Geological Survey, *Minerals Commodity Summaries 2017*, Pittsburgh, Penn.: U.S. Government Printing Office, 2017a.

[6] The World Bank, *Worldwide Governance Indicators,* webpage, 2016.

concentrated.[7] According to these guidelines, whenever a single firm has a market share of over 50 percent, the market is highly concentrated.

Applying these market concentration guidelines, which were originally developed for firms, to materials producing nations is most relevant when the producing nations control materials production or have weak governance. In these cases, there is strong potential for export restrictions or supply disruptions to affect all producers within a country, making the government a reliable surrogate for a company. Hence, the RAND study used a combination of the HHI and the WGI of key producers[8] to identify materials with potential for supply disruption.[9]

Several nations dominate production of critical materials with a greater than 50 percent market share for a single material. However, as illustrated in Figure 1, only China, a country with average WGI percentile of 40,[10] has a market share greater than 50 percent for more than one such critical material. In fact, China has a greater than 50-percent market share for ten different critical materials. China is also a major supplier of more than 19 of the 30 materials for which the U.S. is more than 50 percent reliant on imports.[11]

China achieved its dominance in global raw materials production because of its large resource base and its long-term emphasis on mineral production, as well as its ability to produce raw materials at lower cost because of its relatively lax environmental and occupational health and safety standards. Figure 2 shows how China's dominance in materials production grew from 1990 to 2010 as mines and processing plants in other countries closed because of their inability to compete with China's low-price exports.[12]

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[7] U.S. Department of Justice, "Herfindahl-Hirschman Index," webpage, undated.

[8] The WGI is a percentile score for each country in six categories: voice and accountability, political stability and absence of violence/terrorism, effectiveness of government, regulatory quality, rule of law, and control of corruption.

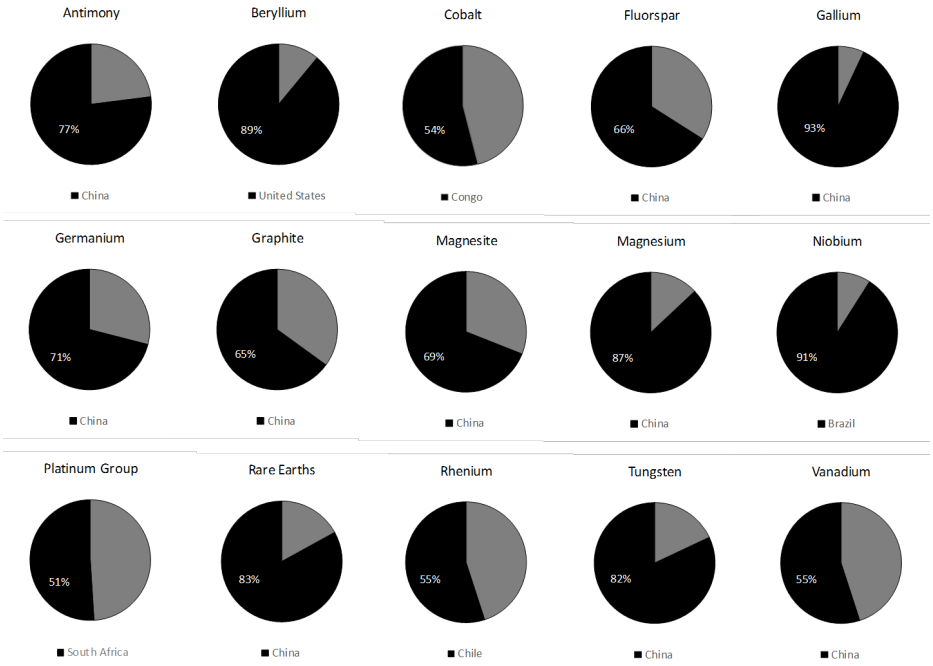
[9] The combination of market concentration and weak governance, as measured by HHI and WGI, respectively, is also used as a measure of supply risk in other recent studies: National Science and Technology Council, *Assessment of Critical Minerals: Screening Methodology and Initial Application*, Executive Office of the President of the United States, 2016; Erin McCullough and Nedal T. Nassar, "Assessment of Critical Minerals: Updated Application of an Early-Warning Screening Methodology," *Mineral Economics*, Vol. 30, 2017, pp. 257–272.

[10] As compared, for example, to the United States (86) and Chile (80).

[11] U.S. Geological Survey, 2017a, p. 8.

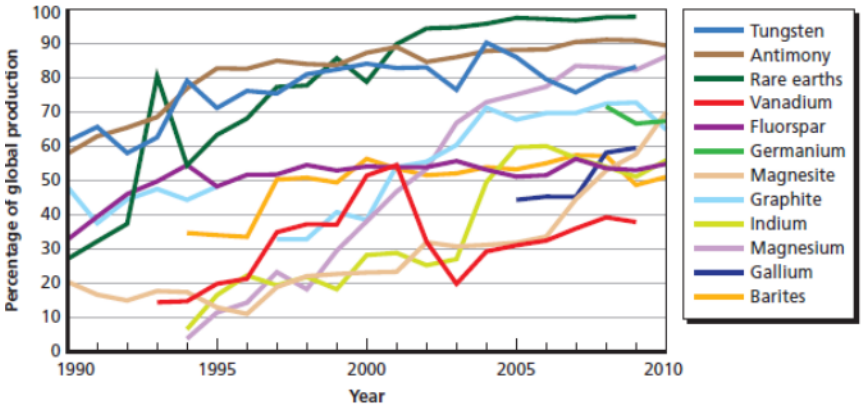
[12] For a tungsten example, see Chelsea J. Carter, "At 8,000 Feet, California 'Mine in the Sky' Is About to Enter Valhalla," *Los Angeles Times*, August 27, 2000; for a rare earth example, see Danielle Venton, "Rare Earth Mining Rises Again in the United States," *Wired*, May 11, 2012.

Figure 1. Percentage of Global Production Within a Single Country



SOURCE: U.S. Geological Survey, 2017.

Figure 2. Growth of China's Raw Materials Production



SOURCES: U.S. Geological Survey, 1996–2011; International Organizing Committee for the World Mining Congresses, 2011.
NOTE: Data unavailable on Chinese market share for germanium prior to 2008. Gallium data are from International Organizing Committee for the World Mining Congresses, 2011.

However, in the latter half of the 2000s, China's position as a reliable low-cost supplier of raw materials for manufacturing deteriorated, as its market share and domestic consumption grew and a combination of production controls, export restrictions (e.g., quotas and tariffs), mine closings, and company consolidation contributed to significant price increases and volatility on

the world market.[14] For example, prices of some rare earth metals spiked by thousands of percent between 2010 and 2013.[15] The price of ammonium paratungstate (APT), the form of tungsten traded on the commodity market, more than doubled from January 2010 to January 2011, recovering half of this increase in two years, before peaking again in early 2013.[16]

The negative effects on competitiveness of non-Chinese manufacturers created by this situation led China's trading partners to bring an unprecedented series of complaints before the World Trade Organization, beginning in 2009 and culminating in May 2015 with China's removal of export restrictions on rare earths, tungsten, and molybdenum. These complaints and their resolution are briefly described below.[17]

- In 2009, the United States and the European Union (EU) brought a complaint against China's trade restrictions on various forms of bauxite, coke, fluorospar, magnesium, manganese, silicon carbide, silicon metal, yellow phosphorus, and zinc. When the WTO ruled in favor of the United States and the EU, China appealed and lost, then took full advantage of the "reasonable period of time" allowed under WTO rules to finally remove export duties on these materials on January 1, 2013—the very day the time for compliance expired.
- In 2012, the United States, EU, and Japan brought an additional complaint against China's trade restrictions on rare earths, tungsten, and molybdenum. This dispute was also settled in favor of the United States, EU, and Japan. After China appealed and lost, it removed export restrictions (e.g., export duties and export quotas, as well as restriction on trading rights of enterprises exporting rare earths and molybdenum) on these materials—but, again, only on the last day possible (in this case, May 2, 2015).

The relatively long timeline for resolution (more than three years) of these disputes and China's delay in putting WTO rulings into practice highlight the vulnerability of U.S. manufacturers dependent on Chinese exports of critical materials. In fact, a recent analysis of global industrial supply chains and trading strategies concluded that among major traders, only China pursued strong resource protection strategies, defined as export and production restrictions, consolidation of industry, and investment restrictions.[18] While the removal of export restrictions should, in principle, eliminate the difference between export and domestic Chinese prices for critical raw materials, it remains to be seen whether China finds other ways to continue to provide its manufacturers with competitive advantages based on its position as a dominant producer.

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[14] Jeonghoi Kim, "Recent Trends in Export Restrictions," OECD Trade Policy Paper No. 101, Paris: OECD Publishing, 2010.

[15] Richard Miller, "Materials Challenges for a Transforming World: Developments for a Sustainable Future: The Example of Rare Earths," *Johnson Matthey Technology Review*, Vol. 61, No. 2, 2017, p. 127.

[16] Vitalmetals.com, "Tungsten Price," webpage, undated.

[17] World Trade Organization, *China—Measures Related to the Exportation of Various Raw Materials*, Dispute Settlement DS394, January 28, 2013; and World Trade Organization, *China—Measures Related to the Exportation of Rare Earths, Tungsten and Molybdenum*, Dispute Settlement DS431, DS432, DS433, May 20, 2015.

[18] Eva Barteková and René Kemp, "Critical Raw Materials Strategies in Different World Regions," United Nations University and Maastricht University, UNU-MERIT Working Paper No. 2016-005, Maastricht University: The Netherlands, 2016.

Tungsten: Case Example of a Critical Material

Tungsten's unique combination of high-temperature mechanical and electrical properties makes it important in applications such as electrical lighting, high-temperature metal alloys, and wear-resistant components. However, tungsten's largest use is in manufacturing of cemented carbides. These composite materials consist of tungsten carbide particles in a binder and are critical to every industrial application that involves cutting or involves component wear. This makes tungsten a basic commodity underpinning the global manufacturing sector.[19]

Tungsten is found and produced in many places in the world, but China is the leading producer and has the largest amount of reserves (the portion of resources that are economic to produce).[21] China has been the leading producer for many years and has dominated both tungsten production and processing into APT, the form in which tungsten is traded on the world market. Figure 3, which shows the flows of raw and processed tungsten between China, the United States, and the rest of the world, illustrates just how dominant China is in the global tungsten supply chain. Not only does China produce much more raw tungsten than any other country, it also imports the largest share of raw tungsten (ore and concentrate) produced by the rest of the world and is the dominant producer of intermediate compounds, including ammonium tungstates, that are critical to manufacturers that create products containing tungsten. This increases the dependence of global manufacturers on Chinese imports. For example, in May 2017, Chinese imports were 48 percent of total U.S. imports for consumption of all forms of tungsten, while Chinese imports were 74 percent of U.S. imports of ammonium tungstates.[22]

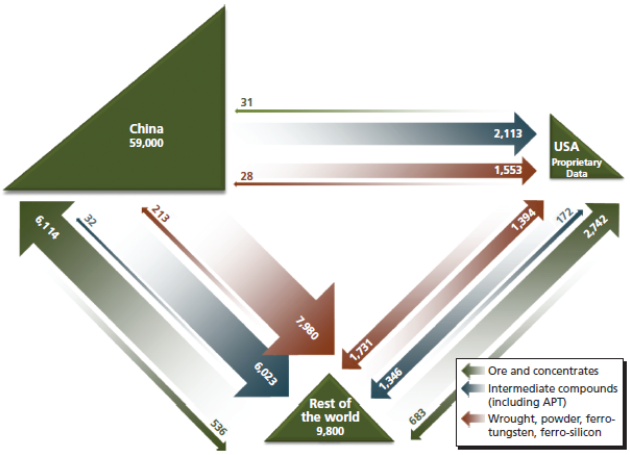
U.S manufacturers recognized this vulnerability. In response to the price volatility noted in the previous section, as well as a tight supply situation stemming from increased demand from Chinese manufacturers and the export restrictions that were the subject of the 2012–2015 WTO disputes, they made a remarkable increase in secondary production from scrap and waste between 2009 and 2011. This reduced import dependence from near 70 percent to about 40 percent. Although import dependence has increased somewhat since, it is still well below its level in the 2000s, as shown in Figure 4.

[19] For a description of tungsten applications, see International Tungsten Industry Association, "Primary Uses of Tungsten," web page, 2011.

[21] U.S. Geological Survey, 2017a, Appendix B.

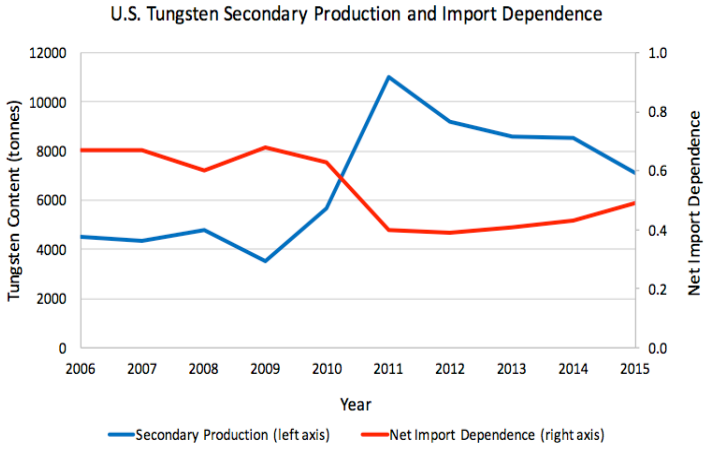
[22] U.S. Geological Survey, *Mineral Industry Surveys: Tungsten in May 2017*, Reston, Va., 2017b.

Figure 3. Tungsten Raw Materials Supply Network



SOURCES: U.S. Geological Survey; United Nations Comtrade, undated.
NOTE: Units are metric tons (tonnes). Figures below country names denote domestic production. U.S. data is proprietary and not disclosed by the USGS.

Figure 4. U.S. Tungsten Secondary Production and Import Dependence



SOURCE: U.S. Geological Survey, *Minerals Commodity Summaries*, 2011-2016.
NOTE: 2015 secondary production and net import dependence figures are estimated.

Current Situation and Recommended Actions

As the case study of tungsten illustrates, issues with the supply of materials are often less about the materials themselves and more about where the materials are produced and processed. As China's export restrictions and the WTO disputes that stemmed from them illustrate, a dominant producer can contribute significantly to market distortions and supply disruptions, creating a strong impact on the manufacturing sector. However, what is most important is not the level of import dependence, but the level of availability of the imported materials at a fair market price. It is important to note that there are dominant materials producers who eschew export restrictions and allow market forces to largely determine supply and demand of the materials they produce, such as Chile, producer of 55 percent of the world's rhenium.

Despite positive trends, such as the resolution of the WTO disputes leading to elimination of export restrictions on several critical materials and the United States's decreased import dependence for tungsten, the underlying problem of U.S. import dependence on China, a country with a history of implementing export restrictions, for many critical materials still remains. After a three-year decline to historically low levels, the price of tungsten is on the rise.[23] U.S. import dependence on Chinese imports of rare earth metals is back to 100 percent since the closing of the Mountain Pass mine in 2015 (although this mine is planned to reopen, albeit under ownership of a Chinese-led consortium).[24] Hence, the two types of actions recommended in RAND's 2013 report remain relevant to mitigate the impact of market distortions on the global manufacturing sector. These are (1) actions to increase resiliency to supply disruptions or market distortions, and (2) actions that can provide early warning of developing problems concerning the concentration of production.

Increasing Resiliency to Supply Disruptions or Market Distortions

Actions to increase resiliency can take two different forms: those that encourage diversified production and processing of critical materials and those that involve the development of alternative sources, such as secondary production or alternative inputs to manufacturing. With respect to the former, the situation described in the previous sections has already encouraged efforts at diversification, such as production and processing of tungsten in Vietnam and exploration and development projects for rare earths at several sites in the United States and many other countries. However, the uncertainty created by a highly concentrated market is a barrier that must be overcome by actions at the local, national, regional, and global levels to create a favorable and sustainable climate for the investments and time needed to bring diversified supplies into place. Coordinated actions by importing countries—such as the previously described WTO cases brought by the United States, EU, and Japan—can be effective. Other areas in which coordination is possible include stockpiling resources[25] and establishing agreements to share limited resources in the event of supply disruptions.

In the long term, actions to increase resiliency may include the development of new methods of extraction, processing, and manufacturing that promote the efficient use of materials; increased recovery of materials from waste and scrap (i.e., secondary production), as occurred with tungsten; and research and development of alternative materials and product designs that use smaller amounts of scarce materials.[26]

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[23] U.S. Geological Survey, 2017b.

[24] Andrew Topf, "Mountain Pass Sells for 20.5 Million: Chinese-Led Consortium Picks Up America's Only Rare Earths Mining Operation," *Mining.com*, June 16, 2017.

[25] The Defense Logistics Agency manages the National Defense Stockpile, which contains quantities of 20 different materials. Detailed operations of the stockpile are described in Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Strategic and Critical Materials Operations Report to Congress: Operations Under the Strategic and Critical Materials Stock Piling Act During Fiscal Year 2017*, Washington, D.C., January 2017.

[26] The Critical Materials Institute, a Department of Energy-sponsored consortium of national laboratories, universities, and industry, is working in many of these areas for energy-related materials. For details, see Critical Materials Institute, "CMI Factsheet," webpage, undated.

Recognizing Developing Problems

Data on the production, processing, and trade of minerals are widely available from government organizations, such as the U.S. Geological Survey and the British Geological Survey, as well as from industrial organizations and the United Nations' Comtrade database. Using these data, how might we recognize developing patterns, such as increasing concentration of production, increasing export restrictions, two-tier pricing, price spikes, or price volatility, before they create harmful market distortions? One approach may be benchmarking of market activity with diversified commodity markets. For example, the Horizontal Merger Guidelines for firms established by the U.S. Department of Justice and Federal Trade Commission state that a change in HHI of 200 in a highly concentrated market is highly likely to increase market power.[27] In our application, if a country with a 50 percent market share were to acquire an additional 14.2-percent share, this threshold would be reached. When such situations occur, international coordination and cooperation could prevent market concentration from reaching the level of concern that led to the WTO disputes against China brought by the United States, the EU, and Japan. The goal of such coordination and cooperation should be to smooth market distortions while allowing the natural economic development of producing countries.

Thank you for the opportunity to testify and I am happy to answer any questions.

[27] U.S. Department of Justice, "Horizontal Merger Guidelines," webpage, August 19, 2010.