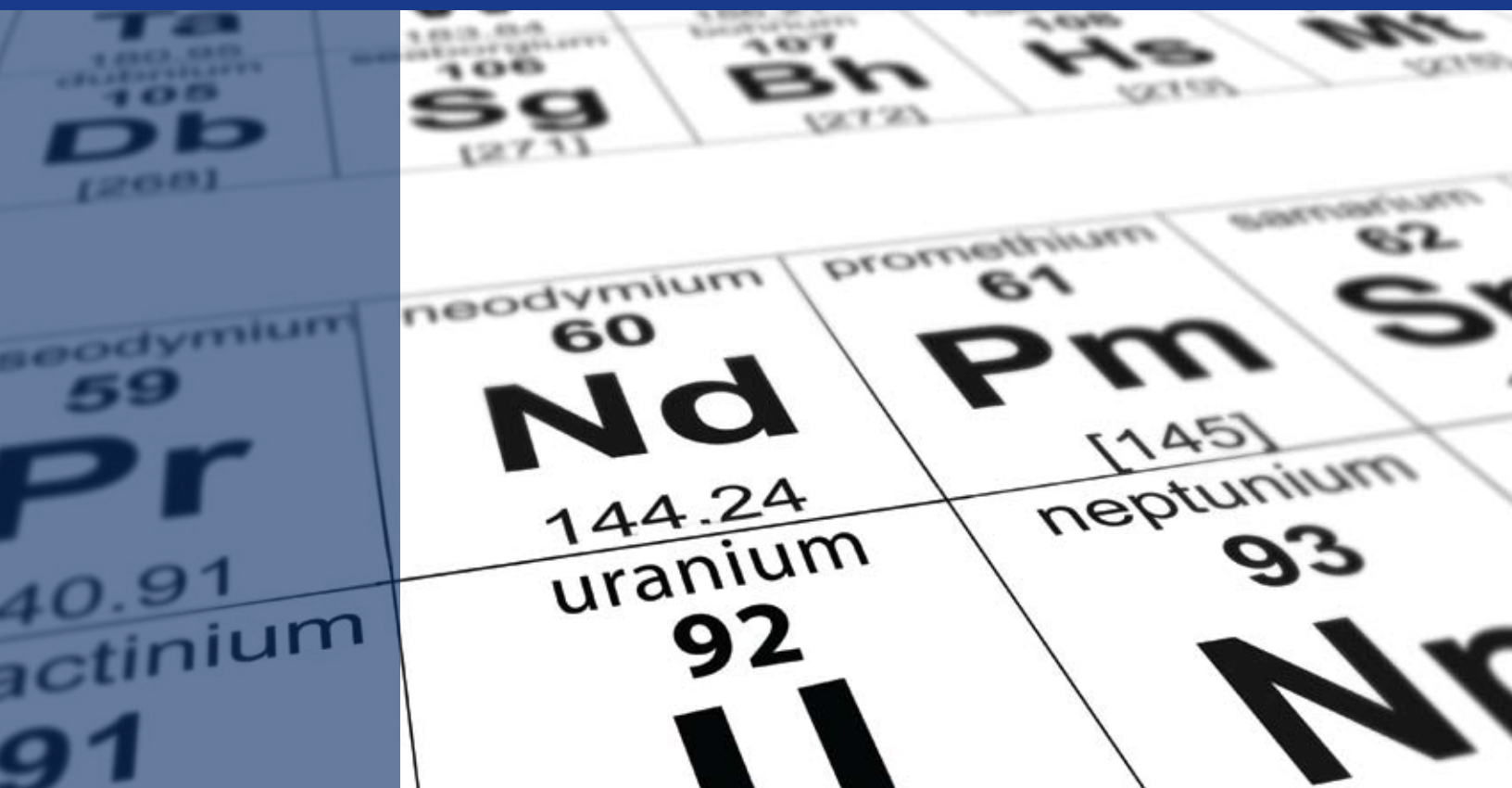




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Elements of Security

*Mitigating the Risks of U.S. Dependence
on Critical Minerals*

By Christine Parthemore



Center for a
New American
Security

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Mitigating the Risks of U.S. Dependence on Critical Minerals

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About the Author

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ELEMENTS OF SECURITY: MITIGATING THE RISKS OF U.S. DEPENDENCE ON CRITICAL MINERALS

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Executive Summary

Reliable access to critical minerals is a matter of both economic and geostrategic importance to the United States. Although concern about access to minerals waxes and wanes, it is rising now due to increasing demand, new competitors capturing large market shares and other trends that defy easy prediction. These same trends can interfere with foreign and defense policy goals and give mineral suppliers easy leverage over the United States and other countries reliant on global supply chains.

Despite renewed attention to critical minerals, America's dependence on these minerals is often misunderstood and miscast in the public debate. Recent tensions with China concerning the supply of rare earth elements, for instance, should challenge U.S. policymakers not because the United States' import dependence is inherently problematic (which it is not) or because rare earth minerals are scarce (which they are not). Rather, rare earths deserve attention because U.S. supply options are limited: Supplies are concentrated mostly in the hands of one supplier with its own rising demand, and the United States currently has no good options for recycling rare earth minerals or substituting more easily obtained minerals. While China is nearly the sole producer and exporter of rare earths today, it does not possess a permanent "corner" on this market. Indeed, China holds only about half of known world reserves – not a terribly high concentration.¹ The loss of a single major supplier such as China may therefore increase the costs of rare earth minerals, but may not affect their long-term availability. The issue, then, is more appropriately understood in terms of managing short-term risks such as disruptions and ensuring that the U.S. government's most important defense and energy needs can be met.

To manage these risks, the U.S. government needs to alter government policy, ensure access to correct information about mineral markets and better assess which minerals are required for a

small number of strategic needs, such as defense and energy. It must also use existing mechanisms, such as stockpiling and research and development funding, to help mitigate risks. The Department of Defense (DOD) can also understand its unique supply needs better by including mineral problems in relevant war games involving regions such as the South China Sea and Latin America.

U.S. policy should focus on:

- Preventing supplier countries and companies from wielding undue leverage over the United States.
- Mitigating fiscal risk and cost overruns in an era of budgetary strain.
- Reducing vulnerability to supply disruptions, especially for critical military assets.
- Ensuring the ability of the United States to meet its economic growth goals in clean energy and other high-tech fields.

The United States should not be complacent about its access to critical minerals. Political and economic risks to critical mineral supplies are still visible on the horizon and the stakes are high. Growing global demand coupled with the mineral requirements necessary for both managing military supply chains and transitioning to a clean energy future will require not only clearer understanding, but also pragmatic and realistic solutions.

Introduction

Minerals are a subject of much contention. On one hand, the United States remains less prepared for supply disruptions, price spikes and trade disagreements related to the global minerals trade than most experts realize. On the other hand, public concern over reliable access to the minerals required in key sectors of the U.S. economy, in particular those needed to produce military equipment, is growing. Too frequently, however, such concerns are based on inaccurate assumptions.

Risks Involving Minerals

- Leverage provided to sometimes-hostile suppliers.
- Persistent cost overruns in an era of budget cuts.
- Lags in military equipment delivery.
- Inability to fully develop clean energy technologies domestically.
- New roadblocks for achieving U.S. foreign policy goals around the world, especially in Asia.
- Trade disputes that entangle other U.S. security interests.
- Unintentionally funding human rights atrocities and fueling black markets.

A sober and informed analysis suggests there are real vulnerabilities, which place critical national security and foreign policy interests at risk. In worst-case scenarios, supplies of minerals that the United States does not produce domestically may be disrupted, creating price spikes and lags in delivery. Even short of major supply disruptions, supplier countries can exert leverage over the United States by threatening to cut off certain key mineral supplies. The United States may also lose ground strategically if it continues to lag in managing mineral issues, as countries that consider assured access to minerals as far more strategically important are increasingly setting the rules for trade in this area.

China's rising dominance is at the heart of this growing public debate. Its 2010 cutoff of rare earth elements² – a unique set of minerals that are difficult to process yet critical to many high-tech applications – attracted particular attention. After Japan detained a Chinese trawler captain over a skirmish in the East China Sea, Japanese companies reported weeks of stalled shipments of

rare earths from China amid rumors of an official embargo. This may sound like a minor trade dispute, but China currently controls production of about 95 percent of the world's rare earths, which are critical to building laser-guidance systems for weapons, refining petroleum and building wind turbines. Coinciding with possessing this incredible leverage over the rest of the world, China has also reduced its export quotas for these minerals. For its part, the Chinese government contended that it did not put any formal export embargo in place, and that its plans to reduce exports simply reflect the need to meet growing domestic demand for rare earths. Japan-China relations experienced further strain in their already tense relationship. In the United States, many reporters, policy analysts and decision makers did not foresee this challenge. Feeling blindsided, some in the United States characterized the situation in a manner that demonized China rather than using the opportunity to better understand the true nature of U.S. supply chain vulnerabilities.

The 2010 rare earths case and others are increasing interest in critical minerals among U.S. policy-makers. Congress held hearings on the strategic importance of minerals between 2007 and 2010, and the 2010 National Defense Authorization Act required DOD to study and report on its dependence on rare earth elements for weapons, communications and other systems.³ During a 2009 hearing on minerals and military readiness, Republican Representative Randy Forbes of Virginia called minerals, “one of those things that no one really talks about or worries about until something goes wrong. It’s at that point – the point where we don’t have the steel we need to build MRAPs [Mine Resistant Ambush Protected vehicles] or the rhenium we need to build a JSF [Joint Strike Fighter] engine that the stockpile becomes critically important.”⁴ In October 2010, Secretary of State Hillary Rodham Clinton stated that it would be “in our interests commercially and strategically”

to find additional sources of supply for rare earth minerals, and stated that China’s recent cuts to rare earth exports “served as a wakeup call that being so dependent on only one source, disruption could occur for natural disaster reasons or other kinds of events could intervene.”⁵ In January 2011, Sen. Mark Begich, D-Alaska, Sen. Lisa Murkowski, R-Alaska, and Rep. Mike Coffman, R-Colo., wrote a letter to Defense Secretary Robert Gates expressing concern for minerals required for producing defense equipment such as Joint Direct Attack Munitions (JDAMs), which stated, “Clearly, rare earth supply limitations present a serious vulnerability to our national security. Yet early indications are that DOD has dismissed the severity of the situation to date.”⁶ Additionally, the Department of Energy (DOE) launched a multiyear effort to explore potential vulnerabilities in supply chains for minerals that will be critical to four distinct areas of energy technology innovation.

While concern is growing, the media and policy-makers often focus too narrowly on what may seem the most compelling indicators – usually import dependence or scarcity – in prescribing solutions to reduce U.S. vulnerabilities, in particular to supply disruptions in critical minerals such as rare earths. This focus is sparking protectionist attitudes, with some worrying that import dependence poses an inherent risk to the U.S. economy. Discussion of minerals also frequently focuses on supply scarcity and resource depletion in absolute terms. However, both the rhenium and rare earth minerals disruptions of the past five years were triggered by deliberate decisions made by political leaders to leverage their positions of strength, not by market forces, disorder or scarcities of these minerals. Countries often revert to hoarding, pressuring suppliers and otherwise behaving as if scarcities are present even when they are not, based solely on concerns that shortages are likely in the near term. In fact, neither scarcity nor import dependence alone is sufficient to signal vulnerability, and a

TABLE 1: SELECT CRITICAL MINERALS AND THEIR USES

MINERAL	BRIEF DESCRIPTION	EXAMPLES OF USES	SPECIFIC ASSETS
Rare Earths Elements (REEs)	A class of minerals that share properties critical for advanced technologies and require extensive processing. Today, China controls more than 90 percent of global supplies.	• Automotive catalytic converters • Petroleum refining catalysts • Metallurgical additives and alloys • Glass polishing and ceramics • Computer monitors • Radar • Permanent magnets • Lasers • Range finders on tanks and other equipment • Target designators	• Joint Direct Attack Munitions (JDAMs) • BGM-109 Tomahawk • Jet fighter engines • Antimissile defense systems • AGM-84E Standoff Land Attack Missile • Smart bombs • Night vision goggles⁷
Gallium (Ga)	Gallium is an element with unique properties useful in manufacturing. Because it is found only in other mineral ores and does not exist alone in nature, reserves are difficult to estimate, and there are a limited number of suppliers.	• Integrated circuits • Semiconductor chips • Light-emitting diodes (LEDs) • Laser diodes • Solar cells • Opto-electronic devices (esp. in aerospace) • Telecommunications equipment	• Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS) system • Satellites • Radar and high-power radio-frequency applications and jammers⁸
Rhenium (Re)	A particularly heat-resistant mineral, rhenium is critical in building many aerospace components. Supplied by few countries, its prices have seen dramatic spikes in times of supply uncertainty and demand growth.	• Petroleum refining catalysts • Superalloys used in high-temperature turbine engine components • Semi-conductors	• F-16, F-18, F-22 Raptor, F-35 Joint Strike Fighter • C-40 Clipper • Divert and Attitude Control System (DACS)⁹

MINERAL	BRIEF DESCRIPTION	EXAMPLES OF USES	SPECIFIC ASSETS
Niobium (Nb)	Used frequently in producing superalloys and steel, known reserves are today primarily located in Brazil and Canada.	• Steel production • Alloys and metals used in aerospace production	• Divert and Attitude Control System (DACS) • Jet engines • Missiles¹⁰
Tantalum (Ta)	Tantalum is used in a wide array of applications for its high resistance to heat and wear, and other properties. It is critical in several high-tech components.	• Tantalum capacitors used in automotive electronics • Specialty steels • Personal computers • Portable phones	• Missile defense systems • Unmanned aerial vehicles • Smart phones¹¹
Lithium (Li)	The focus of much media attention due to its increasing use in advanced batteries, lithium is a commonly found mineral, but one that is often not economical to produce.	• Energy storage and advanced batteries • Alloys and metals for aircraft and space components • Medicinal uses • High-strength ceramics	• Improved Target Acquisition System (ITAS) used in the TOW missile • Non-Line-of-Sight Cannon (NLOS-C) • Hybrid-electric Humvees • Reconnaissance, Surveillance, Targeting Vehicle (RST-V) • Missile defense systems¹²

Note: Given the challenges described in this report of tracing what minerals are used in assets important to the U.S. government – let alone quantities needed – this table is intended to convey the types of systems that require these minerals. While some of the assets listed are no longer in high production or may represent future procurement, this table shows that policymakers should seek greater information on U.S. vulnerabilities to supply chain disruptions for a wide range of assets. Sources taken from those listed throughout this report’s endnotes, and others as specified.

combination of factors including concentration of suppliers is most often required for mineral issues to become security or foreign policy problems.

This report, based on two years of research, site visits and discussions with stakeholders, explores how the supply, demand and use of minerals can impair U.S. foreign relations, economic interests and defense readiness. It examines cases of five individual minerals – lithium, gallium, rhenium, tantalum and niobium – and rare earth elements, such as neodymium, samarium and dysprosium, as a sixth group in order to show the complexity of addressing these concerns. Each of these minerals is critical for defense technologies and U.S. economic growth plans. They share characteristics with minerals that have caused important political or economic concerns for the United States in the past. Additionally, lithium is frequently cited in the media and in discussions of how clean energy supply chains are critical to meeting America's future economic, energy and environmental goals. Within the past five years, two of these cases – rhenium and rare earth minerals – have involved supply disruptions or important threats of disruptions for the United States and its allies. Each of these minerals will require federal government attention in the coming years.

Assessing U.S. Vulnerability

Analysts vary widely in assessing the implications of U.S. dependence on critical minerals, despite broad acceptance of the physical reality that mineral resources are finite and the economic realities that requirements are ubiquitous and demand is growing. On one extreme, some analysts believe the 2010 incident between China and Japan suggests an approaching Hobbesian world in which resource demands outstrip supplies for minerals, nonrenewable energy sources and even food supplies. History indicates that conflict over absolute scarcities is unlikely. At the other end of the spectrum, many still believe that an open market and its invisible hand will continue to determine winners and losers with no serious repercussions

for the United States given its purchasing power. In between these extremes, even staunch pragmatists will point to the 2010 China rare earths episode as proof of one basic tenet: The United States and other market-based economies no longer determine all the rules of global trade.

Central to this narrative is a conundrum for policymakers. Reserve estimates show that global supplies of almost all minerals are adequate to meet expected global demands *over the long term*, and for decades into the future for most minerals. The U.S. Geological Survey (USGS) indicates, for example, that world supplies of rare earths will be adequate for more than 100 years.¹³ These estimates, however, can be meaningless *in the near term* if supplies are insufficient, or if suppliers reduce exports or otherwise manipulate trade. For example, most experts project that global production of rare earths will likely be insufficient to meet the world's demand over the next two to three years. The long-term sufficiency of supplies has no practical effect because it takes years and high capital costs to start up new mining and processing businesses for rare earths. Thus, the risks of inaction are high. A range of political, economic and geographic factors can disrupt supplies and cause price spikes that can create rifts in bilateral relations, trade disputes, accusations of economic sabotage and instability in countries that possess rare reserves of prized minerals. They can also give supplier countries extraordinary leverage that can alter geopolitical calculations, especially when single countries control most world supplies.

For U.S. policymakers, the risks fall into two rough categories: Disruptions, delivery lags and price spikes that affect military assets and place unanticipated strains on defense procurement budgets; and lack of affordable access to minerals and raw materials preventing important national economic growth goals.

The defense industrial base in the modern era differs greatly from any previous time. Often, actual scarcity is not required for problems to arise, as concerns about future scarcities often drive countries to behave as if shortages are occurring. The National Academies recently reported, “The risk of supply interruption arguably has increased or, at the very least, has become different from the more traditional threats associated with the more familiar ideas of war and conflict.”¹⁴ During World War I and World War II, for example, governments counted on domestic steel production – and even civilian willingness to contribute scrap materials for reuse and recycling – for tanks and other equipment. In contrast, modern warfare relies on globalized and privatized supply chains rather than a primarily domestic (and often government-run) network. Vulnerability to mineral supply disruptions is likewise far broader and more complicated than it was in previous eras.

Policymakers should also consider minerals that play uniquely important roles in the American economy. Rare earths, for example, are important in petroleum refining, which today enables the smooth functioning of the economy. Looking to the longer term, much concern is turning toward minerals that may see booming demand as the economy develops a greater reliance on energy efficiency and renewable energy technologies, such as the lithium used in advanced batteries and hybrid and electric vehicles. These minerals will directly affect U.S. economic competitiveness, and plans for improving economic growth and job development.

This vulnerability is not a new concern. Since the early 1900s, U.S. defense analysts and national policymakers have worried about U.S. vulnerabilities to supply disruptions of the minerals critical to manufacturing defense systems, from tanks and munitions to communications equipment. These concerns were generally heightened in wartime. The Organization of Petroleum Exporting

Countries (OPEC) oil embargo and related oil crises of the 1970s further brought into question the assumption that the United States could depend on imports, as it became apparent that broader global conditions and political decisions by other countries could dramatically hinder the U.S. ability to openly purchase sufficient commodities at affordable costs. This conclusion was reinforced when supply disruptions and threats of disruptions by apartheid-era South Africa, the hostile Soviet Union and its satellites led to a wave of congressional hearings, government reports and independent analysis of the conditions contributing to U.S. vulnerability.¹⁵

Following these Cold War-era events, policymakers held hearings and commissioned studies in order to understand which specific factors were most important in signaling that U.S. economic and security interests may be in jeopardy. American analysts generally agreed that the following factors were the most important to track:

- Level of substitutes and the uniqueness of specific minerals.
- Level of U.S. domestic supplies and dependence on foreign sources.
- Geographic concentration of supplies.
- Stability of producing countries and their region.
- Distances and routes of supply chains.
- Availability of technology to recover and process the minerals.
- Economic price of the resources themselves.
- Inability of foreign governments to coordinate minerals policies.
- Level of domestic demand in producing countries.

Some of these concerns remain today, but changes in technology, economics and the international security environment will pose new challenges as well. Analysts often pinpoint China’s rising resource

demand as the major new cause for concern, yet limited transparency and the changing nature of the defense industrial base and the broader economy will also affect U.S. mineral supplies in the coming decades. Looking forward, major concerns for the U.S. government will include: Lack of sufficient information for policymakers; understanding the evolving energy paradigm; increasing exploration of space and seabed territory; and a changing defense industrial base.

Poor information is a major obstacle to addressing critical mineral vulnerabilities, and it is creating conditions in which hype could drive policy debates.

Poor information is a major obstacle to addressing critical mineral vulnerabilities, and it is creating conditions in which hype could drive policy debates. For example, the media and others focused heavy attention throughout 2009 and 2010 on Bolivia's potentially large lithium supplies, often noting the populist, and at times erratic, behavior of the Bolivian president as a reason for great concern over future lithium availability. In reality, many independent experts agree that reliable exporters such as Chile and Argentina will prove to be the most important lithium suppliers for years, and supply gluts in the lithium market will continue for the foreseeable future even in the face of rising demand. Yet the popular media focus on lithium rarely, if ever, includes this market information.¹⁶

Identifying when and how mineral supply disruptions (or threats of disruptions) could affect U.S. defense industries or foreign relations is further

complicated by both often-long global supply chains and the nature of transactions. In some cases, natural disasters or strikes halt production at specific mines that produce large proportions of global supplies. In murkier cases, "disruptions" manifest as long contracting or legal delays (often intentional, for pricing or political reasons) or long lags in delivery. Whether disruptions are abrupt and clear, or long and uncertain, delivery times and prices of important energy technologies and military equipment can rise significantly. Today's global supply chains are incredibly efficient, as companies have worked to reduce the slack in their transit routes and shipping plans. This efficiency can save energy and money, but as infrastructure, routes and people are taken out of service, it also reduces options when things go wrong.¹⁷

Four other trends are changing the ways in which minerals affect U.S. security and foreign policy interests.

A NEW ENERGY PARADIGM

Efforts to develop alternative energy sources will influence the global demand for minerals. Governments around the world are promoting a more sustainable, lower-carbon energy paradigm that includes increasing adoption of renewable energy sources, energy efficiency technologies, advanced batteries and other products. Just as rare earths and other minerals are critical to petroleum production, developing and manufacturing wind turbines, solar energy systems and efficient batteries on a large scale will drive new mineral demands. In particular, energy storage will be critical in the coming decades for military-specific energy innovation, electric grid security, clean energy development and much more. As a result, the Obama administration has already identified energy storage as a key technology area for research and development investment. The Department of Energy has increased loans and grants related to energy storage, and DOD has begun fielding renewable energy generation and

advanced energy storage units in Afghanistan. Such significant investments in research and development are likely to produce new technologies that trigger major changes in global mineral requirements over the decades ahead, making it crucial for the U.S. government to monitor mineral supply chains.

A NEW SPACE RACE

Due to requirements for advanced technologies and components that can withstand extreme conditions, the expansion of countries' space capabilities over the coming decades will influence demand for critical minerals. A range of nations – from India to Iran – aim to bolster their reputations as space powers and develop more advanced satellite systems and launch capabilities. The U.S. government must therefore expect demand growth (and potentially growth that is not linear or predictable) for minerals like rare earths that are critical in space technologies. On the supply side, many countries are considering the possibility of mining space objects, and even the 2010 U.S. National Space Policy suggests that the United States should “identify potentially resource-rich planetary objects.”¹⁸

A REVOLUTION IN SEABED EXPLORATION

Seabed mineral exploration is high on the agenda for a range of countries and companies and, if major new supplies are discovered, will substantially change the global market for critical minerals. After decades of major investments in seabed exploration by scientists, petroleum producers and others, the world is experiencing great advances in the technical and economic viability of undersea exploration and exploitation. Countries seeking to mine these potentially important seabed mineral reserves may engage in territorial disputes as a result, even though doubt remains over whether, where and at what price seabed mineral supplies may become economical to produce. For example, territorial disputes over areas of the Arctic that are opening up to exploration and

in the South China Sea – areas seen as having great mineral supply potential – are already concerning U.S. military strategists and diplomats. The possibility of seabed mining is already fueling a renewed debate about whether the United States should ratify the U.N. Law of the Sea Convention (UNCLOS).

A GLOBAL DEFENSE INDUSTRIAL BASE

Given the state of the modern defense industrial base, the National Academies of Science determined in 2008, “The Department of Defense appears not to fully understand its needs for specific materials or to have adequate information on their supply.”¹⁹ In the information age, the U.S. military increasingly relies on dual-use equipment and depends on globalized supply chains. Military equipment for the modern battlefield includes communications technologies, robotics, computer systems and space assets that are used by DOD, civilian government agencies and private enterprises alike. Indeed, a 2008 Defense Science Board report noted, “Military-relevant technology will continue to change rapidly and will be increasingly global.”²⁰ Defense supply chains are, therefore, less distinct from those in the broader economy as they once were, and the dual-use nature of a broad range of assets also means that many supply chains are more globalized than ever. Moreover, “higher risk of and uncertainty about supply disruptions owing to the fragmentation of global supply chains”²¹ can further threaten assured access to critical minerals. Much of today's defense equipment is purchased directly from civilian vendors and designed to meet both civilian and military needs. Consider modern warfare's dependence on computer systems, satellites, radar and Global Positioning System. The National Academies study notes, “The globalization of materials production and supply has radically changed the ability of the United States to produce and to procure materials vital to defense needs,” and that the stockpiling system is inadequate given today's global supply systems.²²

The Evolution of Stockpiling

After experiencing several supply disruptions for minerals critical to war efforts, the United States established a stockpile of defense-critical minerals and raw materials in 1939. This stockpile has morphed greatly over the past seven decades, and its management is under renewed scrutiny now that minerals are once again emerging as strategically important.

Since the 1990s, Congress has instructed the Department of Defense (DOD) to sell off minerals from the National Defense Stockpile Center due to budgetary considerations, and because the minerals critical to defense assets at the height of the Cold War are no longer as relevant to modern military technology. However, Congress did not replace these stockpiles with minerals necessary for today's military and economy. For example, the U.S. government appears to stockpile tantalum and niobium, but it does not stockpile rhenium, gallium, lithium or rare earths.²³ While private companies may have reserves of these minerals in their own stockpiles, this information is not

always shared with the government. The lack of government-operated reserves can therefore prove worrisome in times of disruptions and allow suppliers to leverage exports for political ends.

To address this challenge, the Department of Defense is in the process of changing its stockpiling system. In 2008, a National Academies report declared, "The design, structure, and operation of the National Defense Stockpile render it ineffective in responding to modern needs and threats," and, "The Department of Defense appears not to fully understand its needs for specific materials or to have adequate information on their supply."²⁴ The Pentagon responded to this critique in April 2009 by setting plans to establish a Strategic Materials Security Management System to evaluate DOD mineral needs and develop stockpiling strategies more comprehensively.²⁵ Yet, at a hearing just a few months later, one expert noted that this stockpiling approach focuses on mineral shortages during "a full-scale national security emergency."

The expert argued that assessing stockpiling needs should more broadly "encompass a range of less than full-scale emergency conditions [to] plausibly include potential material supply disruptions due to natural disasters, political instability in key foreign countries and selective terrorist attacks."²⁶

Despite Pentagon efforts to improve U.S. stockpile management, many members of Congress still worry that DOD is not taking threats of minerals supply disruptions seriously enough, and that it may be placing too much faith in the private sector to address the strategic threats posed by threats of supply disruptions to critical minerals. To mitigate these concerns, DOD should be more transparent about its mineral policies, including its process of reconfiguring the stockpile. Even if Pentagon officials believe that they can develop proper inventory strategies to hedge against challenges to military readiness, they will still require congressional support for their efforts to continue modernizing the stockpiling system.

These risks, coupled with long-enduring vulnerabilities, are heightening concerns about U.S. access to minerals. We can gain an even deeper understanding of the security challenges involved by examining specific minerals in detail.

Economic, Geographic and Political Risks

Though supply chains differ for every mineral, several steps are common across most of these supply

chains and can help analysts identify potential points of vulnerability. Once potentially profitable reserves are discovered, companies must obtain the technology, permits and capital needed for mineral extraction. Since most minerals are not pure ores – extracted resources typically contain many different materials in various concentrations – the minerals must be processed and separated. Unless the deposits are processed on site, the minerals

may be shipped multiple times before they are ready to use. Many minerals are sold in commodities markets, which requires additional physical shipment or financial steps. Finally, the minerals are purchased, shipped to the consumer and used.

Analyzing this supply chain prompts the question: What factors should serve as warning signs to policymakers who want to better anticipate and mitigate mineral supply disruptions, trade disputes and other challenges? Most headlines focus on import dependence and the concentration of supplies in the hands of a single country. As this section will show, however, additional geographic, economic and political factors also affect the degree to which mineral supplies challenge U.S. interests. These factors include whether substitutes are readily available, whether minerals can be recycled and reused, and whether the United States stockpiles them.

GEOGRAPHIC FACTORS

The geographic locations of mineral resources are mostly static, since the composition of the earth does not change dramatically on human timescales. However, our understanding of geology does change, which affects supply estimates. Geographic concentration of supplies is therefore a critical factor in determining vulnerability to disruptions.

Looking at the minerals examined in this report, in the past decade the most severe case of disruptions with national security implications involved rare earth elements, which are not particularly concentrated geographically. At least eight countries have known reserves, and unknown reserves are expected to be high. The media often refers to China as dominating the rare earths market because it produces and exports almost all of current world supplies, but it possesses only about half of known world reserves – not a terribly high concentration.²⁷ The loss of a single major supplier such as China may therefore increase the costs of rare earths. However, it may not affect their long-

term availability, as eventually supplies will be developed elsewhere.

Similar to rare earths reserves, lithium is not highly concentrated despite its small number of current suppliers. Chile holds about 58 percent of currently known lithium reserves, but at least seven other countries have identified significant reserves. Additionally, Bolivia, Afghanistan and other countries possess significant lithium resources that are not yet quantified due to lack of existing infrastructure and because prices are not high enough to make their estimation and production profitable.²⁸ Gallium presents a difficult case, as it is found only in other mineral ores; deposits do not exist alone in nature. According to the USGS, “Only part of the gallium present in bauxite and zinc ores is recoverable, and the factors controlling the recovery are proprietary. Therefore, an estimate of current reserves comparable to the definition of reserves of other minerals cannot be made.”²⁹ However, neither bauxite nor zinc (the two minerals most often found with gallium) is highly concentrated geographically.³⁰

Other minerals important to the U.S. economy appear to be more geographically concentrated. Chile holds about 52 percent of quantified world reserves of rhenium, followed by the United States (with about 15 percent of reserves) and many other smaller-scale producing countries. Known tantalum reserves are even more concentrated, mostly in Australia and Brazil, and Brazil also possesses between 80 percent and 90 percent of the world’s niobium deposits.³¹

Geography affects supply in ways that are not always intuitive. For instance, it seems logical that vulnerability would correlate directly with distance: The further minerals must travel to their end user, the greater the risk that something will go wrong. The globalization of supply chains discussed above, however, has made the length of routes increasingly irrelevant.

Today, chokepoints and routes through unstable locations are more important. In some cases, air transit is more economical or practical than maritime freight, which could reduce opportunities for disruptions despite long distances between exporter and importer. Likewise, supplies traveling through unstable or inefficient Latin American countries, or through the most violence-plagued Mexican cities, could potentially be vulnerable to disruption despite their relatively short journey to the United States.

ECONOMIC FACTORS

When examining whether specific minerals will be available to meet U.S. government needs, it can be tempting to look simply at whether world supply is adequate to meet global demand over the long term. This is an accessible metric, and one that USGS estimates regularly. According to USGS calculations, the world's supplies are adequate to meet long-term demand for each of the minerals examined here – gallium, lithium, niobium, rare earths, rhenium and tantalum – for decades in absolute terms.

This long-term picture is deceptive, however. Policymakers should instead consider a range of nuances in evaluating mineral-related vulnerabilities. For instance, when production costs are too high relative to prices, mines can shut down – temporarily or for years – and supplies can decline in the short term regardless of long-term supply sufficiency. Many countries that hold large reserves also lack the technology, expertise or funding to develop these minerals on their own, which can lead to greater concentration of suppliers. Today this is of greatest concern for gallium, rare earth minerals and rhenium given their limited number of suppliers.³²

Many economic factors can influence the supply of critical minerals to the United States, but they are often oversimplified or misinterpreted. Import dependence, for example, is not inherently

problematic, but it can cause great problems for the United States if suppliers refuse to meet demand for political reasons or to ensure supplies for their own manufacturing sectors, as occurred with China's reduction of rare earths exports.

Though the economics of most every mineral are unique, those examined in this report share several important dynamics.

United States demand for minerals changes over time as the government and industries develop new military platforms and invest in new technologies. As DOD makes acquisition decisions, for example, it creates new dependencies and increases demand for specific minerals and raw materials. Other countries often design interoperable systems, similar capabilities or purchase from U.S. manufacturers, thereby amplifying global demand. Changes in domestic demand in mineral-producing countries can also affect export levels or prices if supplies do not increase commensurately. However, clear information on domestic demand in foreign countries can be elusive, since many countries do not thoroughly collect or publicize this information. Translation and financial costs can also present barriers.³³

The overlap between military and private sector needs can complicate tracking shifts in demand and their implications given the military's dependence on dual-use technologies such as communications equipment, computers and satellites. This makes the defense-related supply of critical minerals vulnerable to the rise and fall of commercial demand. All minerals examined in this study are dual-use in U.S. consumption: Niobium is used mostly in steel production and aerospace applications; rare earth minerals are in everything from computer monitors to satellites; and rhenium is used in turbine engine components and in superalloys because of its heat resistance and other properties.³⁴

An important factor is whether a given mineral has unique properties that make substitution difficult or impossible. For many minerals and raw materials, consumers have options to substitute different minerals with similar properties if something is unavailable or too costly. Others possess properties for which scientists and manufacturers have yet to find substitutes. Rare earth minerals fall into this category. In many defense applications, for example, certain rare earths retain magnetism at extreme temperatures to a degree not readily found in other minerals. Niobium and tantalum can be replaced in some applications but with reduced effectiveness. For rhenium and lithium, however, there are a variety of substitutes in use today, with additional substitutes currently being tested and developed. Gallium can be replaced for many of its uses, although some substitutes are also vulnerable to disruptions and price spikes.³⁵

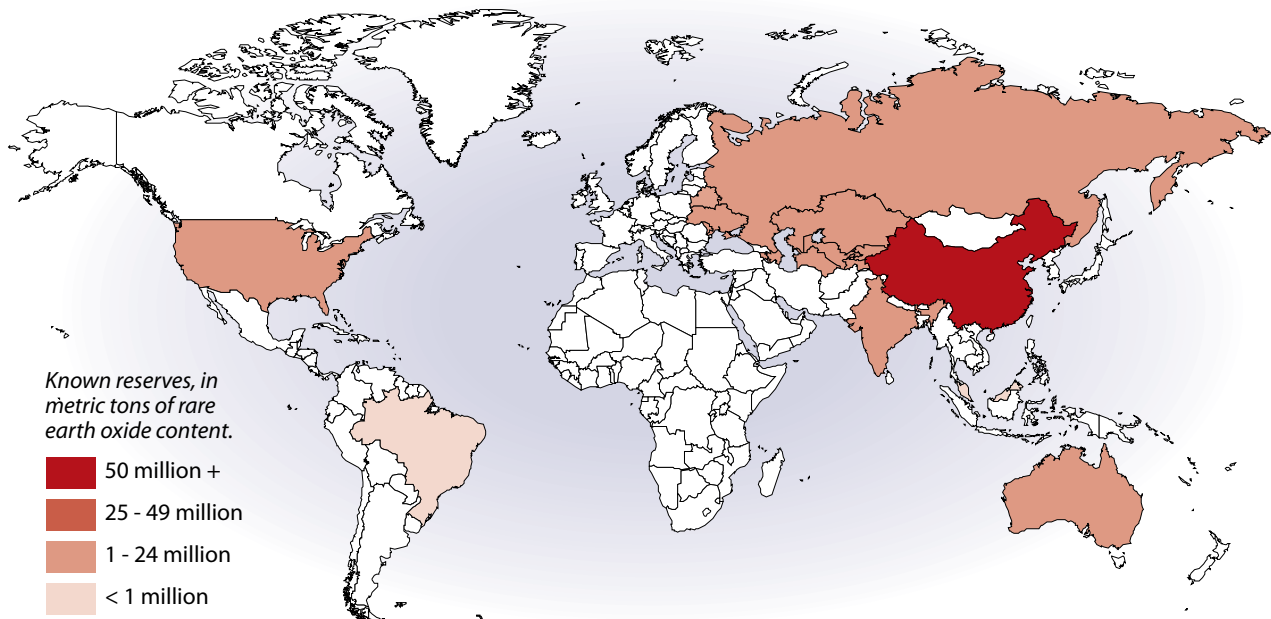
The ability to recover and recycle minerals economically can expand sources of supply. Minerals can be removed from manufactured items that are headed for the landfill, extracted and then recycled. Lithium, for example, has good recycling potential, and economical recycling and reuse is being researched extensively. Gallium can be recovered and reprocessed in some cases, as can rhenium, niobium and tantalum. However, for most rare earths, very little material can be recycled or recovered economically given current technologies and methods.³⁶

A lack of domestic supplies and the resulting dependence on foreign sources is the economic factor identified most frequently as an indicator of U.S. vulnerability. This, however, is somewhat misleading. Many minerals are not (or are no longer) produced in the United States for environmental reasons or because U.S. production is more expensive than in other countries – not necessarily because American deposits of the minerals cannot be found. As global demand growth generates higher prices, the costs of extraction in the United

States may become tolerable, making domestic supplies economical. For example, although the United States has been 100 percent dependent on imports of rare earths for years, this was not always the case. Several companies once extracted rare earths in California. The United States also imports 100 percent of its gallium, and it has not produced niobium or tantalum for decades.³⁷ From 2006 to 2010, import dependence for rhenium hovered between 80 and 86 percent, and dependence on foreign suppliers for lithium is only about 43 percent as of early 2011.³⁸ High import dependence for some minerals also coincides with reduced demand within the United States, given the dramatic changes in the American manufacturing sector over the past several decades. At the same time, the United States relies on imports to meet 100 percent of its needs for at least 17 commodities,³⁹ and in most cases, this dependence has had no geopolitical or foreign policy repercussions.

Finally, examining the concentration of suppliers helps identify vulnerabilities to disruptions. Various economic conditions can lead to concentration of suppliers, for example when low labor costs or environmental advantages in one country price other potential producers out of the market. The United States has relied on China for an average of 92 percent of its rare earths supplies since 2006. It also relies on Brazil for 84 percent of its niobium supplies, on Chile to meet 93 percent of its rhenium metal powder demand and Kazakhstan for more than half of its supplies of ammonium perrhenate, a common form in which rhenium is traded. In contrast, the United States imports tantalum from a far more dispersed network of suppliers; it imports only 17 percent of supplies from its top suppliers, Australia and China, and receives tantalum from more than a half dozen additional countries. Likewise, Germany, the top single U.S. supplier of gallium, supplies only about 26 percent of U.S. demand.⁴⁰ Lithium provides a mid-range case in this area. Chile supplies about

KNOWN RESERVES OF RARE EARTH MINERALS



Source: USGS Mineral Commodity Summary 2011

Known reserves worldwide totaled 110 million metric tons as of January 2011. The Commonwealth of Independent States combined hold 19 million metric tons. Additionally, other countries hold a combined 22 million in known reserves.

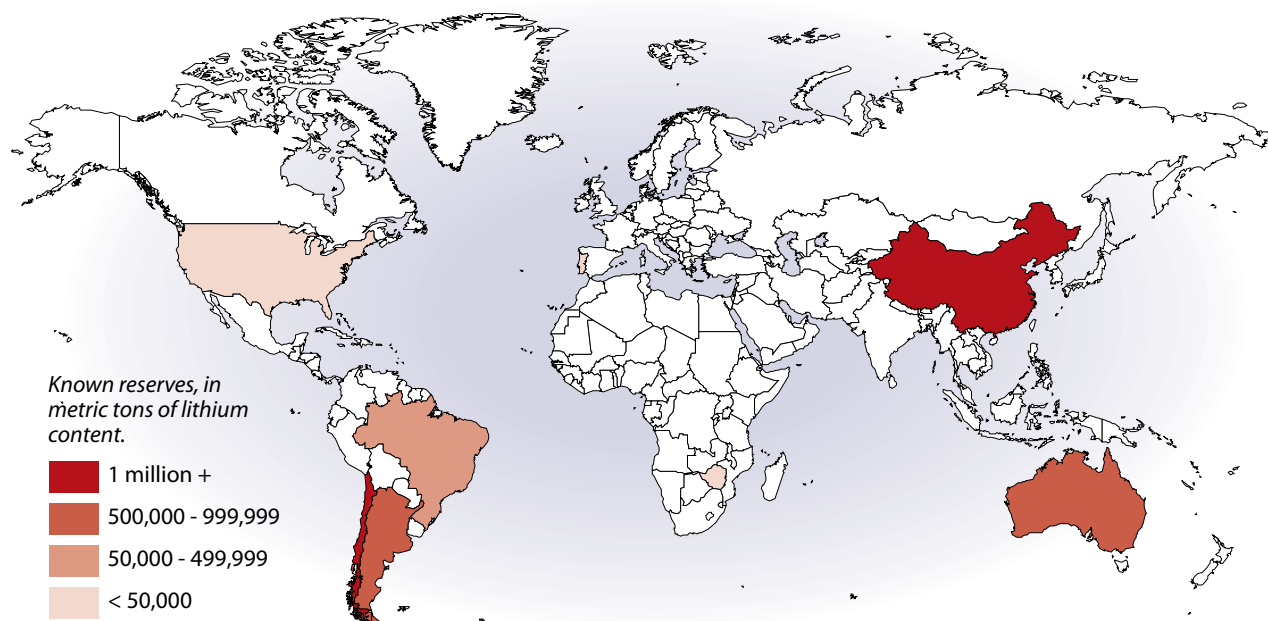
IMPORT SOURCES OF RARE EARTH MINERALS



Source: USGS Mineral Commodity Summary 2011

Other countries produced 2 percent of supplies to the United States.

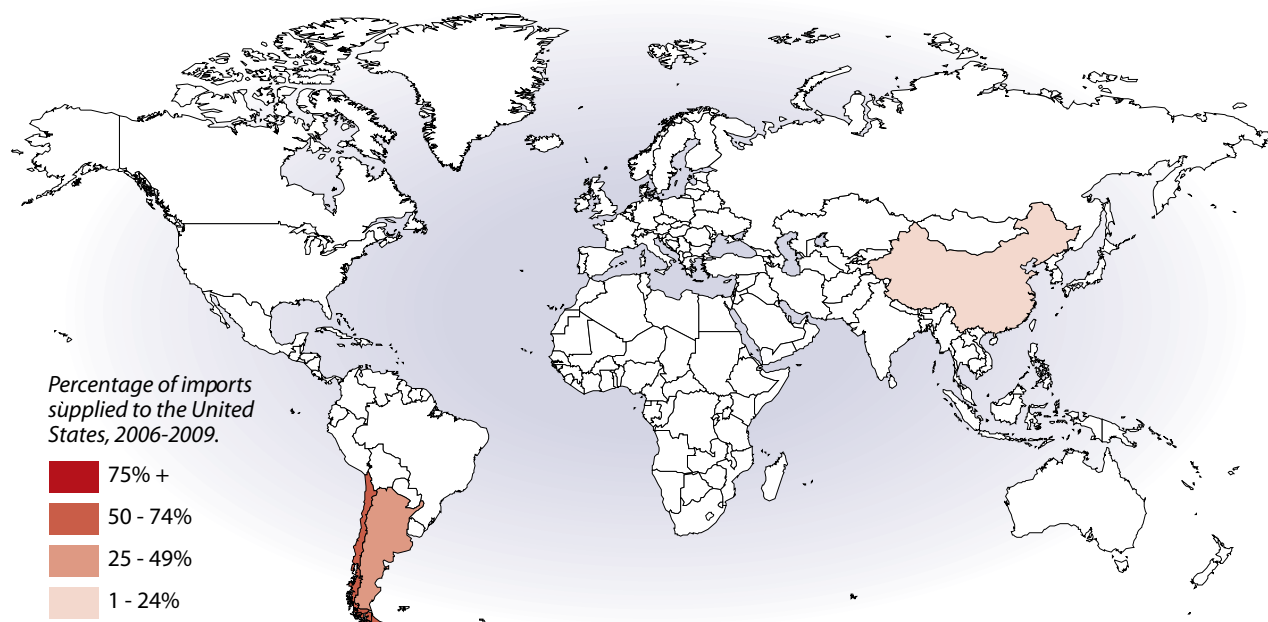
KNOWN RESERVES OF LITHIUM



Source: USGS Mineral Commodity Summary 2011

Total known reserves worldwide totaled 13 million metric tons as of January 2011. Note that Bolivia and other resource holders are not listed by USGS until their known reserves are quantified.

IMPORT SOURCES OF LITHIUM



Source: USGS Mineral Commodity Summary 2011

Other countries produced 2 percent of supplies to the United States.

59 percent of U.S. lithium consumption, with 38 percent of the remaining demand being met by Argentina. Although global supplies of lithium are not at all concentrated, Chile's uniquely dry environment, high-quality resources and well-developed infrastructure make it by far the most economical place in the world to produce lithium.⁴¹

POLITICAL FACTORS

Supply disruptions can result from political or policy decisions, either by the United States or other governments. Many political factors, however, are difficult to quantify. Beyond regulations, important political factors include: instability in producing countries and their regions, labor strikes and insufficient U.S. government stockpiles.

Geopolitical calculations and domestic political factors can both influence mineral supply availability. In some cases, producers (whether companies or countries) deliberately withhold supplies. Their decisions to do so depend, in part, on their calculation of the economic impact of disrupting supplies, and their ability to control the global market. The 2010 Japan dispute with China over a skirmish in the East China Sea serves as an example. In this case, Chinese officials denied that the country had instituted an official embargo, but Japanese firms continued to report supply disruptions for several weeks.⁴² These types of bold geopolitical moves can generate sticky foreign policy problems in addition to the direct effects of supply disruptions.

Interestingly, while political stability of producing countries and their regions has influenced the supply of minerals historically, stability of supplier countries does not appear very important for the minerals discussed in this report. Every year, *Foreign Policy* magazine and the Fund for Peace produce the Failed States Index, an annual report on state stability that ranks all the countries of the world. China, today's primary producer of rare earths, ranked as the 57th-least stable country in the world in 2010, though it is not classified as being within the index's "alert" zone.

Potential rare earth minerals-producing countries, including the United States, Australia, Brazil and Malaysia, all rank as even more stable. Rhenium- and lithium-producing countries generally rank as moderately or primarily stable, including the United States, Canada, Australia and Chile, with Zimbabwe, Russia and Kazakhstan among the less stable exporters of these two minerals. For gallium, all but two important producers (China and Russia) are among the most stable half of countries. The major producers of niobium (Brazil and Canada) and tantalum (Australia and Brazil) are also generally stable.⁴³

Though this index evaluates political conditions only at the state level, political disruptions can occur at the local level as well, most notably in the form of labor strikes. The 2010 USGS minerals commodity summaries and other U.S. government assessments highlight three cases of strikes disrupting minerals supplies over the past five years (to bismuth, cobalt and nickel), but do not indicate that strikes affected any of the minerals examined in this report.⁴⁴

At the national level, leaders alter export quotas, subsidize domestic production or increase the stockpiles of minerals critical to defense needs based on political considerations – including misperceptions. Overconfidence in or lack of attention to minerals markets can also lead to political complacency. In the United States, for example, Congress has instructed DOD to sell off minerals from the National Defense Stockpile Center since the early 1990s due to budgetary considerations but did not invest in increasing stocks of minerals important to emerging technologies.⁴⁵

Sometimes internal politics motivates foreign suppliers' decisions about whether to export critical minerals. For example, in 2007, the U.S. State Department was forced to intervene when China halted shipments of rare earths to a U.S. petroleum refining and chemicals company for so long that it drove concerns for nationwide refined petroleum shortages.⁴⁶ From China's perspective,

Since the United States depends on minerals for its defense and economic vitality, it is time to update American policies to reflect current global conditions.

domestic demand was rising quickly, and rare earths production was already creating major environmental problems that could unleash local unrest. The country's political leaders therefore began restricting exports and promoting efficient consumption.

Political crises can also disrupt supplies. In 2005 and 2006, the United States experienced a supply disruption in rhenium, triggered by a domestic dispute in Kazakhstan. Exports from Kazakhstan, which supplied 25 percent of the U.S. demand at that time, "were halted from the third quarter of 2005 until the fourth quarter of 2006."⁴⁷ A supplier to Kazakhstan's state-owned rhenium producer blocked trade over a financial dispute amid additional political tensions between governing officials who variously wanted to open rhenium reserves for foreign investment and, on the other side, expand the state's monopoly.⁴⁸ By early 2006, rhenium prices were rising precipitously just as demand was increasing for use in petroleum refining and, important for DOD, in jet engine production.⁴⁹

Recommendations for U.S. Policymakers

Since the United States depends on minerals for its defense and economic vitality, it is time to update American policies to reflect current global conditions. As policymakers address these issues, they must understand the complexity of the challenge and develop multifaceted solutions. No

policy prescription aimed at a single geographic, economic or political variable will reduce U.S. vulnerability to supply disruptions. Policymakers, nongovernmental analysts and the media must pay far less attention to singular factors like import dependence and focus on the full range of economic, geographic and political factors.

In developing new policies related to minerals, policymakers must remember that substantial government intervention already exists, including permitting exploitation on government lands and regulating environmental impacts. However, policymakers must navigate a market that is not always easy to predict and in which the need for federal government intervention (or nonintervention) is not always obvious. In the recent rare earths case, the private sector responded by providing some capital for a domestic mining operation to resume. This does not always solve the foreign policy and geopolitical challenges the U.S. government experiences. In particular, for minerals that private companies will not reliably produce or more defense-specific applications, U.S. government interests may be at stake while private interests are not.

To manage circumstances where the federal government must act to protect U.S. interests against the threat of supply disruptions, various federal agencies have existing mechanisms that must be preserved and utilized. The Departments of Defense and Energy already have mechanisms for offering low-interest loan guarantees for businesses in a broad range of strategically important fields, from semi-conductors to military assets to energy infrastructure. Similarly, these agencies can use loan guarantees to facilitate production or advance research and development related to minerals, including lending funds to support research on the more efficient use of rare earths, rhenium or lithium in defense or energy applications. Only a willingness to use these tools is required.

TABLE 2: KEY VULNERABILITIES FOR SELECTED MINERALS

TYPES OF VULNERABILITIES		REEs	Nb	Ta	Re	Ga	Li
Economic	Lack of substitutes/uniqueness of specific minerals (esp. in defense applications)	Yes	Yes/ No	Yes/ No	Yes	No	No
	Importance of specific minerals for producing defense equipment	Yes	Yes	Yes	Yes	Yes	No
	Inability to recover and recycle economically	No	No	No	No	No	No
	Import dependence for more than 90 percent of supplies	Yes	Yes	Yes	No	Yes	No
	Known supplies inadequate to meet projected global demand	Yes, in 2011/2012	No	No	No	No	No
	Concentration of suppliers to the United States (fewer than three suppliers for 2/3 or more of supplies) ⁵⁰	Yes	Yes	No	Yes	Yes	Yes
Geographic	Geographic concentration of supplies (more than 50 percent known reserves in single country's possession)	No	Yes	Yes	Yes	No	No
	Major natural disasters (that created major disruption to United States)	No	No	No	No	No	No
Political	Instability of producing countries and their regions	No	No	No	No	No	No
	Strikes	No	No	Yes	No	No	No
	Lack of U.S. government stockpile	Yes	No	No	Yes	Yes	Yes

Note: Table 2 lists the vulnerabilities identified through this report, and notes which minerals have exhibited each one between 2005 and the present. The “Yes/No” label in the first row indicates that substitutes may be available, but with a loss of characteristics that may be critical to defense assets. The only two minerals for which the United States experienced disruptions in the past five years, rhenium and rare earths, differ in whether reserves are geographically concentrated and in most economic factors. This indicates a need for policymakers to examine a wide range of factors specific to each critical mineral in order to best hedge against disruptions.

Source: Compilation of sources listed in the endnotes; table compiled and created by the author.

In making policy choices, policymakers should embrace one key principle: **avoid blanket protectionism**. While supporting domestic production may be a useful remedial action for some specific minerals, domestic production is not a panacea. Often, protectionist tendencies reflect a misdiagnosis of U.S. mineral problems as a result of import dependence, which this report shows is not the core problem in most cases. Moreover, protectionism could be an overly narrow policy solution that would not mitigate other serious risks. Since increased domestic production is not always possible or economical for all minerals, some dependence on imports is unavoidable.

To protect against the risks of dependence on critical minerals at an acceptable cost, the U.S. government should take the following steps:

Administration officials and Congress should identify the minerals most important to defense acquisitions, energy innovation and other key functions as they build tailored strategies to mitigate potential supply disruptions. In other words, government officials should evaluate mineral issues proactively as a regular, ongoing part of their operations. The Department of Defense and Congress have been largely reactive, responding to the recent rare earths disruptions and issuing one-off reports. By contrast, DOE has adopted a proactive approach that prioritizes the minerals most important to its missions. A major evaluation in December 2010 prioritized four distinct areas of energy technology development and explored mineral supplies of high importance to those particular categories, and DOE plans to regularly analyze potential risks and supply chain vulnerabilities in these areas.⁵¹ The Department of Energy's willingness to prioritize is particularly noteworthy: Given that DOE's work is global and involves more than 100 distinct minerals, seeking to address all contingencies could have negative side effects or be so broad as to lack effectiveness.

The Department of Defense should conduct new assessments of defense supply chains. Developing a proactive and prioritized approach will require serious consideration of the future of warfare, drawing on expertise from other government agencies, academia, non-governmental organizations, think tanks and private industries. While DOD is currently reviewing rare earths in its supply chains and will deliver its report to Congress in the summer of 2011, its efforts must not end with consideration of rare earths. The Defense Science Board should conduct a new assessment building on its 1999 and 2008 studies examining the changing nature of defense supply chains, to include more extensive consideration of minerals and raw materials.⁵² These two studies outlined many of the key dynamics that are heightening mineral and raw material concerns today and described DOD's increasing dependence on dual use technologies and global supply chains. However, neither study focused specifically on control of minerals or raw materials, which could give suppliers strategic leverage over the United States. Beyond these omissions, the nature of minerals trade and the global supply system have changed enough in the past five years that an update is warranted. The Defense Science Board would be sufficiently neutral and would complement the DOE's ongoing work by focusing specifically on defense needs.

To protect the U.S. government's ability to manage critical minerals appropriately, Congress should protect the government's role in analyzing critical mineral vulnerabilities and producing its own data. As congressional leaders in both political parties strive to reduce spending and seek efficiencies, they should maintain a strong U.S. government capacity for research and analysis – a public good that is both necessary to protect U.S. interests and undersupplied by the private sector. Without vigilance, the United States risks being blindsided by regular

trade disputes and supply disruptions, and by countries exerting political leverage. Improving how the U.S. government handles mineral issues should not require major increases in manpower or spending. But the administration and Congress must maintain the existing capacities and preserve the knowledge infrastructure that the government has redeveloped in the past few years (See Key U.S. Government Offices box).

In addition to continuing to produce good data, the U.S. government can do more to leverage its relationships with contractors. The private sector will continue to withhold important information in order to keep information proprietary or because it could be harmful to the bottom line if shared with the government. But when DOD, for example, has billion-dollar contracts with suppliers for critical military assets, it should be able to have contractual requirements that these companies share information about major supply chain vulnerabilities that can provide other countries with leverage over the United States or potentially cause major disruptions. The 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act is an important model for requiring due diligence in understanding and reporting supply chain information among manufacturers that source minerals from the Democratic Republic of the Congo.⁵³

The Department of Defense should integrate conflicts over minerals and raw materials into relevant war games. One of the chief risks in ignoring access to critical minerals is the leverage such negligence can provide to suppliers, which alters the strategic context in which DOD operates. Exploring how disruptions or threats of disruptions in mineral supplies could affect various American interests would provide valuable information for U.S. policymakers. Relevant games should include a range of scenarios in which supplies of minerals critical to defense equipment are cut off for extended periods of time and supplier countries use embargoes for political leverage.

Major seabed mining sites should be included as strategic locations in games focusing on the East and South China Seas and the Arctic, among other locations, just as energy resources and storage facilities are mapped in considering assets that countries may protect or target today. Appropriate scenarios would also include those involving great unrest or major, long-term strikes that halt exports from Latin America or South Africa.

Congress and the executive branch should update stockpiling policies. Stockpiling critical minerals (for example, those important to current and future defense production, concentrated in the hands of only a few suppliers and also experiencing high global demand growth) remains one of the best policies for ensuring supplies, especially for DOD. In a 2008 report, the National Academies recommended that DOD develop a new inventory system (versus simply stockpiling) that would “assess the risks in order to make better-informed decisions on mitigating them (for example, deciding if stocks need to be held),” “spot vulnerabilities in the supply chain and redesign it to eliminate or mitigate them before events occur” and “design and manage the supply chain to be more resilient to disruption.”⁵⁴ DOD has been working to update its stockpiling policies, and should fully embrace the National Academies report’s recommendations. Congress also has a role in supporting and funding these changes. (See the Evolving Tool of Stockpiling box) However, DOD should be far more open with Congress and the public regarding how it intends to modernize its stockpiling policies than it has been to date.

The U.S. government should create incentives to reduce consumption when its interests are on the line. This report focuses primarily on the nature of current and potential supply challenges, but solutions must also include reducing demand for minerals that see major disruptions or erratic prices. Policymakers can maximize the potential of substitution and recycling by clearly identifying

Key U.S. Government Offices

The following offices and agencies have in recent years proven to be among the most important in mitigating mineral-related risks to U.S. interests.

The U.S. Geological Survey's (USGS) work is critical for the government's ability to make sound policy given its unique ability to provide free, public data on mineral trends. Beyond what is provided by the USGS, most data that policymakers need to make decisions is prohibitively expensive to purchase from private vendors, if it is available at all. Without USGS efforts to provide the government and public with neutral information and unbiased analysis, the United States would be forced into a persistent reactionary state whenever concerns about minerals arise – and the U.S. government will be far less well equipped to deal with episodes like the 2010 rare earths dispute with China.

The Department of Energy's Office of Policy and International Affairs has conducted the federal government's most important work to date in analyzing how the changing global minerals trade and America's goals for energy intersect. The Department of Energy (DOE) should maintain this capacity going forward, with support from the Congress.

The Obama administration's fiscal year 2012 budget for DOE recommends creating an "Energy Innovation Hub" focused on minerals critical to energy innovation, modeled on existing hubs focused on alternative fuels and energy efficiency.⁵⁵ Congress should approve this budget request, and take an active role in monitoring the effectiveness of this hub as it is established and begins operations.

Also at DOE, the Advanced Research Projects Agency-Energy has played an important role in

identifying mineral supply chain concerns related to energy innovation. It also funds unique research and development that may help reduce U.S. vulnerabilities, such as developing substitutes for rare earths and permanent magnets that may help minimize the risks for defense-critical assets.⁵⁶

The White House Office of Science and Technology Policy (OSTP) is coordinating an inter-agency working group to prevent U.S. government agencies from being blindsided by supply disruptions and minimize broad mineral-related vulnerabilities. In this role, OSTP should include representation from the State Department's regional bureaus to improve U.S. government coordination among relevant stakeholders. OSTP could also play an important role in developing accepted economy-wide definitions for "critical" and "strategic" minerals.

the minerals for which U.S. government interests are affected most directly, and then offering incentives to develop substitutes for these minerals. Developing efficient solutions, however, will require addressing the daunting information challenges discussed earlier.

The Senate should ratify the U.N. Convention on the Law of the Sea (UNCLOS). While today the United States recognizes UNCLOS as customary international law, ratifying this treaty would increase the ability of U.S. policymakers to promote

the rule of law and freedom of navigation around the world and also to participate in important discussions about critical minerals. Today, the United States cannot play a full role in the Arctic Council because it has not ratified UNCLOS, and its position of promoting the rules enshrined in this treaty rings hollow to international audiences. Since American concerns over seabed mining informed the initial refusal to ratify this treaty, these issues are likely to resurface in any debates about UNCLOS. To date, efforts toward UNCLOS ratification have stalled out of a misguided notion that the treaty would

Minerals and Conflict in the Democratic Republic of the Congo

Black market and even legal trade in minerals can directly fuel conflict, instability, corruption, human rights atrocities and other broad foreign policy and security concerns. The most glaring current example is in the Democratic Republic of the Congo (DRC), where trade in minerals such as tin, copper and Columbite-tantalite (coltan) funds militias that have killed, raped and robbed millions, and that perpetuate regional instability.

International concern had grown in recent years over the ways in which minerals contribute to conflict in the DRC. During her August 2009 trip to the DRC, Secretary of State Hillary Clinton remarked, “I think the international community must start looking at steps we can take to try to prevent the mineral wealth from the DRC ending up in the hands of those who fund the violence here ... this is a very challenging problem but we’re going to address it.”⁵⁷ Embargoes and other traditional tools for

stemming this problem, however, would prove ineffective. Many minerals found in the DRC are produced in only a few mines globally or can be purchased more cheaply from sellers in this war-torn country than elsewhere, leaving no shortage of buyers. Due to corruption and the informal nature of much of the DRC’s economy, even if Congolese officials wished to provide greater transparency on its minerals trade, they would have great difficulty doing so.

At the same time, the DRC example also highlights potential solutions available to U.S. policymakers. To date there has been little effort by manufacturers to track where the minerals they use originate, providing little incentive for any company or country to cease purchasing minerals that fuel conflict in the DRC. This is beginning to change. The 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act requires due diligence in understanding and reporting supply

chain information among manufacturers that source minerals from the DRC.⁵⁸ The United Nations and other nongovernmental organizations are similarly working to require greater transparency and source reporting in minerals supply chains as a means of curtailing support for militant groups.⁵⁹ The executive branch should continue to enact the Dodd-Frank bill, and maintain direct involvement in efforts by the United Nations, private companies and other groups that are working to establish certification processes, due diligence requirements and other transparency measures. This movement toward greater transparency can make it easier to tell when money is being transferred to militants and human rights violators, and therefore easier to find ways to cut off this minerals-related funding of rogue groups. Though these efforts are imperfect, they can assist in minimizing the ways in which U.S. minerals procurement fuels other security challenges.

negatively affect U.S. sovereignty, as it recognizes exclusive economic zones for countries around the world. Ratification, however, has strong support from the armed services, the private sector and a wide range of security and foreign policy experts. Despite the lack of a strong political constituency for ratification, there is widespread belief that the treaty is integral to protecting U.S. economic and security interests in U.S. coastal areas, and in serving as a neutral voice in territorial disputes in regions like

the South China Sea. Growing mineral concerns will make ratification all the more pressing.

Finally, Congress and the executive branch should promote information sharing with the private sector and internationally. Regular dialogues and information sharing among the U.S. Departments of Energy, State and Defense, and industry and international stakeholders can be a cost-effective means of helping the U.S. government prevent mineral disruptions and trade disputes from

Complacency is perhaps the biggest risk facing the United States. Given the global trends highlighted in this report, a variety of mineral-related risks are visible on the horizon.

negatively affecting U.S. foreign policy goals, defense readiness or economic growth. Over time, regular dialogues and greater transparency can help policymakers to access better information on minerals, and can create an “in-group” mentality in which companies and government agencies alike increasingly see the professional benefit for sharing certain types of information. For instance, more open dialogue can provide important information to companies on emerging government concerns and geopolitical trends that may affect their businesses.

Conclusion

It is time for the United States to reassess its dependence on critical minerals. America’s vulnerability to mineral supply disruptions carries a number of persistent risks: high cost overruns for weapons that rely on key minerals, lags in military equipment delivery, leverage provided to supplier countries and an inability to fully develop clean energy technologies. Global demand for minerals – and the ways in which minerals affect security and foreign policy concerns – will also continue to evolve. Countries other than China may attempt to use the leverage created through controlling majority shares of global supplies. Technology will evolve in non-linear ways, and new mineral demands may challenge the United States in ways not predictable today. A systematic evaluation of the factors involved with mineral supplies will be required,

or else policy will be based on conjecture and unproven assumptions about this area of trade.

Complacency is perhaps the biggest risk facing the United States. Given the global trends highlighted in this report, a variety of mineral-related risks are visible on the horizon. The U.S. government should be proactive in preventing mineral issues from impinging on security, foreign policy or economic growth plans, and not lose its newfound vigilance in the years ahead.

ENDNOTES

1. U.S. Geological Survey, "Minerals Commodity Summaries" (2010): 129.
2. Rare earth elements are a class of minerals with similarly unique physical and chemical properties, including yttrium, lanthanum, neodymium, samarium and europium. These minerals are not actually rare in nature; however, they are found in such small concentrations that extensive, precise processes are required to separate these minerals. Because of their unique properties – for example, some retain magnetism at extreme temperatures – these minerals are important in an array of modern technologies such as laser-guidance systems, telecommunications equipment, satellites and permanent magnets used in jet engines. For a good overview on rare earths, see David Biello, "Rare Earths: Elemental Needs of the Clean-Energy Economy," *Scientific American* (13 October 2010).
3. "Text of H.R. 2647: National Defense Authorization Act for Fiscal Year 2010," <http://www.govtrack.us/congress/billtext.xpd?bill=h111-2647>.
4. Opening Statement by Rep. Randy Forbes, R-Va., "House Committee on Armed Services, Subcommittee on Readiness Holds a Hearing on the National Defense Stockpile" (23 July 2009).
5. Secretary of State Hillary Rodham Clinton, "Briefing by Secretary Clinton, Japanese Foreign Minister Maehara," U.S. Department of State (27 October 2010), <http://www.america.gov/st/texttrans-english/2010/October/20101028123524su0.6718823.html#ixzz1HXW7Fpcs>.
6. Sen. Mark Begich, D-Alaska, Sen. Lisa Murkowski, R-Alaska, and Rep. Mike Coffman, R-Colo., Letter to Secretary Robert Gates (28 January 2011).
7. See, for example, Mark Begich, Lisa Murkowski and Mike Coffman, "Letter to Secretary of Defense Robert Gates," (28 January 2011); James B. Hedrick, "Rare Earths in Selected U.S. Defense Applications," paper presented to the 40th Forum on the Geology of Industrial Minerals, Bloomington, Ind., (2-7 May 2004); Marc Humphries, "Rare Earth Elements: The Global Supply Chain," *Congressional Research Service* R41347 (30 September 2010); Peter Robison and Gopal Ratnam, "Pentagon Losing Control of Bombs to China's Monopoly," *Bloomberg* (29 September 2010), <http://www.businessweek.com/news/2010-09-29/pentagon-losing-control-of-bombs-to-china-s-monopoly.html>; Jeffrey A. Green, "Defense, Energy Markets Should Brace for Shortage of Key Materials," *National Defense* (October 2009): 16-18; and John T. Bennett, "Bill Calls for the Establishment of First U.S. Rare Earth Minerals Stockpile," *Defense News* (18 March 2010), <http://www.defensenews.com/story.php?i=4545073&c=POL&s=TOP>.
8. See, for example, "Missile Systems Integration to Take More of Raytheon's Defense Work," *Inside Missile Defense* 11: (7 December 2005); "Raytheon Integrated Defense System: gallium nitride chips achieve operational milestone," *Military and Aerospace Electronics* (1 September 2009), <http://www.militaryaerospace.com/index/display/article-display/368554/articles/military-aerospace-electronics/online-news/raytheon-integrated-defense-system-gallium-nitride-chips-achieve-operational-milestone.html>; Dave Majumdar, "GaN Revolution: After Long Germination, Industry Readies High-Power Chips," *Defense News* (28 February 2011), <http://www.defensenews.com/story.php?i=5819236>; and "Large-Area Hydride Vapor Phase Epitaxy of Gallium Nitride," *Defense Tech Briefs* (1 June 2010), <http://www.defensetechbriefs.com/component/content/article/8006>.
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28. *Ibid.*: 95; and author interview with U.S. Geological Survey officials.

29. *Ibid.*: 59.

30. *Ibid.*: 27, 189.

31. *Ibid.*: 111, 131, 163.

32. *Ibid.*: 59, 129, 131.

33. Information on global demand by country can be available through expensive trade and investment reports that can cost thousands of dollars per document. However, one can imagine that issues of translation, false and inadequate information – and the proprietary nature of much relevant information – affect the accuracy of the data in these publications as well.

34. U.S. Geological Survey, "Minerals Commodity Summary" (2011): 110-111, 128-129, 130-131.

35. *Ibid.*: 58-59, 94-95, 110-111, 128-129, 130-131, 162-163.

36. *Ibid.*

37. *Ibid.*: 58, 110, 128, 162.

38. *Ibid.*: 94, 130.

39. National Academy of Sciences, "Managing Materials for a Twenty-first Century Military," Committee on Assessing the Need for a Defense Stockpile, National Research Council (Washington: National Academies Press, 2008): 47.

40. Percentages averaged between 2006 and 2009. U.S. Geological Survey, "Minerals Commodity Summary" (2011): 58, 110, 128, 130 and 162.

41. Author interview with U.S. Geological Survey expert; U.S. Geological Survey, "Minerals Commodity Summary" (2011): 94.

42. See, for example, "China Halts Top-Level Ties with Japan over Dispute," *BBC News* (19 September 2010); Risa Maeda and Chikako Mogi, "Japan Trade Min. Hears China Rare Earth Exports Halted," *Reuters UK* (24 September 2010); and Jae Hur and Emi Urabe, "Ohata Urges China to Export More Rare Earths as 124 Firms Face Shortages," *Bloomberg News* (5 October 2010).

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46. Kent Garber, "America's New Energy Dependency: China's Metals," *U.S. News & World Report* (1 July 2009).

47. Michael J. Magyar, "Rhenium," *USGS 2006 Minerals Yearbook* (March 2008).

48. *Ibid.*

49. An additional disruption at a Chilean mine in 2008 further tightened the market and sent prices soaring. See "Majilis withdraws draft law on state monopoly after prime minister's speech," *Kazakhstan General Newswire* (28 June 2006); Ovid Abrams, "Supply shortage sends rhenium prices soaring," *Metals Week* (13 March 2006); and "Rhenium supply tight," *Metals Week* (2 June 2008).

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51. Department of Energy, "Critical Materials Strategy" (December 2010), <http://www.energy.gov/news/documents/criticalmaterialsstrategy.pdf>.

52. These two reports are titled "Creating an Effective National Security Industrial Base for the 21st Century: An Action Plan to Address the Coming Crisis" (2008) and "Final Report of the Defense Science Board Task Force on Globalization and Security" (1999).

53. U.S. Senate Committee on Banking, Housing, and Urban Affairs, "Brief Summary of the Dodd-Frank Wall Street Reform and Consumer Protection Act" (2010), http://banking.senate.gov/public/_files/070110_Dodd_Frank_Wall_Street_Reform_comprehensive_summary_Final.pdf. For more extensive work on the need for transparency, see for example John Prendergast, Fidel Bafilemba and Ashley Benner, "Why a Certification Process for Conflict Minerals is Urgent: A View from North Kivu," *Enough! Project* (February 2011).

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56. According to the Department of Energy, "In Fiscal Year (FY) 2010, the Office of Science, the Office of Energy Efficiency and Renewable Energy (EERE) and the Advanced Research Projects Agency-Energy (ARPA-E) together provided approximately 15 million dollars for research on rare earth materials and possible substitutes for magnets. An additional 35 million dollars was spent by ARPA-E on next generation battery technologies that don't require rare earths." U.S. Department of Energy, "Critical Materials Strategy," (December 2010): 53.

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