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STRATEGIC MATERIALS - SEMINAR 18**INDUSTRY STUDIES REPORT**

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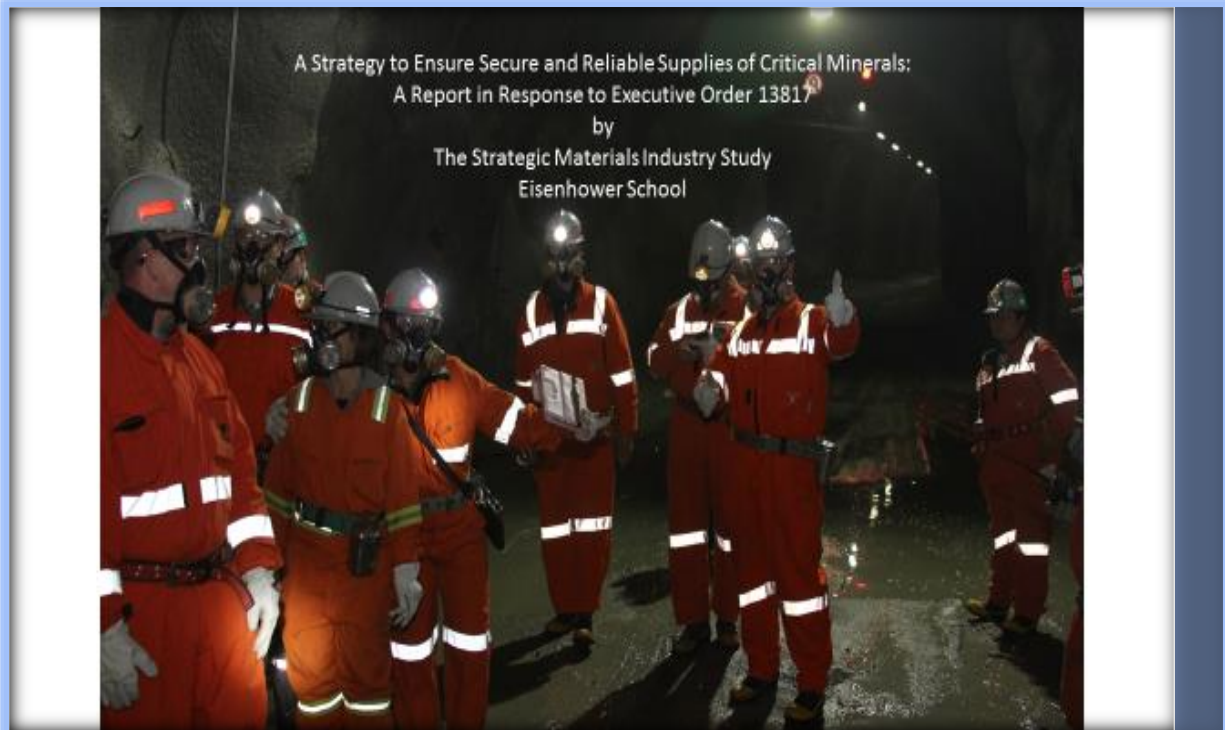
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The Eisenhower School for National Security and Resource Strategy (ES) is part of the National Defense University, located in Washington, DC. The ES provides a mid-career, 10-month, in-residence master's degree program for about 300 students. Approximately 60% of the students are active-duty US military officers; 10% are senior foreign officers; and, the rest are from different agencies in the federal government. A small number of students from private sector companies also attend. The students average about 20 years of public service, and the military students are at the lieutenant colonel/colonel or navy-equivalent commander/captain ranks.

Originally named the Industrial College of the Armed Forces, the ES traces its roots to a study undertaken in response to the US's problems mobilizing for the First World War. This study recommended that the then-Department of War create a school "to remain in touch with industry." In its present form, the "Industry Studies" component of the ES curriculum is mostly contained in the spring semester, during which the students body is divided into 21 teams, each analyzing a different "industry."

In addition to basic classroom sessions and guest speakers, Industry Studies have historically included a field studies component, in which students visit companies, tour facilities, and hold in-depth discussions with companies, government organizations, and other organizations associated with the particular industry, in order to personally assess that industry's general performance, and its specific capacity to support the nation in time of need.

*[America's] trade will always be a protection,
and her barrenness of gold and silver
[will] secure her from invaders.*

- Thomas Paine, "Common Sense," 1776

*This land is your land, this land is my land
From California to the New York island;
From the Redwood Forest to the Gulf Stream waters
This land was made for you and Me.*

- Woody Guthrie, "This Land Is Your Land," 1944

*Only when the last tree has been cut down,
the last fish been caught,
and the last stream poisoned,
will we realize we cannot eat money.*

- Cree Indian Proverb

Contents

Introduction	6
Methodology - Robust Dialogue.....	7
The Current Environment	8
Definitions and Select Governance Processes.....	8
Extraction and Production	10
Authorities	14
Oversight.....	15
Convening Power	16
Innovation	16
Strategy	17
Desired End State	17
Strategic Methods	18
Method One: Federal Land Access - History and Opportunity	18
Method Two - Defense Production Act (DPA)	21
Method Three - Recycling	25
Method Four - Investment and Trade with Allies and Partners.....	31
Method Five - Comprehensive US Mapping	34
Method Six - Streamlined Permitting	35
Closing Recommendations	38
Appendix A - Summary of Meetings and Travel	41
Appendix B - Mapping Campaign Plan.....	61

Introduction

For several years, STRATMAT has focused its study on minerals and materials that support the United States's (US) national security efforts. With this broad scope background and the concomitant institutional knowledgeⁱ that one might consider a "head start," STRATMAT was eager to draft a response to Executive Order 13817, 20 December 2017, "A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals." ("Order").

The Order was issued in the context of growing US security and prosperity dependencies on foreign imports. The US is in the midst of a necessary, growing recognition that its domestic economy - and, therefore, the nation itself - is increasingly reliant on foreign suppliers of both raw critical minerals and the processes necessary to bring them into application. Critical minerals and strategic materials - terms that this paper shall address in detail - are now constantly present in our collective experience. These substances are essential to virtually all products upon which we rely. One need only consider: the smartphone, used to pay a bill that keeps the household electricity account in good order; the artificial intelligence system, built to more accurately identify market trends and inform trading decisions; and, the advanced weapons system, designed to accurately apply lethal force.

From these perspectives - one of dependence, the other importance - the Order directed the development of two reports. First, it required the Department of the Interior to publish a list of non-fuel minerals or mineral materials that are: (1) critical to our "economic and national security;" (2) vulnerable to supply chain disruption; and, (3) "essential [] in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security." Second, the Order requires the Department of Commerce to submit a strategy to reduce our strategic risk with respect to these critical minerals. Pursuant to the Order, the Department of the Interior submitted its "Draft List of Critical Minerals" on 16 February 2018.

The paper opens by briefly outlining STRATMAT's methodology in developing its assessment. A description of the current environment follows. Then, we offer a fundamental strategic end state and a portfolio of methods to achieve it. The paper concludes with several supporting recommendations.

Dominant themes

Identifying strategic materials and critical minerals exemplifies complexity.

Free market forces, augmented by fair trading practices, are best suited to mitigate risks while fueling innovation and advancement.

The US economy in general - and certainly the extraction and production industries - have the best chance of optimization in an ecosystem characterized by the invisible hand of free market forces. The US must act quickly to optimize regulation while loosening what we view as an overly tight grip on the processes that would otherwise facilitate this essential industry.

Methodology - Robust Dialogue

STRATMAT attempted to obtain sufficient information in order to develop meaningful strategic recommendations. The methodology consisted basically of invited guest speakers and extensive domestic and international travel,ⁱⁱ followed by internal discussions and analysis of matters covered in these interactions, listed below (Appendix A offers additional information regarding the relevance of these engagements):

Industry

Albemarle, Charlotte, NC
Alkane Resources, Ltd., Victoria Park, WA, AUS
Colorado Mining Association, Denver, CO
Construction, Forestry, Maritime, Mining, and Energy Union, Sydney, NSW, AUS
Delta Beryllium Mine (Materion), Emery County, UT
Electron Energy Corporation, Landisville, PA
Empresa Nacional de Minería (ENAMI), Santiago, CL
EXPOMIN, Santiago, CL
J.A. Green & Company, Washington, DC
Hazen Research, Inc., Golden, CO
Hecla Mining Company, Coeur d'Alene, ID
Henderson Mine (Climax Molybdenum, Freeport McMoran), Clear Creek County, CO
Materion, Elmore, OH and Delta, UT
Minerals Council of Australia, Canberra, ACT, AUS
National Mining Association, Washington, DC
Resource Capital Funds, Denver, CO and Santiago, CL
Rio Tinto, London, UK
Rio Tinto Kennecott Copper Mine, Bingham Canyon, UT
Silver Peak Mine (Albemarle), Silver Peak, NV
Jim Sims, NioCorp, Centennial, CO
El Teniente Mine (CODELCO), Sewell, CL
United Steelworkers, Pittsburgh, PA

Federal Government

Bureau of Land Management, Salt Lake City, UT
Environmental Protection Agency, Washington, DC
Department of Commerce, Washington, DC
US Forest Service, Denver, CO
US Geological Survey, Reston, VA
Government Accountability Office, Washington, DC
US Senate Committee (Staff) on Energy and Natural Resources, Washington, DC

State Government

Lieutenant Governor Spencer Cox, Salt Lake City, UT
Department of Energy, Salt Lake City, UT
Division of Reclamation and Mining, Department of Natural Resources, Denver, CO

Australian Government

Australian Nuclear Science and Technology Organisation (ANSTO), Sydney, NSW
Department of Industry, Innovation, and Science, Canberra, ACT
Department of Foreign Affairs and Trade, Canberra, ACT
Department of Treasury, Canberra, ACT
Geoscience Australia, Canberra, ACT
Ministry of Defence, Canberra, ACT
New South Wales Department of Industry, Sydney, NSW

Chilean Government

Comisión Chilena del Cobre (COCHILCO), Santiago
Consejo Meniro de Chile, Santiago
Corporación de Fomento de la Producción (CORFO), Santiago
Corporación Nacional del Cobre (CODELCO), Santiago
Empresa Nacional de Minería (ENAMI), Santiago

Academia

Colorado School of Mines, Golden, CO

* STRATMAT traveled to California, Colorado, Nevada, Ohio, Utah, Pennsylvania, Australia, and Chile.

Based on these numerous engagements domestically and abroad, STRATMAT validated the basic challenges addressed in the Order. These are indeed areas of challenges that policymakers should address with strategic solutions to supply chain risk. However, STRATMAT's internal and external collaboration also identified additional areas of overarching challenge, which form the basis for the paper's following organization: a scan of the current environment, a basic strategic end state, supporting strategic ways and means, strategic lines of effort directed by the Order, and concluding recommendations.

The Current Environment

Definitions and Select Governance Processes

As the point of departure for describing the environment, we adopt and recommend maintaining the Order's definition of "critical mineral." This is a mostly useful, if incomplete, term of reference. Given the general preference towards free market systems within the US, the lack of a consensus definition for a strategic mineral and the further conditions warranting government involvement create challenges to reducing the national security risks created by a growing mineral import dependency.

The Order defines critical mineral as: (i) a non-fuel mineral or mineral material essential to the economic and national security of the United States; (ii) the supply chain of which is vulnerable to disruption; and, (iii) which serves an essential function in the manufacturing of a

product, the absence of which would have significant consequences for our economy or our national security.

This definition reflects the work of the National Science and Technology Council (NSTC) in 2016 to define critical mineral resources, as the characteristics described in (ii) and (iii) largely mirror their wording. However, the Order does not use the NSTC's definition of strategic minerals, as a more precise subset of critical minerals essential for national security applications; it also segregates without explanation non-fuel and fuel minerals. Although different executive branch agencies manage fuel and non-fuel minerals, both categories are essential to the US economy and national security; both have also experienced a growth in import reliance. Supply disruptions from a fuel mineral, such as uranium, or non-fuel mineral, such as cobalt or rare earth elements, create similar challenges to accomplishing national security objectives. In this regard, a common definition would facilitate increased coordination and integrated actions within a US strategy to reduce the risks from import reliance.

Additionally, the definitions for strategic minerals proposed by the Strategic Materials Protection Board (SMPB) and Congress, in 2008 and 2011 respectively, identify the characteristics warranting government action in order to reduce the risk to national security could be warranted. Collectively, these characteristics narrow the NSTC's strategic mineral characteristics in a way that transcends mere essentiality. The SMPB proposed a very focused set of criteria: (i) essential for the production or sustainment of defense equipment; (ii) unique in the function it performs and lacking in viable alternatives or substitutes.(iii) the supply of which could be restricted by actions or events outside the control of the US government.

To enable the development of an integrated strategy to reduce the risks created by import dependency, the US should expand its definition of critical minerals to include fuel minerals or mineral materials. The US should also add strategic mineral to its national security lexicon, using the following definition: (a) a mineral or mineral material, fuel or non-fuel, upon which the production or sustainment of defense equipment is dependent; (b) lacking in viable alternatives or substitutes for the function performed; and, (c) the supply of which could be restricted by actions or events outside the control of the US government.

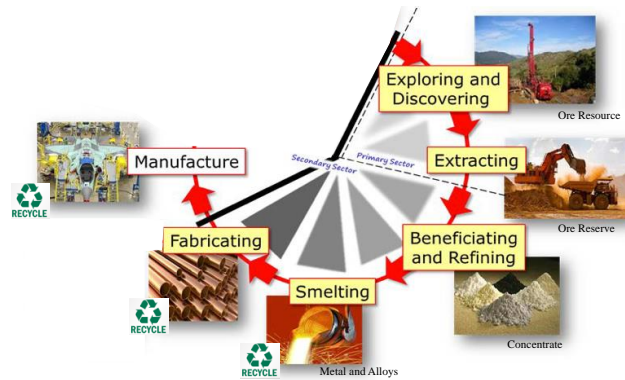
The SMPB should assess vulnerabilities with respect to thusly-defined minerals or mineral materials within the next five years, focusing on current and projected domestic consumption requirements. Additionally, the SMPB should assess and categorize each for its importance to the component and overall system.

Based on these assessments, the SMPB should annually recommend whether the government should take action to secure domestic and allied/partner production. While government involvement may increase costs relative to current market prices, the failure to assess and scope the domestic consumption requirements for the critical and strategic minerals inhibits necessary action to mitigate risks to achieving national security objectives. These definitions and procedures establish the necessary framework to assess potential government involvement and integrate actions, while remaining flexible enough to respond to changes in the economy and defense equipment over time.

Extraction and Production

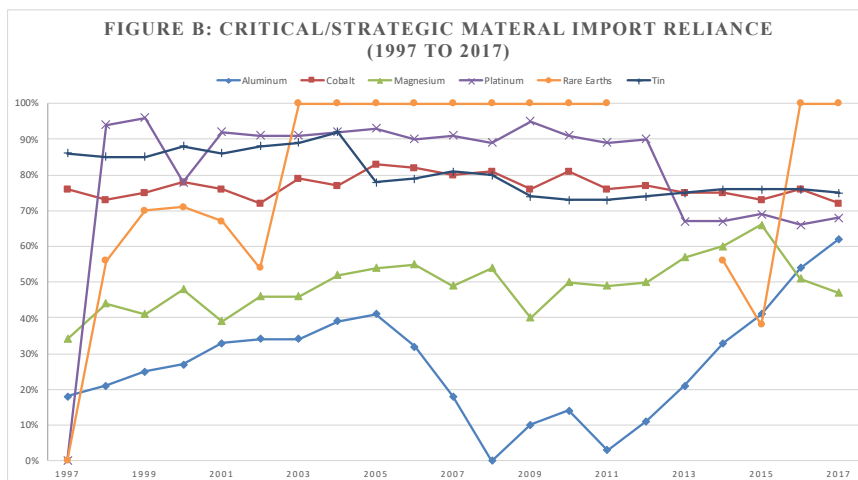
The extraction and production of minerals and mineral materials requires a broad and interdependent range of activities. While figure A depicts the entire value-chain, the process begins with exploration and ends with the creation of alloys, which enable the fabrication of components and manufacture of final products.

Figure A: Value-chain activities.



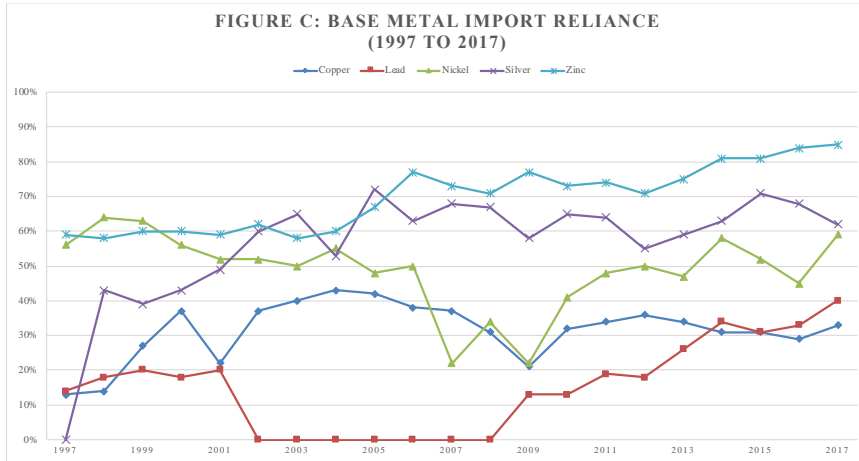
Although the US possesses the potential for domestic production of a wide range of minerals due to a diverse and favorable geology and skilled workforce, the sector has experienced the same challenges as the broader US manufacturing base over the last several decades. Additionally, the cyclical nature of mineral prices, complex regulatory requirements, and competition with state-sponsored firms create lower returns on investments than many publicly traded or privately financed companies seek. These interconnected conditions challenge our ability to maintain domestic capacity throughout the value-chain across numerous minerals and mineral materials as the figures below will outline.

The 2018 USGS Mineral Commodity Summaries (MCS) outline a continued increase in import reliance for a number of critical minerals. Figure B below summarizes USGS data for six.



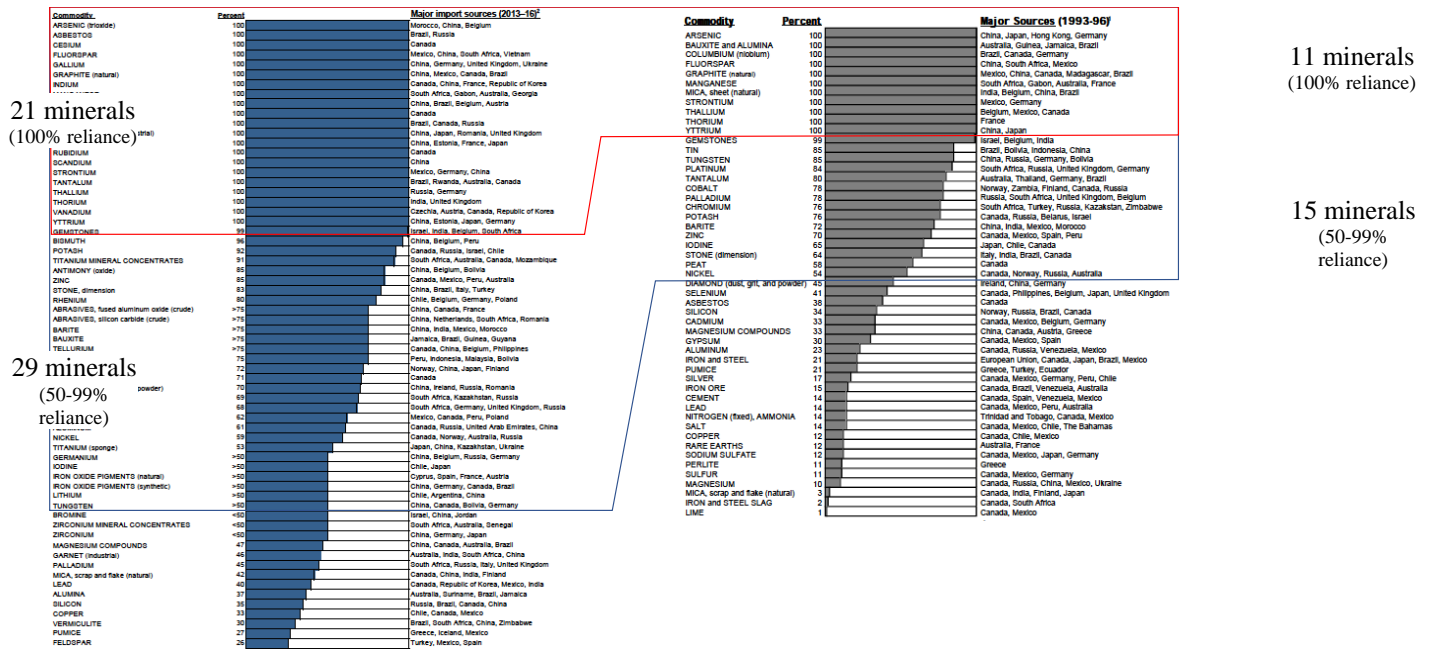
Insufficient data was available to categorize import dependency for Rare Earths in 2012 and 2013.

Figure C depicts a similar trend in five other base mineral materials. While not currently identified as critical by the Department of Interior, these mineral materials enable the manufacture of important products such as electronics, electric vehicles, stainless steel, dry-cell batteries, and photovoltaics.



Ten of the eleven mineral materials identified in figures B and C have experienced an increase in import reliance since 1997, and the majority have seen a marked increase since the financial crisis in 2008. Importantly, figure D below shows this growth in the full range of minerals surveyed over the last two decades. The US now imports more than half of domestic requirements for 50 nonfuel mineral materials and was 100% reliant for 21 of those – a nearly 100% increase in both categories since 1997. Additionally, figure D shows the major sources of import dependence in 2017 – 33 of the 50 minerals with greater than 50% import reliance have sources identified as competitors in the 2017 National Security Strategy.

Figure D: US Net Import Reliance (2018 MCS in blue; 1997 MCS in gray)



The importance of these minerals to defense equipment our national security innovation base produces makes an increasing reliance on imports from competitors that have demonstrated the will to restrict trade to achieve geopolitical objectives – such as China and Russia - an issue of national security. While free market principles should remain a priority, the US must stimulate reliable production sources or stockpile critical materials to reduce the risk from an interruption to free-trade.

Current exploration efforts within the US mineral sector occur through a combination of publicly traded and privately held companies without significant government involvement. This dynamic largely relies on "junior" firms not currently conducting extraction operations, who in the interim survey and drill in order to locate mineral resources.

While topographic maps compiled by the USGS facilitate exploration, significant advances in technology since the US was last mapped (early 1990s) place the US government at a disadvantage compared to other countries in understanding and aiding exploration. Hyperspectral remote imaging; airborne and surface exploration using magnetic, gravity, radiometric, resistivity, or seismic sensors; and a digital mapping architecture able to incorporate the variety of data inputs from these sensors would significantly advance current understanding of potential mineral resources within the US.

Allies such as Australia and Canada have already undertaken initiatives to update topographic surveys utilizing these technologies, and the US government has facilitated hyperspectral remote imaging in Afghanistan to aid their economic development. Updating topographic and geologic mapping information for the US would fundamentally enable better decisions for mineral exploration, and potentially lower overall capital requirements. Projections of the cost of exploration per ounce of mineral recovered from 2005-2014 place the US as the second highest in the world, \$71 per ounce-equivalent, and almost twice that of our strategic competitors, \$38 per ounce-equivalent, which likely inhibits exploration of domestic resources.ⁱⁱⁱ

Exploration attempts to identify and map an ore body, enabling the necessary mine design and feasibility studies to determine the economic viability of extracting the mineral. Collectively, exploration and mine design can take five to fifteen years and require capital investments of \$100 million or more before extraction begins and the operation generates revenue. This timeline and level of capital investment creates a barrier to entry for junior firms to develop discovered resources. Within the US this development generally occurs when a major corporation, with the necessary capitalization, acquires the rights to the mineral resource. In contrast to the US model, other nations - including strategic competitors - subsidize mineral production.

The USGS performs a key role in monitoring the current and projected status of domestic and global exploration for critical mineral resources. Additionally, the USGS assesses the status of mineral production from proven reserves and recycling relative to consumption in order to identify future trends, collecting data through voluntary surveys of the industry and detailed analysis of markets, exchanges, and other sources. While this process has largely worked to enable government decisions to mitigate risks and source domestic consumption requirements over the last two decades, it experiences challenges in opaque markets, such as rare earth elements. Because the process generally bases projected consumption on proven industrial applications, new uses for a mineral can significantly increase consumption requirements above projections and the competition for resources.

US efforts to strengthen domestic production of strategic and critical materials must take into account several factors within the environment. Some factors are common to the 35 materials identified by USGS while others are unique to each of the materials themselves. The market price for materials depend upon the supply of any given material and the requisite demand. An important difference among materials is the degree to which they resemble a commodity. Commodity materials, such as aluminum and uranium, trade on an international market with world-wide buyers and sellers setting prices daily. Both buyers and sellers have access to current pricing information, which facilitates transactions. Conversely, many minor metals are traded outside of public view. An example is rare earth elements (REE). Although traded internationally, there are limited commonly understood unit prices for REE materials. Sales between sellers and buyers are facilitated by an opaque network of buying agents and reporting of transaction prices are undependable.

The nature of the individual markets for critical and strategic materials affect efforts to strengthen domestic production. A major challenge posed by these markets is that many strategic and critical materials relevant to national security exist at the margins of economic viability. Many are minor metals whose markets are dwarfed when compared to major commodity metals, such as of copper. Lower demand and lack of commodity status results in increased difficulty in securing funding for projects. Companies producing such materials are dependent upon contracts with metals buyers or downstream companies and are denied the transparency offered in commodity markets where prices are widely known. It is common for many strategic and critical materials to be either co-products or by-products of major metal extraction operations. Some of these materials experience volatile demand making investment in refining and processing infrastructure risky. Mining companies may be less likely to invest capital in these less profitable

and hence more risky projects and instead invest incremental dollars into projects that extract materials with established markets.

Authorities

The US possesses several authorities to intervene in the market in the interests of national security. The government has used these authorities to ensure the availability of certain materials.

The Strategic and Critical Materials Stockpiling Act authorizes the national defense stockpile. This act was originally passed in 1939 and has been amended periodically to supply the military, industrial, and civilian needs of the nation in the context of national security. It authorizes the appropriation of funds over two-year periods for the acquisition, “transportation, processing, refining, storage, security, maintenance, rotation, and disposal of materials” contained in the stockpile. The Defense Logistics Agency (DLA) administers the stockpile on behalf of the Department of Defense (DoD), currently maintaining 42 different materials valued at \$1.1 billion.

The Specialty Metal Clause of the Defense Federal Acquisition Regulation Supplement (DFARS) is intended to protect the domestic US specialty metal industry, requiring the DoD to acquire defense articles manufactured with specialty metals produced in the US. This requirement originated during the Vietnam War and was intended to protect domestic suppliers of steel alloys during a time the industry was affected by subsidized imports into the US. The requirement has been expanded to include a growing list of possible exceptions, including waivers when a given metal is unavailable in sufficient amount or quality, when the metal in question is contained in a commercial acquisition item, and when the metal in question was processed in a “qualifying country.”

Though the Defense Production Act of 1950 (DPA) will be covered in greater depth later, as part of a portfolio of hedging strategies, it is appropriate to briefly introduce it here. The DPA establishes specific President authorities to influence industry in matters of national defense. Authorities are organized in Title I, Title III, and Title VII of the act. Title I, under the administration of the Department of Commerce (DoC), can require businesses to accept prioritized contracts and allocate distribution of resources. Administrations somewhat routinely prioritize contracts but rarely direct resource allocation. Title III, administered by DoD, authorizes a variety of funding in the commercial sector. Commonly used authorities consist of purchases, subsidized payments, assistance agreements, and the purchase of equipment. Less commonly used authorities consist of loan guarantees and direct loans. The Office of Manufacturing and Industrial Base Policy (MIPB) currently administers the Title III program for DoD with annual investments of approximately \$30-100 million. Title VII, administered by the Department of Treasury (DoT), provides an assorted mix of authorities. The most significant to strategic and critical materials is the authority to review mergers, acquisitions, and takeovers for potential national security impacts. This authority is implemented through the Committee on Foreign Investment in the United States (CFIUS).

Section 232 of the Trade Expansion Act of 1962 provides authority to investigate the effect of imports on national security. The President is authorized to restrict the import of an article, if it is determined that the quantities or circumstances threaten national security. DoC conducts these investigations and has addressed the imports of materials such as steel, aluminum, iron ore, and uranium.

Aside from the Order under consideration for this paper, two other EOs are particularly relevant to the topic. EO 13766, Expediting Environmental Reviews and Approvals for High Priority Infrastructure Projects, was issued on January 24, 2017. This order directs the White House Council on Environmental Quality (CEQ) to determine if projects qualify as “high priority.” If so, the CEQ is to coordinate with the heads of relevant executive agencies to expedite environmental reviews. It is uncertain whether strategic and critical mineral efforts qualify for this expedited review process.

EO 13806, Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States, was signed on July 21, 2017. This order directs the DoD, in consultation with other departments, to assess the manufacturing capacity, defense industrial base, and supply chain resiliency of the United States. The order specifically requires an assessment of the raw materials essential to national security.

Allied and partner nations of the US possess their own means of intervening in materials markets. Australia fields the Major Projects Facilitation Agency administered by the Department of Industry, Innovation, and Science. This organization provides national government-level assistance to projects with over \$50 million in investment. Involvement of this organization in prospective projects serves to de-risk ventures and reflects the desire of the government to assist in project success. Eighteen projects have received this status and assistance thus far.

The US possesses similar authority to coordinate activities among departments. "Service First" is a congressionally-established authority that allows the Departments of Agriculture and Interior to conduct joint activities or activities on behalf of one another. It also allows for the collocation of offices and transfer and reimbursement of funds for multi-year projects. It is feasible for this authority to be leveraged to provide expedited permitting and access for surface and subsurface rights in all federal lands. Such an interface with industry could de-risk projects sufficiently to make prospective strategic or critical material projects economic to companies and attractive to investors.

Oversight

The industry is subject to oversight in the areas of safety, environmental, commerce, and defense from numerous agencies at the federal level. While this diffusion of regulatory authority may be considered a barrier to reducing our import reliance, options exist to adjust current federal processes and gain efficiencies.

Described above, the Service First program enables DoI and DoA to collocate and act jointly or on behalf of one another in order to issue unified permits, applications, and leases and increase operational efficiency. Collocation of the offices of mineral management within the

Bureau of Land Management and US Forest Service has demonstrated the opportunities for streamlining operations while meeting regulatory requirements. While not currently authorized outside DoI and DoA, expanding the authority to collocate operations for all agencies involved in the permitting process could continue to improve operational efficiency and customer service by establishing a single point of entry and clearinghouse for critical and strategic mineral actions.

Convening Power

Outside the diffusion of responsibility for critical and strategic minerals among numerous organizations at the federal level, the framework of our federal system established in the Constitution ensures a further dispersion of authority between federal and state governments. Without clearly enumerated powers, the single best option the Executive branch possesses to reduce our import dependency on minerals is to utilize its convening power to bring together stakeholders at the local, state, and federal level. Annual meetings to discuss critical and strategic minerals with a significant or high value to the economy or risk to supply disruption could help build the consensus necessary for government involvement to strengthen production or stockpile.

Innovation

The US possesses all of the geologic deposits that it will ever possess. Deposits with which the nation is endowed have experienced a reduction in ore grades as deposits easiest to access have already been exploited. The US lacks any deposits of some other materials and will always be reliant on sources outside the country for them. Some materials are present within the country but not economic to extract. The concentrations are either too low, the ore bodies too deep, or the materials science does not exist to beneficiate and refine the extracted material into a saleable product. The US is dependent upon innovation throughout the mining cycle from extraction to fabrication to remain competitive. Sufficient advances in technology can facilitate ever-increasing economic extraction of materials and reduction in dependency from abroad.

There are indicators that innovation lags in the mining industry. Several studies are available that make this observation and offer reasons such as the significant physical challenges of operating underground. It is important to understand that mining is a long-term endeavor that commonly requires more than a decade to proceed from project initiation to the extraction of a saleable product. This time from investment to profitability represents additional risk to investors. The boom and bust cycles that characterize much of the industry may discourage investment in innovation as future bust cycles can extend payback. Companies are apt to exploit existing ore bodies when prices are high, lower production when prices are low, and put operations into a caretaker status when necessary in lieu of closing a mine outright. Investments in innovation take time to implement and a bust cycle may interrupt fielding of new technologies or processes. In this environment, companies are more apt to exploit existing ore bodies than use capital for exploration of new sites.

Various entities are engaged in research. Governments, universities, industry, and science organizations are researching aspects of the extractive industry. Common themes in research include “green tech,” environmental impact and mitigation, and the exploitation of mining tailings. The Department of Energy (DoE) sponsors the Critical Minerals Institute (CMI).

Sponsored by the DoE Efficiency and Renewable Energy Office, this organization serves as an innovation hub to enable clean power in the US. Several minerals classified by the USGS as strategic and critical are the subject of CMI-sponsored research to recover minerals from the smelting of copper, through tailings processing, and recovery of materials via e-waste recycling. CMI forms teams composed among national labs, universities, and industry partners. CMI operates under a five-year, \$120 million budget and faces a renewal in 2018.

Writ large, research and development lower the technical risk of projects and allows companies to secure investment. Companies in the industry are more likely to invest in process innovation to extract material at lower cost than invest in product innovation to expand the downstream market of a material or exploit new deposits. The US is an important player in this space and should consider expanding investments in research across the extractive spectrum. These efforts could open up domestic sources of strategic and critical materials for extraction.

Strategy

Desired End State

With respect to strategic materials - and perhaps with respect to all matters of strategic importance - our national end should be an ecosystem of innovation based on emergent ideas, where we simultaneously understand, exploit, and mitigate risks inherent in the global marketplace, while maintaining our commitment to US values, security, and prosperity

We must build and maintain this ecosystem with a view toward demonstrating our strategic resilience to allies, partners, and adversaries. We should embrace the National Intelligence Council's assessment that "[t]he most powerful actors of the future will be states, groups, and individuals who can leverage material capabilities, relationships, and information in a more rapid, integrated, and adaptive mode than in generations past."^{iv}

Market forces naturally dominate efforts to locate, mine, and process the earth's minerals, whether they are critical or not. This is the primary driver of our basic strategy. Virtually no markets bear the same structure; instead, markets tend to settle somewhere along a spectrum that ranges from "free" to "controlled." It is beyond the scope of this brief paper to fully address or argue whether the US is a free market system. However, it is important to emphasize here that the US market is relatively much freer than those found in the economies of competitor nations.

We should recognize and take advantage of the distinct nature of the US economy, where the relative decentralization of market forces facilitates innovation and long-term efficiencies. The "invisible hand," rather than the visible hand of government intervention, has proven its superiority as an optimizing market force.

Critical Minerals and Thinking

Various companies and representatives voiced their efforts and successes with respect to influencing the recent USGS report designating the "official" list of critical elements. Regardless of the

political or financial motivations, “champions of elements” excluded from the initial draft of the DoI list inadvertently highlighted the underlying flaw in an authoritative-list of “critical” elements: all of them are inextricably controlled by the laws of demand and supply.

The “critical” element of today, considering the rate at which humans innovate progressing, may not be as critical in the near future. And, even while “non-critical” elements like copper and steel are staple elements of production, demand and supply determine their criticality.

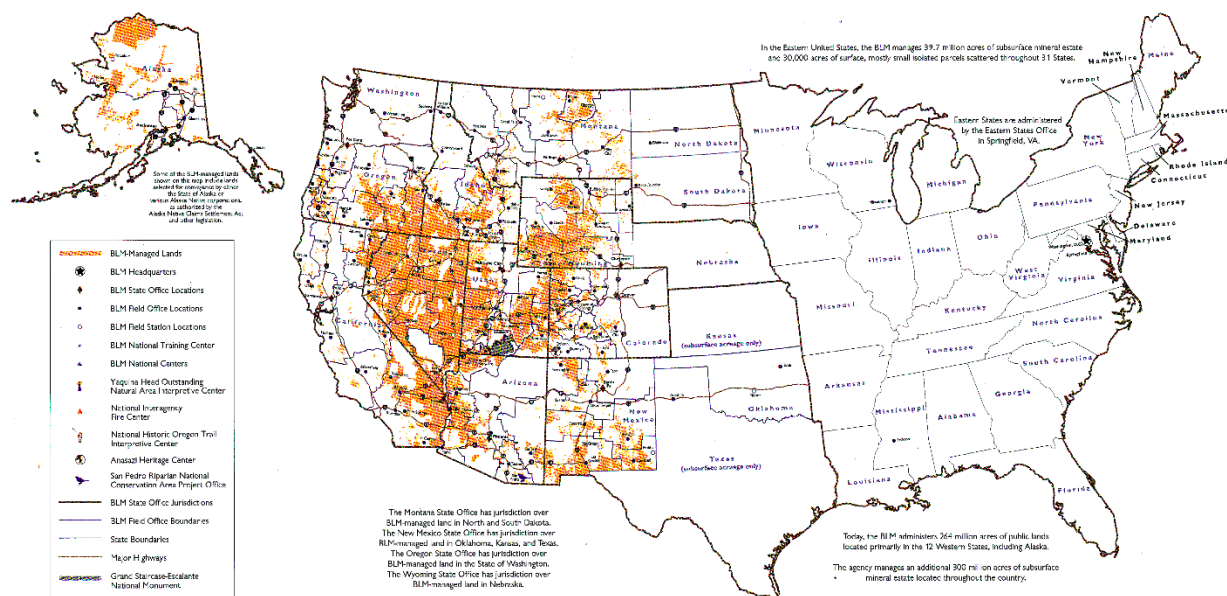
Strategic Methods

Method One: Federal Land Access - History and Opportunity

One way toward our strategic end relies upon the process of granting access to federal lands. To summarize the problem before describing it in detail, the federal government has intervened to disrupt a market that might otherwise seek to capitalize on these public assets.

The Bureau of Land Management (BLM) currently manages 264 million acres of federal surface lands and an additional 300 acres of subsurface mineral rights. Hard rock minerals are largely governed by the 1872 US Mining Law (Mining Law), which was instrumental in settling the West, creating wealth, and sparking American growth for over a century. In the period of 1872 until 1994, when Congress established a moratorium on granting mining patents on these lands, the US privatized 3.1 million acres of federal land under the Mining Law.

Figure E: BLM-managed lands



Since 1994, BLM has continued to process nearly 300 grandfathered patent requests submitted before the moratorium. However, nearly a quarter century later, some 30 grandfathered applications await adjudication.

The moratorium was a function primarily of cost to the government, and inability of the DoI and BLM to process the number of claims being filed. While these factors may have been compelling in 1994, modern national interests justify implementing new workflow processes, in order to remove obstacles to potentially economic sources of strategic materials. at the time of the moratorium but may not be in America's best interests now. We acknowledge that BLM and DOI face shortfalls in the human resources required to handle their current workloads, and we recognize lifting the moratorium would only increase that work. In order to ensure relevant federal agencies can competently respond, they must review how they gain and maintain required expertise.

We do not advocate simply lifting the moratorium and returning to the status quo ante with respect to mining patents. The Mining Law's original patenting process was transparently intended to facilitate western migration in the decades after the Civil War. In order to achieve this objective, patents cost between \$2.50 and \$5 per acre, and these prices remained unaltered until the moratorium. Anchoring these prices at a level which encouraged speculative investment a century and a half ago is unrealistic and not in the best interests of the US. This is particularly true where, for amply good reason, locatable minerals production requires no royalty payments to the government. Associated with lifting the moratorium, the US should reevaluate the appropriate, market-based cost of patents.

By reinstating a process of transfer of ownership through patents issuance, mining firms may be more positively disposed to make real investments that will have a lasting impact over time. Ownership would not extinguish extant land-use regulatory requirements (e.g., environmental permitting), but it would offer welcome incentives for firms to make the kind of improvements that make the mines better places to both work and live rather than being a part of a more strictly economic equation of mineral extraction on lands that remain in government control. Mining projects are exceptionally expensive and long-term prospects; some still operating in the US have been operating for well over 100 years. Mining firms will benefit from ownership of the land containing deposits by having greater autonomy to make decisions on the use and improvement of their property.

Additionally, the US may enjoy reduced spending in the long term if mining firms expand their infrastructure to a point that they are shouldering the burden of cost of utilities and infrastructure under their ownership and control. There are still instances in the US of "company towns" in which firms created and continue to maintain infrastructure including transportation, energy generation, schools, and medical facilities that support employee populations - especially in remote locations. Firms do not create and sustain such services upon land they do not own. The mining industry is specifically suited to this long-term approach to private industry's ownership of services as some mines stay active for over a century. As scale develops, firms' land ownership could result in the production of excess service capacity, such as energy generation, which will benefit local communities independent of the mining companies.

Firms will have increased incentive to cooperate on the continued mining of certain materials required in evolving technology if they own the land upon which this is done via resumed patenting. Increasingly, advances in technology have resulted in new demands in materials that were unforeseen just a decade or two ago. Specifically, in the areas of high technology communications devices and transportation and space industries, some producers increasingly insist on new materials instead of recycled ones. In the long term, the US best assures its sufficiency in these materials by ensuring that an optimal number of them are produced within the US or in near Western Hemisphere nations whose supply chains would be exceptionally difficult to disrupt.

We recognize that, associated with the inordinately inexpensive patent costs from 1872 to 1994, a practice of what may be described as "blocking" developed. Firms commonly purchased patents - therefore ownership - of federal lands, not with the intent of exploring them, but rather with the intent of blocking competitors from access. This practice - which emerged in the US and less than a handful of other nations - was an indirect result of unnaturally low patent prices. In combination with reassessing the market-supported costs of mining patents, the US should encumber future patents with a time-based requirement that purchasers either explore and extract economically feasible materials. If a purchaser does not fulfill such a requirement, the patent and land ownership should revert to the US.

Rare Earths Elements (REEs) - A Closer Look

REEs illustrate the potential advantages of increased federal land access. The economic amount of these materials is never in demand nor produced on the same scale as larger volume materials with which mining firms truly make most of their profits. Incentivizing REE efforts would help ensure REEs available in the US will be available to industry in sufficient levels to make their inclusion in products viable. Currently, many American industrial manufacturers deliberately limit or prohibit research including the creation of alloys with REEs, because the supply chain is erratic or subject to disruption, such as China's 2010 curtailment of REE exports. The US is ceding technological advantage to its adversaries if American industry does not competitively research the applications of alloys involving REEs. Presently, there is much research involving REEs in American universities, but to the greatest extent possible REEs should be a part of industrial research.

Although it may be most advantageous for a mining firm to patent the land upon which REEs are discovered, REEs' relatively rarefied presence in end items (not to be confused with their essential function, or their abundance in nature), tends to reduce their economic viability. For this reason, the US should establish sui generis considerations for REEs, which would better encourage firms to commit to the economic risks of mining them. In this

regard, the US should consider discounted pricing on acreage of patented land, for purposes of REE extraction and production efforts.

Method Two - Defense Production Act (DPA)

The DPA, introduced earlier in our description of the current environment, offers an additional way for the US to mitigate and reduce risk associated with import reliance. A description of its original context is in order, as it should refine our focus upon its limited but important purpose and utility.

Hostilities in Korea during the summer of 1950 revealed significant US industrial shortfalls for responding to national security needs. Economic turmoil and expectations for a peace dividend following the Second World War placed the nation on difficult footing when it responded to aggression on the Korean peninsula. The Truman administration asked Congress to pass the DPA in 1950 in order to urgently mobilize needed supplies and services for the war in Korea. Congress enacted the DPA, giving the President a significant mobilization tool and authority to shape the industrial base in the name of national defense.

President Truman put these powers into immediate operation with controversial results. His eventual nationalization of the steel industry and the Supreme Court decision concluding Truman overreached his constitutional authorities likely contributed to curtailment of some of the DPA powers. Today, the DPA requires periodic reauthorization to remain in effect. Titles II, IV, V and VI of the act expired in 1953 and were not reauthorized.^v The most recent reauthorization of the remaining authorities, Titles I (Priorities and Allocations), III (Expansion of Productive Capacity and Supply) and VII (General Provisions),^{vi} occurred in September of 2014 and extended the DPA until 2019.

The defense industry relies upon a steady supply of critical minerals, many imported from foreign countries, from which it builds an impressive array of weapons systems. A significant number of these imported raw materials exist naturally within US borders. The DPA offers an avenue to reduce this foreign dependency, by using its statutory authority to encourage domestic extraction and production.

Of the powerful and broad authorities available under the DPA, the US mining industry would best benefit from Title III-based federal purchase commitments in order to assist nascent or degraded mineral sectors. Although other authorities - such as capital investments - are attractive to industry and government alike, the risk of non-availability for any given material does not currently outweigh the long-term risks and unintended adverse effects of government intervention in this complex market ecosystem.

A Title III-based DPA approach, as explained below, offers a logical solution to existing problems in the extractive industry. This analysis focuses upon peacetime use of DPA powers. Although obtaining secure sources of materials in time of conflict is of the utmost importance, this review shall only consider what actions should be taken in times of peace in order to best prepare for times of war.

Materion - An Example

The extractive industry presents a noteworthy example of Title III action. In 2005, the US obligated \$73.23 million to Materion Corporation, pursuant to Title III. This action enabled Materion to re-establish its domestic high purity beryllium metal production capacity, which it curtailed in 2005. This five-year government investment represented approximately 66.4% of the \$110 million total costs necessary to build this facility known as the “pebble plant,” derived from its conversion of beryllium hydroxide powder into beryllium metallic pebbles.^{vii} This conversion *is just one of many steps* necessary to convert beryllium-containing ore into finished products such as the Forward Looking Infrared (FLIR) optical system on the AH-64 Apache attack helicopter or the aluminum-beryllium investment cast components found on the F-35 Joint Strike Fighter.

For any given mineral, the production cycle contains varying steps of differing complexity depending upon the mineral concentration and coincident materials. Of the 35 critical minerals published in the Order no two minerals are processed identically. The unique facilities required to smelt and refine each ore type are expensive and "one-off" builds for each type of ore. Therefore, the design and permitting of these processing facilities are unique, resulting in an expensive and time-consuming process.

Mountain Pass - A Prospect

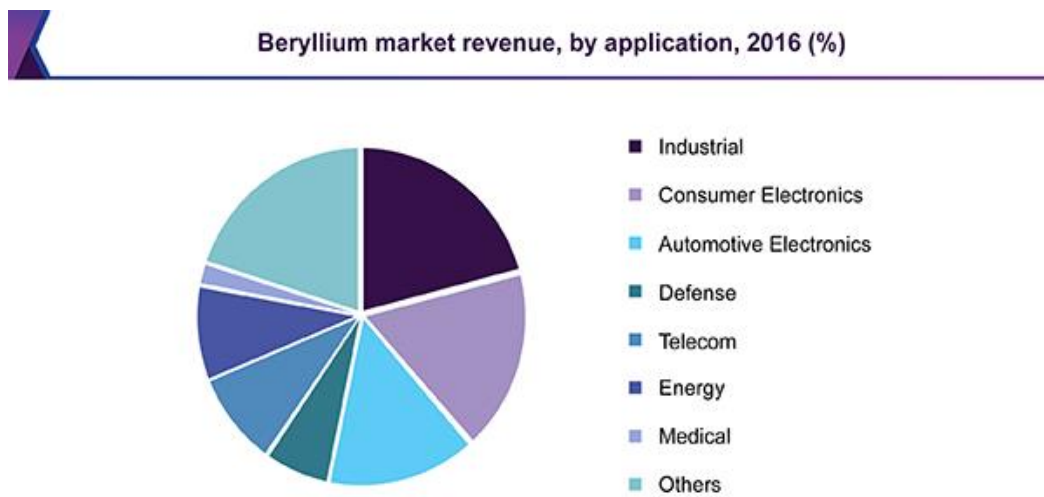
Even a rough order of magnitude cost to establish a vertically integrated domestic capacity is difficult to ascertain for any given mineral. However, California's Mountain Pass REE mine illustrates the scale and volatility involved. Molycorp, now-bankrupt, purchased an existing REE mine in 2010 and invested \$1.25 billion before declaring insolvency in 2015.^{viii} Critics argue that Molycorp over engineered their processing facilities, but this fact only further highlights the difficulty inherent to establishing productive ore refinement and element extraction efforts at an economic price. In a 2014 presentation on critical minerals and their supply chains, the United States Geological Survey (USGS) provided an estimate of the cost and time necessary to go from the initialization of mining exploration through finished products on any given mineral. They stated the process could take a minimum of 10-15 years and have a total cost from \$1.5 to \$2 billion.^{ix}

The US can afford to use Title III, if such actions are limited in scope and, to the maximum degree possible, informed by precise assessments of national security needs and accurate market-based research. However, the US cannot afford to use the DPA - *and*

STRATMAT is unable to contemplate any other model of economically-sound government intervention - to establish domestic extraction and production for any or all of the 35 critical minerals identified by DoI. A conservative estimate of the cost to establish mines and supply chains for the products derived from these minerals easily climbs into the tens of billions of dollars - a difficult sum in any budget environment.

Compounding the national security challenge, the DoD is a minor customer compared to overall global demand for most critical minerals. Beryllium offers one example. Figure F indicates 2016 beryllium consumption; defense applications for this metal only consisted of approximately 15% of global sales.

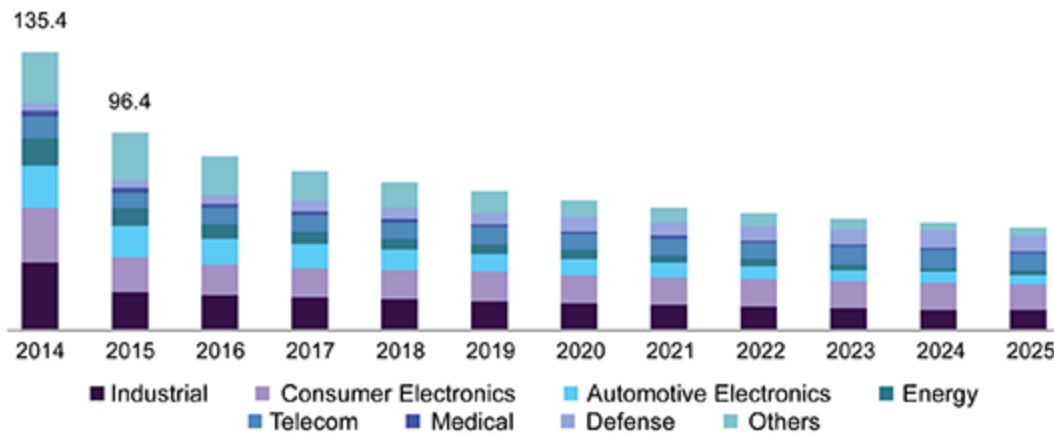
Figure F: Global beryllium consumption, 2016 (Source, Grand View Research)



Analysts expect defense applications for beryllium to increase for the foreseeable future, but overall domestic demand is expected to drop; Figure G depicts this assessment. Factors contributing to this projected decline in commercial use may include the health hazards from exposure to beryllium dust and the strict handling procedures required because of this risk.

Figure G: US beryllium consumption forecast (Source: Grand View Research)

U.S. beryllium market revenue, by application, 2014 - 2025 (USD Million)



These demand projections signal only one outcome for the defense beryllium market: reduced reliance on the commercial sales and continued dependence on the DoD for support. However, this prospect runs counter to the DPA, which states “the President should give consideration to the creation or maintenance of production sources that will remain economically viable after such assistance has ended.”^x Rather than continuing to support domestic production alone, the DoD would be best served if it could undertake efforts to foster commercial markets for these critical minerals and reap the ancillary benefits.

As a result of the high cost of capital investments found in this industry, as well as the pitfalls inherent to supporting capacity without a robust commercial market, this analysis recommends the government use traditional commercial practices as much as possible when engaging in this industry. Of the available DPA authorities, purchase commitments most align with what the industry refers to as “offtake agreements.” These contract instruments are usually signed prior to the receipt of the capital investment necessary to build full productive capacity. They provide sufficient confidence in the endeavor to allow creditors to release financing. To limit the government’s interjection into the commercial marketplace this analysis recommends that, to the extent feasible, the government should not take delivery and become a broker of these materials. Instead, the terms of the purchase commitments should require the government to take delivery only as a last resort if other commercial firms are unable to take delivery at market prices.

The DoD should look to its allies and partners when considering stable sources of supply. Section 702(7) of the DPA currently defines a domestic source as one performing substantially all of its work in the US or Canada.^{xi} Section 881 of the 2017 National Defense Authorization Act added the United Kingdom and Australia in the definition of the ‘national technology and industrial base’ and required the DoD to submit a plan to further reduce barriers between industrial persons and organizations.^{xii} This work recommends the expansion of the DPA definition of a domestic source to include the ‘national technology and industrial base’ countries

of the UK and Australia as a means to reduce barriers. Such action would further expand the tools available to establish secure sources of these minerals.

The US defense industry relies upon a steady supply of basic minerals, many imported from foreign countries. A significant number of these imported raw materials exist naturally within US borders and use of the DPA is a potential avenue to reduce this foreign dependency. Of the powerful and broad authorities available under the DPA, investing in full supply chains for the 35 critical minerals identified with domestic availability risk is simply unaffordable. Instead, federal purchase commitments are the best means to assist nascent or degraded mineral sectors. However, to the extent possible, the government should not take delivery of these materials. Instead, the terms of the purchase commitments should require the government to take delivery only as a last resort if other commercial firms are unable to purchase at market prices. Additionally, Congress should expand the DPA definition of a domestic source to include the UK and Australia thereby increasing the tools available to achieve secure sources for these critical materials.

Method Three¹ - Recycling

The concept of recycling is remarkably similar to mining. It all begins with a requirement. This implies a market for the finished product. Without that, recycling will fail. Likewise, recycling requires a concentration of the desired element. In mining, the concentration determines the economic viability of extraction. With recycling, concentration becomes slightly more complicated only in that collection and separation take the place of extractive mining. However, the overall concept remains the same, and firms will not attempt recycling unless the expected benefits exceed the costs, up to and including the production of the final product from which the demand is derived.

Site visits and interviews with various levels of the mining industry revealed the fundamental driving forces of return-on-investment (ROI), rational ignorance (intentional ignorance of resource abundance), and self-preservation all prevail over national security of strategic and critical materials. The dynamic and unpredictable nature of the mining industry fosters these types of cultures. Coupled with the liabilities and protracted legal processes, industry leaders are faced with the harsh choices of viability with little regard for the “potential” impacts on national security demands. Despite the obstacles, initial efforts are being made by various companies and investment groups to capitalize on recycling as a potential source of readily available materials.

Other factors may be used to help concentrate the critical material for recycling to help increase its concentration and make the possibility of recycling more cost effective. For instance, electronics sales outlets could be encouraged to provide collection sites for e-waste, which then increases the concentration of the critical materials used in electronics. In this manner, the recycling possibility may be enhanced. This concept is similar to mining the past tailings from abandoned mines, which could contain higher concentrations of desirable materials.

¹ Methods Three through Six respond directly to the Order, along the four lines of strategic effort directed therein.

This is an area that is frequently discussed, but difficult to act upon due to the legal structure related to environmental cleanup in the United States.

Often, the technology for extracting materials is very complicated, leading to concentrations of intellectual property (IP) in only a few firms. This IP normally resides in mining, beneficiation or smelting firms. The recycling of materials is competition to these firms, so any attempts to use the required IP may be thwarted, unless incentives exist such that the mining firms accomplish the recycling. Also, not all recycling IP for recycling processes resides in the US, so domestic recycling may not be possible without significant R&D expenditure.

The universal drivers of economies of scale apply with equal force in this area. The higher the concentration of recyclable material, the lower the economies of scale have to be in order to justify recycling. Conversely, if the concentration is low, greater economies of scale are required to justify recycling. Thus, recycling of a critical material will not begin unless both the concentration and volume are sufficient to justify the expense. Furthermore, the flow of material must be assured prior to establishing the recycling process. The continuous flow of sufficient volume will ensure that the recycling enterprise has sufficient return on investment to justify establishing the production line.

The idea of volume and flow in recycling has further implications with respect to the timing of recycling. If an element is newly in demand, and the end product for which the element is used has a relatively long shelf life, sufficient volume and flow to justify recycling may not be available until a large number of end products have achieved the end of their service life.

Lithium - Build Recycling Capacity Now!

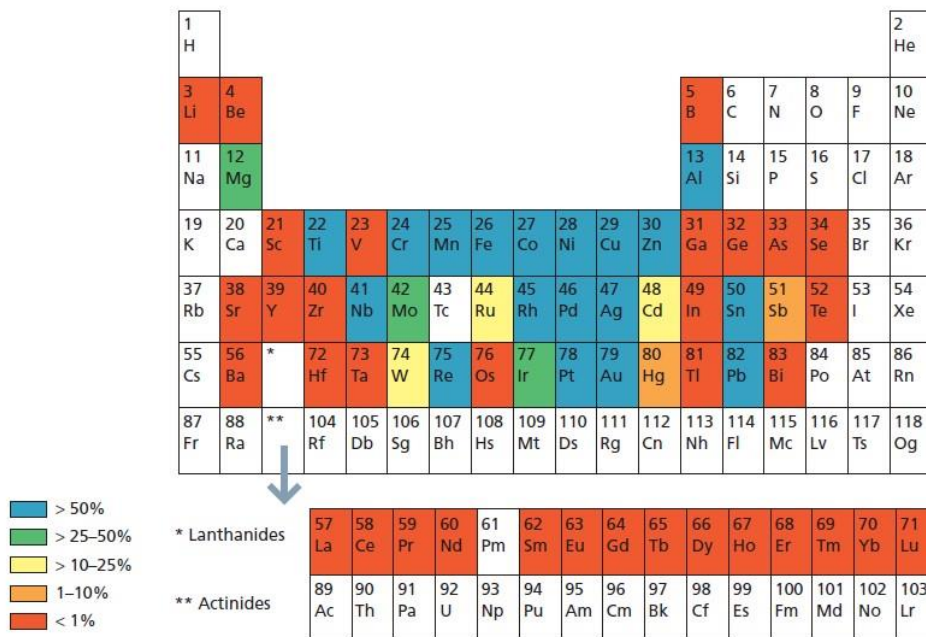
Lithium is currently not recycled. The low concentration of lithium in personal electronic devices does not justify the cost of collection, concentration, and extraction. However, with the advent of electronic vehicle (EV) technology, lithium is starting to be used in bulk, which can be more easily concentrated for recycling. But the first generation of EVs is still in service, so there is insufficient volume and flow of lithium at present to economically justify recycling. Once large numbers of EV batteries reach the end of their service life, the calculations will change, and lithium recycling may prove to be economically efficient. If, however, EV technology changes in the interim, and lithium is no longer utilized, its demand may decrease, and lithium may not be recycled. This, however, is unlikely, since lithium is a light weight material and its use, in addition to providing power storage, enables a lighter vehicle relative to other alternatives. Like lithium, increased demand for critical minerals and their use in alloys and products means that in the future more scrap materials for recycling will be available as they mature or their life time of use is over.

One major difference between recycling and mining is that government intervention can affect the concentration of valuable elements within the recycled waste. Government at any level can intervene in the market to encourage collection of recyclable material. This can be done through a deposit system in which original end users pay a refundable deposit, returned when an item is provided to a recycling center.^{xiii}

Government sponsorship of recycling collection centers is another way to reduce the direct costs of recycling, and thus encourage the practice of increasing the concentration of recyclable materials. Mandating recycling of waste is another of the myriad ways for incentivizing the concentration of recyclable material. Likewise, government purchase of the final product will increase the incentive for recycling. Irrespective of the method, government intervention can increase the amount of recyclable material concentration that occurs by either reducing the cost of recycling or, conversely, increasing the cost of not recycling. Even though recycling efficiency differs for different minerals, general trends in the US show that recycling and secondary production of minerals has increased.

According to USGS's 2017 MCS, "Domestic raw materials and domestically recycled materials were used to process mineral materials worth \$675 billion. These mineral materials were, in turn, consumed by downstream industries with an estimated value of \$2.78 trillion in 2016, a 3% increase from the revised figure of \$2.69 trillion in 2015." The trend is increasing worldwide. According to paper prepared for European Environment Agency "About 3.1 million tons of WEEE was reported collected in the EU in 2008, but it is estimated that around 7 to 8 million tons of WEEE was generated, equal to a collection rate about 40%." Exact levels of worldwide recycling are difficult to obtain. However, the European Academies' Scientific Advisory Council provides an estimate of worldwide recycling in Figure H.

Figure H: 2011 Worldwide Recycling Estimate^{xiv}



R&D in pursuit of new methods for recycling strategic minerals from untraditional sources like vegetation, animals, ground, dirt and matured filters and equipment from factories, and environment in proximity of factories and mines can be also be useful. R&D projects for recycling of minerals from untraditional scrap or sources like vegetation growing in the environment of mines and smelters for specific mineral also present potential options for new recycling sources and methods.

“Re-concentrating” recyclable material is not free. It involves collection, sorting, transportation, processing, and re-purposing. Issues may arise with respect to cost of processing (time, energy, additional resources used). Additional issues may arise with the comparative quality of the final re-purposed output. The technology for extraction of useful material from the previous “end-product” may not exist, or the recycled product may be of lower grade or quality. In the case of chemicals, the process for un-doing a chemical reaction may not be known, may require an excessive amount of energy, or may require hazardous processes. The bottom line is that concentration or recycling costs may negate the value of recycling. The market cost reflects the total cost of providing a product (including opportunity cost). If costs of recycling an item exceeds that of replacing it, recycling, by definition, then uses more valuable resources than it saves (whether in energy, materials, capital expenditure or time).

Two distinct forms of recycling exist, pre-consumer and post-consumer. Pre-consumer recycling may take place at any point in the production chain, prior to sales to the final customer. Post-consumer recycling takes place after the final good has been produced and the good is no longer under the control of a producer.

Pre-consumer recycling generally involves collecting scrap used in a manufacturing process. This type of recycling has a cost advantage in that the scrap being recycled is concentrated in a limited number of locations, and thus less expensive to sort. This recycling generally involves returning the scrap to a previous point in the production process where it is intermingled with other material in the process. In some situations, the recycled product may be a format which limits the set of uses, since certain compounds, once intermingled, may be difficult or expensive to separate or extract. Pre-consumer recycling also entails some costs associated with collection, sorting, and labeling to prevent intermingling of incompatible materials.

Post-consumer recycling contains all the costs and caveats associated with pre-consumer recycling, plus the added costs of collection and sorting after the product has been dispersed to consumers. Often the desired material is only a very small proportion of the final product and significant effort is required to extract the desired material for recycling. The economic factors associated with such a process are very similar to that of mining itself; post-consumer recycling can be thought of as trash mining. If the concentration of the desired material is too low, the extraction (i.e. recycling) may not be worth the cost. In some cases, post-consumer concentration of materials lends itself to recycling since the product is used in a concentrated area. Rhenium in jet engines, for instance, can be recycled readily, since its use is concentrated in only a few areas. Germanium in night vision devices fiber optics is another example. In general, if the material is used to provide a service, such as air transportation, or internet service

in the above examples, the industry providing the service provides a manner to concentrate the material and may decrease the cost involved in collection and sorting for recycling.

Recycling What is Rare

Agmetalminer.com reported that a team of researchers at Worcester Polytechnic Institute may have developed both a technically and commercially viable means for recycling neodymium, dysprosium and praseodymium from the drive units and motors of discarded electric and hybrid cars. Their method is based on aqueous-based technology, one of three main Rare Earth Elements (REE) extraction processes, the others being electro-slag refining and liquid metal extraction.^{xv}

Elsewhere, a new rare-earth magnet recycling process developed by researchers at the Critical Materials Institute (CMI) dissolves magnets in an acid-free solution and recovers high purity rare earth elements.” “Recycling is a possible solution to the supply-chain problems, but until now has faced serious economic and ecological challenges.” CMI, a US Department of Energy Innovation Hub led by Ames Laboratory, was able to overcome several hurdles to the environmental viability of rare-earth recycling with this processing technology, according to lead researcher Ikenna Nlebedim.^{xvi}

As previously discussed, current industry efforts toward recycling R&D are relatively inactive, for even R&D costs associated with recycling are too intimidating for industry leaders to entertain. Entities abroad have pulled into a slight and somewhat isolated lead on this front, with ANSTO undertaking preliminary research into rare-earth recovery methods. Currently, separation by precipitation, fractional crystallization, solvent-solvent extraction, liquid-solid extraction, electrochemical methods are not practical for the recovery of processed elements.^{xvii} In cooperation with ACSEPT (Actinide reCYcling by SEParation and Transmutation), a program in the European Union, ANSTO is researching electrochemical methods based on molten alkali salts (referred to as a pyroelectrochemical process). In addition to pyroelectrochemical extraction, other new processes may involve liquid-solid extraction.

However, efforts like those of ANSTO were isolated when compared to the inquiries made of all of the companies visited. The harsh financial impacts (both long and short term) to a mining company that were to effectively shift its operations towards what represents an entirely different industry all together, were the principle deterrents, especially when compared to the abundance and ease of procurement of critical materials, even if purchased overseas.

Creation of a centralized (unified) data base or list of products categorized by elements (minerals), to be used for building products, with data about estimated lifetime of the products can contribute for better recycling, and significantly reduce effort for scrap in which minerals are used. This database can be expended by products already in use and their estimated lifetime

cycle. Additionally, creating common list of critical materials within the North Atlantic Treaty Organization (NATO) and other allied nations, then dividing responsibilities for maintain certain amounts from specific minerals can significantly reduce costs of maintaining national reserves for all strategic materials.

A recent development in foreign “partner” recycling is Chinese rejection of continued dumping of electronic waste. Exportation of scrap electronic waste on Chinese vessels returning to China was far more economically feasible than domestic disposal. China eventually earned the lead in global waste management, however heightened awareness on the environmental impacts are presenting potential risks to global markets. China’s recent evaluation of the long-term impacts on the environment and populations has prompted increased regulations on imported waste contamination. If continued, companies may eventually be forced to research local avenues for waste management.

Current R&D efforts surrounding waste recovery and disposal is severely lacking and will likely take years before development investment takes place. Necessity being the mother of invention, it is likely that until waste disposal becomes cost prohibitive and exporting threatens domestic waste management policy, the path of least resistance will continue to be China as the primary global waste site.

Tailings from extractive efforts offer promising potential as a source of recycling efforts. What was previously considered low-grade waste material from early mining efforts is now being evaluated against current technology and practicalities of “re-mining” these relatively accessible sources of critical materials. Tailings, both liquid and solid, are typically removed from mining sites and stored in relatively concentrated and accessible locations. The ease of access and concentration of these untapped elements are becoming the topic of discussion in the industry. Colorado State University hosts an annual “Tailings and Mine Waste” Symposium, where reclamation is receiving increased attention.

Similar to the fundamental ROI imperative, investment in the technologies and processes associated with beneficiation and extraction are the foundations upon which critical element security will be realized. Entities like Hazen Research and ANSTO, both of which specialize in this type of research, or Materion’s on-site experimentation with extractions processes are the foundations upon which the US will build critical mineral independence and surge capabilities.

Additional recycling opportunities abound among abandoned mining sites that are purchased by new individuals or companies, which currently can be held financially responsible for the clean-up and restoration pursuant to EPA “Superfund” legislation, regardless of the potential costs. These sites are often held to standards that have yet to be defined, creating an inherent deterrent for any sort of investment from potential buyers.

Currently there is an initiative to implement a “Good Samaritan” policy in order to mitigate many of these barriers to potential investors. The environmental cleanup liability associated with recycling these abandoned tailings often discourages this form of recycling. Several attempts across the several states to enact a “Good Samaritan” law have been unsuccessful. These legislative proposals, described generally, would limit liability for firms

conducting environmental cleanup. Passage of such a law would encourage the recycling of mine tailings, improve the environmental conditions of abandoned mine sites, and potentially increase the availability of critical materials at a lower cost, without requiring government subsidies to encourage recycling or environmental cleanup. If enacted, incentives would increase for companies to recycle abandoned tailings and other untapped deposits. Of the approximate half-million abandoned mines in the western United States, many have only been sub-optimally explored in order to accurately assess ROI.^{xviii}

Method Four - Investment and Trade with Allies and Partners

The 2017 US National Security Strategy, like its predecessors, recognized the “invaluable advantages that our strong relationships with allies and partners deliver.”^{xxix} International trade in critical minerals has allowed the United States to obtain resources that are unavailable domestically, while paying lower costs, diversifying supply, reducing the environmental impact in the US of mining and processing, and facilitating US land use for other productive purposes.

The US is fortunate to have multiple opportunities toward optimized engagement with foreign partners to meet the challenge of securing our supply of critical minerals.^{xx} Given the potential vulnerability of sea lines of communication during a potential conflict scenario, this examination looks first at our neighbors in North America, Canada and Mexico, and then at our treaty allies and other partners further afield, particularly Australia, given Australia’s robust mining industry, abundance of minerals, and unique relationship with China.

The economic realities of mining have resulted in an industry dominated by large companies, whose interests are often supranational and whose decision-making is governed by market forces, competition, and profit margins. With the exception of state-owned companies like those in China, Russia, and Chile, these firms must answer to international investors and are often dual-listed on multiple stock exchanges.^{xxi} Nevertheless, through strategic engagement with allied and friendly governments, we can optimize our ability to leverage our respective industrial bases to secure our collective future.

Canada and Mexico

Canada is among the world’s largest mining nations, producing more than 60 minerals and metals. Canada is a leading global producer and/or a primary source of US imports of potash, uranium, niobium, cobalt, aluminum, platinum group metals, indium, graphite, rubidium, vanadium, germanium, cesium, magnesium, tellurium, titanium, tungsten, nickel, gemstones, sulphur, diamonds, zinc, and gold.

Sixteen of these products are on the DoI proposed list of 35 critical minerals.^{xxii} Canadian provinces made up 5 of the top 15 jurisdictions rated by the Fraser Institute for their attractiveness for mining investment in 2017, and the Geological Survey of Canada’s (GSC) foundational writ was to help “develop a viable Canadian mineral industry by establishing the general geological base on which the industry could plan detailed investigations.”^{xxiii} GSC’s latest strategic plan identified completing the onshore geological framework mapping in areas of Canada’s north, improving understanding of major mineral deposit types, and targeted offshore

resource assessments among its key commitments.^{xxiv} Canada is a close strategic ally, a fellow member of the NATO, and as noted above, has been designated in domestic law as part of the US industrial base.

Mexico is a leading producer of silver, gold, fluorspar, zinc, and lead, as well as the USGS-designated critical minerals bismuth, graphite, manganese, and strontium, and is expected to see future growth in the production of copper, and the copper byproduct rhenium.^{xxv} Article 6 of Mexico's Mining Law of 1992, the national law that regulates mining concessions, ensures that mining has priority over any other land use, including agriculture and housing.^{xxvi} In September 2017, the Mexican Government estimated that mining investment in Mexico had increased 50% over the past year to \$5.5 billion.

North America - Essential Security and Economic Partnership

Taken together, Canada and Mexico currently produce over half of the critical minerals identified by the DoI. The US has done much of the heavy lifting to make trade with these, our closest neighbors, as efficient as possible through the North American Free Trade Agreement (NAFTA). Congress expects the details of a new round of NAFTA negotiations to be announced May 17, 2018.^{xxvii} The US maintain strong ties to these key trading partners to leverage our joint resource strength. The US faces stiff competition for Canadian and Mexican resources, particularly from China. China is the third largest trade of both Canada and Mexico, and the collapse of NAFTA would likely increase our neighbors' reliance on the Chinese market, decreasing US influence and increasing our net import reliance on strategic materials.

The rest of the world includes a wide range of countries, including treaty allies, close diplomatic or trade partners, and potential adversaries both strategic and regional. Some of these are of interest to the US because they are key sources of critical minerals, either in raw or processed form. Leaving out China, Canada and Mexico, other *top* suppliers or producers of critical minerals include countries as varied as Kazakhstan, South Africa, Democratic Republic of the Congo, Norway, Qatar, Australia, Chile, Brazil, Rwanda and Peru.^{xxviii}

Others are of interest to the US, because in addition to being allied to us on defense issues, they also have advanced economies, are key trade partners, and have themselves grappled with the question of dependency on foreign resources. Resource-poor Japan, for example, has long conceived of and conducted "resource diplomacy" as part of its overall foreign policy, based on the need to secure critical raw materials. (China in recent decades has followed a similar approach, although on a far larger scale.) Likewise, in recent years EU member nations - some of them NATO allies - have become more aware of their own security or economic vulnerabilities related to the supply of critical minerals. This awareness and common interests with the US led to several formal US-Japan-EU information exchanges, as well as joint US-Japan-EU action in the World Trade Organization against China's restriction of REE exports.

Australia is of particular interest to the United States. In addition to being a close, longstanding strategic ally and trade partner, mining is a significant part of the Australian economy, and it is one of the world's leading suppliers of critical minerals. Australia has a complex relationship with China. Similar to the United States, Australian-Chinese trade has boomed in the past few decades. China is Australia's main export destination and import source^{xxix}—a fact that is not lost on decision-makers in Canberra or Beijing. China has sought to wield influence over Australian policy, threatening to retaliate for Australian defense support to the United States.^{xxx}

Improved Governance

In order to increase effectiveness of US foreign relations in this field, increased accountability and consistency are necessary. To this end, the US should designate a senior executive branch official to serve as a “critical mineral czar,” responsible for coordinating US foreign policy, diplomacy, and associated government actions on critical mineral issues. Given the Department of State's lead role in the formation and implementation of US foreign policy, this position should be established under the supervision of Under Secretary for Economic Growth, Energy, and the Environment.^{xxxi} The “critical mineral czar” would need to consult and coordinate closely with other relevant US government agencies and sub-agencies, in particular DoD (especially DLA and MIBP), DoI (especially USGS), DoC, United States Trade Representative, and US Agency for International Development. This official's responsibilities should include:

- Ensure awareness of global critical mineral-related issues and developments among US policymakers.
- Expand information-sharing with partner governments, both bilaterally and in larger fora, akin to previous US-EU-Japan consultations, beyond the ad hoc or infrequent exchanges to date.
- Foster dialogues between government and industry on international trends and developments to share situational awareness of issues of common concern. Such dialogues would need to be structured so as to avoid creating the perception of government favoritism or preferential treatment towards certain firms.
- Monitor attempts by any controlling producer (such as China) to increase its market share of a critical mineral in third countries, and seek to prevent such an outcome through the use of bilateral and/or multilateral diplomacy. In particular, seek to prevent potentially hostile country firm, SOE, or investor attempts to purchase controlling stakes in local firms that either mine or process critical minerals.
- Coordinate US development assistance, such as USAID programming, Overseas Private Investment Corporation (OPIC) political-risk insurance, and EXIM Bank loans, to diversify the supply of critical minerals. Such assistance could be used

to expand processing of ores in other countries, to create a favorable and sustainable climate for investments, and to allow the time needed to bring diversified supplies online.^{xxxii}

- Consider the possible limited use of Defense Production Act Title III funds to underwrite firms or initiatives in treaty countries. Even prior to the 1992 amendment to the DPA that defined a “domestic source,” production facilities in Canada were counted as domestic and thus were eligible for participation in DPA Title III projects.^{xxxiii}
- Negotiate and establish agreements with like-minded countries about sharing resources, especially critical minerals, in the event of prolonged supply disruptions.
- Establish long-term supply agreements and joint exploration initiatives, converting the national defense stockpile into a Strategic Materials Security Program (SMSP), to monitor markets, enable planners to take advantage of global market conditions, establish supply chain commitments with producers and suppliers, assist with financing and monitor timely delivery.

Method Five - Comprehensive US Mapping

In the USGS's 139 years history, less than 50 percent of the nation has been mapped to a level of detail necessary for today's critical minerals challenge. This is unsustainable, but a remedy is available.

To overcome this challenge a resource informed plan must be rapidly developed to provide a comprehensive topographical, geological, and geophysical mapping survey database of the 50 United States and Puerto Rico. This effort must yield a survey database that consolidates all that is known with regards to critical minerals and increase private sector domestic exploration, extraction, and production. The DoI should be the lead federal agency for this effort, to include consolidating, maintaining, and making mapping data publicly available.

STRATMAT estimates Congress could adequately fund the critical minerals mapping program by appropriating an additional \$500 million, over ten years, for this purpose. This funding should supplant mapping appropriations identified within the National Geologic Mapping Act of 1992 or subsequent National Geological Reauthorization Acts signed in to law in 1997, 1999, and 2009. Funds appropriated for mapping surveys should be separate and distinct from the United States Geological Survey's annual operating budget. The DoI should assign this critical mission to the capable offices of the USGS, which should in turn rapidly coordinate, manage, and conduct nation-wide mapping surveys, analyze and interpret mapping survey data, upgrade and update databases in order to provide users with the most advanced topographic, geologic, and geophysical data available. Appendix B offers a detailed, execution-ready plan of action.

Method Six - Streamlined Permitting

Permit decisions take too long. We heard this complaint frequently, in all quarters of our engagements with others and virtually every time we discussed the general topic of permitting. The general objects of complaints were two-fold. Industry representatives most often assigned blame to the executive government agencies responsible for permit decisions. Government officials, on the other hand, often blamed actual or the perceived threat of litigation as obstacles to permitting decisions. The permit delay narrative is certainly that - a narrative - but it is unclear whether it amounts to a truth. In fact, one speaker's refreshingly candid assessment of the 10 to 15 year lapse included no attempt to parse the amount of time taken for permitting, versus the amount of time required for proponents to fine-tune their processes and procedures.

Our review of the publicly available litigation statistics with respect to the National Environmental Policy Act suggests the volume and results of such litigation are not so immense or adverse to government agencies or firms in the industry.^{xxxiv} The narrative of permit delay as the center of gravity for mining delay begins to sound more like an unproven alibi, asserted by some industry proponents who undoubtedly face corporate pressures to perform. And, the narrative of litigation delay begins to sound like an unproven alibi, asserted by some government representatives as the reason that it takes so long to decide whether a permit is appropriate. Nonetheless, STRATMAT concludes that permitting agencies involved in the industry are significantly influenced by a culture that places excessive weight on the risk of litigation. Executive agencies can solve this problem by conducting an enterprise-level, issues-based and time-based risk assessment focused on litigation trends, likely leading to accelerated permit decisions.^{xxxv}

Logic suggests permit decision making timelines are also directly proportional to the level of complexity associated with the activity for which a permit is sought. Considered in this way, one would expect extraction and production permitting processes to take substantial time. Based on STRATMAT's engagements and study, the US is not particularly unique in this respect.

In modernized countries, the major deterrents reported by companies are related to regulation and protected lands. Using Canada as an example, the Fraser Institute reports that 3 of the top 5 investment barriers are related to regulation some of it as a result of duplication (Figure 1). The Prospectors and Developers Association of Canada released a survey of 34 junior and mid-tier mining firms operating all around the world that showed that slow permit approvals were one of their greatest challenges. The permitting process is costly for firms, as they must invest time and resources to comply with the various requirements. These costs can especially rise when the process lacks transparency, is inconsistent or overly time-intensive.

In the 2014 Fraser Institute's Survey of Mining Companies, 65% of respondents indicated permit approval timelines have increased over the last decade with 39% believing it had lengthened considerably (Figure 2). As part of this same survey, miners reported that ~40% of their decision to invest is driven by policy-related factors despite the mineral potential. Richard Schodde, a mining consultant, found that on average it currently takes over 12 years to progress from discovery into production.

The trends for mining are concerning, particularly considering increased social resistance to unsightly or perceived dangerous sites near populated centers. The bar for sustaining a social license is consistently being raised by concerned stakeholders. This coincides with the fact that most minerals are less accessible and lower in concentration, for richer ore closer to the surface has already been harvested.

Prospective firms should recognize - and in our assessment, they do - that to initiate new mining operations, substantial investments of time and money involving serious collaboration with an array of stakeholders are required. However, at the same time, governments interested in reaping the economic and security benefits of having a vibrant mining industry need to consider non-value added regulatory activities that may be delaying investments.

While there is little easy remedy for resolving issues of land claims and protected land, there are potential best practices that can be observed from analyzing the practices in mining-intensive but responsible countries of Australia, Canada, Chile, and Finland. While there are variances in the application of mineral rights, land access, types of permitting, environmental requirements and health/safety standards, there are more similarities than differences.

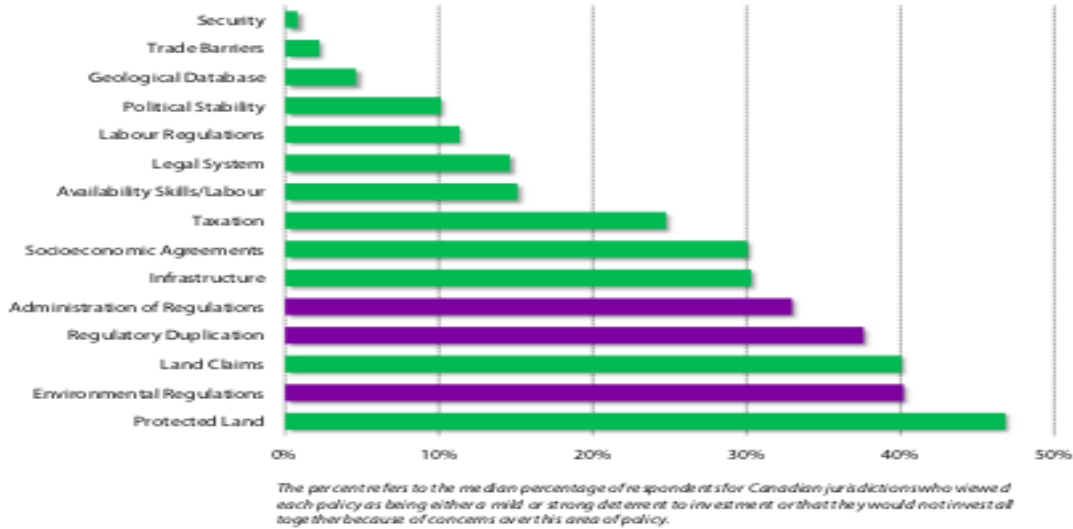
Each country is working to achieve a balance between the social demands, economic benefits and long-term environmental impacts associated with the mining process. There are no easy solutions to resolving stakeholder concerns however fairly recent legislation in Finland and Canada as well as current procedures in certain Australian states do show promising potential to resolve delays associated with overly concurrent processing, duplicative reviews and delays due to poor requirement transparency. Finland successfully transferred mining authority into one agency, the Finnish Safety and Chemicals Agency (TUKES), to serve as a clearinghouse for approving mining projects. Canada established the Impact Assessment Agency of Canada to be the single federal body leading all impact assessments and coordinating Crown consultations for all federally designated projects and established an improved process (Figure 3).

Certain provinces in Canada and Australia also outline in detailed guidebooks, very clear expectations and proposed management practices for addressing issues that typically arise during the mining process. This is a best practice to enable greater transparency in terms of what mitigation measures would be expected in a permit application process. Some Australian states also utilize business development representatives to serve as a gateway to obtain advance information. The Australian government also designates certain strategic or economically vital mining efforts as Major Projects which companies view as a means to obtaining a “thorough, smooth and potentially faster approval process.”

The US should consider establishment of a Bureau of Mines, under supervision of the Department of Commerce, in order to serve as the clearinghouse with the Departments of Interior and Agriculture to ensure that permit applications are more efficiently and quickly decided. It also provides greater opportunities to coordinate strategic objectives and potentially expedite important projects. As a first step towards this recommendation, the US should reinvigorate the Service First (SF) initiative authorized in 2012 but not consistently utilized. This will enable greater coordination amongst the various approval agencies and state governments given the co-location and shared responsibilities under this construct. These

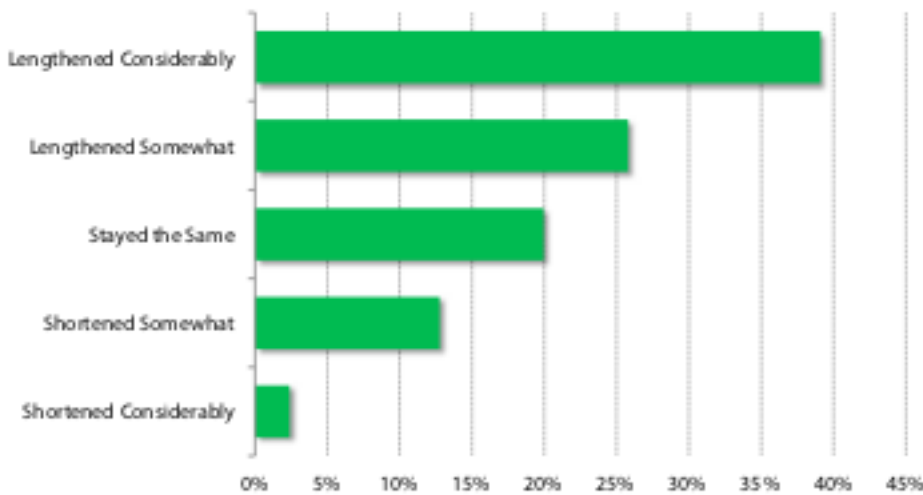
regional SF offices can also work more closely with the state on developing more thorough guidebooks that would be useful for mining entities in their application preparations. These efforts will be a step in the right direction for the US to meet its stewardship responsibilities while also encouraging the development of strategic materials that are important to the US economy and to national security.

Figure I - Barriers to Investment in Canada, Median Deterrent to Investment Scores, 2014



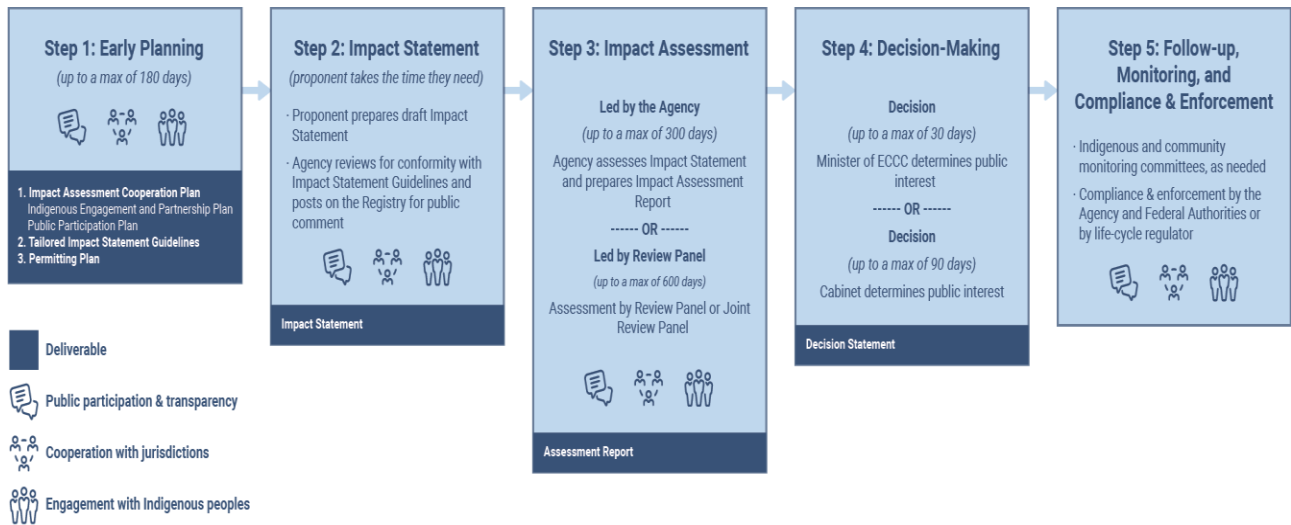
Source: Jackson and Green (2015). *Survey of Mining Companies 2014*.

Figure J - Changes in the Time to Permit Approval over the Last 10 Years



Source: Jackson and Green (2015). *Survey of Mining Companies 2014*.

Figure K - Canada's Impact Assessment Process



*Regional and strategic assessments would be proactively conducted outside of individual project reviews. This will help inform project assessments, manage cumulative impacts, and support decision-making.

Closing Recommendations

Temperance is difficult, yet that is the quality which must underscore US reactions to our risk exposure with respect to strategic materials. Democratically-elected governance brings with it useful accountability, which in turn predisposes those in government - who are often already intrinsically motivated toward public service - to take *action* toward *controlling and solving* the problem at hand.

In matters of economics, if not all facets of lawful human interaction, our federal government was deliberately designed to function in a manner such that it is *constitutionally* ill-suited to intervene. While a few recommendations involve some affirmative government control actions, they are modest. In the main, our recommendations are driven by our underlying assessment that our government should loosen the reins.

1. *Understand and Trust free market forces*, which in combination with fair trade practices are best postured to determine the critical nature and cost of materials required for our national security.
2. *Recognize the increasingly global nature of economic activity* has facilitated global supply chains that both contribute and bring risks to our national security.
3. *Understand global supply chain development* and maintenance are characterized by multiple market philosophies in tension with one another, particularly with respect to the necessary and proper role of government.

Further understand that non-commodity, critical minerals-based markets involve the additional complexity of exceptionally opaque pricing forces;

and, *understand* the direct and indirect effects of this complexity on availability of end-use applications.

4. *Commonly define "strategic material"* in order to facilitate coordination and integrated actions within a US strategy to reduce import reliance risks.
5. *Re-define critical minerals (in 30 days or less)* to include fuel minerals or mineral materials.
6. *Revise (in 30 days or less) EO 13766*, in order to specify that extractive industry projects shall receive expedited environmental reviews.
7. *Expand "Service First"* authority beyond the DoA and DoI, in order to more broadly expedite permitting and access for surface and subsurface rights in all federal lands.
8. *Lift the moratorium on federal land patents* - reopening land to exploration under the Mining Law of 1872, while increasing patent prices based on market research and analysis.
9. *Encumber future land patents* with the condition that purchasers will explore, extract, and produce economically viable resources, or the patents will revert to the US.
10. *Use DPA authority in a limited way*, by making market-informed purchase commitments to assist nascent or degraded mineral sectors that supply strategic materials. However, delay execution of such commitments, taking delivery only as a last resort if other commercial firms are unable to purchase at market prices.
11. *Increase recycling technology R&D spending*, focusing on on critical materials for which recycling technology exists but is not being accomplished by the US or it allies and partners.
12. *Eliminate barriers to tailings recycling*, by pursuing "Good Samaritan" legislation to adjust the inherited Superfund liability associated with abandoned extraction and production efforts.
13. *Explore public-private recycling ventures*, with a view toward preparing to recycle lifecycle replacement items already rich in concentrated strategic materials.
14. *Maintain US commitment to alliances and partnerships*, in order to mitigate the risk of global supply chain disruption.
15. *Establish a critical minerals czar*, responsible for coordinating US foreign policy, diplomacy, and associated government actions on critical mineral issues.
16. *Secure funding for a DoI (USGS)-led mapping effort*, focused on the United States and its territories, culminating with a publicly available database of strategic materials and their locations.

17. *Assess (in 30 days or less) actual and perceived litigation risks* associated with permit decision-making processes in the executive branch (encourage the same effort among state governments), with an open-minded approach that embraces the possibility that discrete cases have contributed to an overly generalized narrative portraying our judicial system as a roadblock to the strategic materials industry. Equipped with a fact-based assessment, take steps to intelligently manage litigation risk and, as a result, accelerate permit decision-making.

Appendix A - Summary of Meetings and Travel

STRATMAT traveled extensively to many places, learning about the importance of strategic and critical minerals and materials as well as rare earth elements. The purpose of our travels was to determine the what the minerals, materials and elements are, what they are used for, and how they are important to our nation's national security. Most of these materials are used for countless technologies we use day to day as well as within our various weapon systems. The intent of this paper is to inform the reader on all the places we visited, who we engaged with, what we learned about each company or agency, what element, material, mineral, or rare earth the companies mine and process and how these materials align with our nation security. We also wanted to gain a better understanding of the mining processes from an International perspective to see if the United States could improve or streamline processes. We traveled to three local sites, 15 domestic sites and 18 international sites (within Chile and Australia) to ensure we fully understood the strategic materials industry from a local, state, federal, and private sector perspective.

Local Travel

United States Geological Survey

Our meetings began locally where we traveled to the United States Geological Survey (USGS) located in Reston, Virginia. We visited the USGS to gain a better understanding of what their role is as an Agency and what their interest and relations are to strategic materials. We met with the Deputy Associate Director, a Rare Earth Commodity Representative, a Commodities Director, a Material Flow Analyst, a Beryllium Commodity Specialist, a Magnesium Commodity Specialist, and a Lithium Commodity Specialist.

During our visit, we were briefed on strategic materials' importance. We learned about the importance of mineral resources and how they are used within just about everything we utilize on a daily basis. For example, the evolution of the cell phone went from using 30 elements (the brick cell phone) to now using about 75 elements. The construction of the cell phone is totally dependent on what resources are available and the cost of the cell phone can be driven by the access to such resources. We learned about the National Minerals Information Center, whose mission is to:

- Collect, analyze, and disseminate data,
- Provide information for recipients to make informed decisions,
- Provide open access to publishable information (some data must be withheld because of private industry),
- Be industry “judges” as it relates to regulation, and
- Oversee over 90 commodities.

Here we discussed the global demand for minerals commodities and how China has used more mineral commodities within the last 4-6 years than the United States has within the last 100 years. The USGS analyzes the supply and demand of such commodities. We discussed the

properties and uses for beryllium, tantalum, platinum, copper, coal, aluminum and aluminum alloys, molybdenum, rhenium, magnesium, lithium, and rare earth elements.

The USGS provided statistical information regarding our net import reliance (% of apparent consumption and how much we are net reliant of a particular item), analyzed our supply chain risk of materials we may choose not to mine, and how China has taken over the world market. Amongst many other topics such as conflict minerals, the Dodd-Frank legislation and the 3TG conflict, we also discussed how China is now beginning to take over the higher chain commodities where we were once the world's top producer.

Electron Energy Corporation

The Electron Energy Corporation (EEC) is a family owned rare earth magnet company that was founded by Marlin Walker and is located in Landisville, Pennsylvania. Mr. Marlin pioneered the development of Sm-Co which is a new class of permanent magnets. Their mission is based on specialist in rare earth magnets and systems and they feature employees with integrity and imagination. Their vision consists of people, growth, customer focus, and technical leadership. In terms of making the materials (magnets), EEC is the last in the United States to do so.

We were briefed by the President and CEO who walked us through the process of making their parts and the products and services they offer. We were informed of the current partnerships they have with universities, laboratories, government agencies, as well as their industry partners. Some of the application they provide are aerospace, medical devices, nuclear devices, instrumentation, motion and sensor, and Defense. We were given some insight into some of the more common applications they do, some current applications they are working as well as some future applications that are being explored and developed. They believe they would be prepared to meet our surge demands should that occur. Currently, they have no interest in investing in a mine because they are too small of an organization for such a risky investment.

United States Senate Committee on Energy and Natural Resources

We met with the US Senate Committee on Energy and Natural Resources. We discussed the Senate's concern about critical materials and what they believe means for our nation. The committee discussed the Executive Order that identified 34 different minerals and the potential risk within supply chain. The market issues and government/regulatory issues from their perspective. Further discussions about the energy shortage and global competition were engaging. The has some initiatives regarding the ability to get minerals out of the ground in the most economic way.

Further into our visit we discussed the committee's thoughts on the mining workforce, federal workforce needed for the permitting process and how we get there as a country. The visit concluded with discussions regarding the final Executive Order and the roles and interaction the committees will have with one another.

Domestic Travel

Materion Pebble Plant, Elmore Ohio

Our domestic travel began with a trip for discussion and tour of the Materion Pebble Plant (both old and new) in Elmore, Ohio. The purpose of our visit was to gain a better understanding the total life cycle of Beryllium from exploration to fabrication and some end use products. We had a particular interest in this facility because this is a Title III investment. We were given a guided tour of the facility, and engaged in a briefing given by their senior leadership. We discovered that in 2000, Materion (formerly Brush Engineered Material, Inc.) closed its beryllium facility in Elmore, Ohio. When the United States realized that we were without a reliable supplier of beryllium, the Defense Production Act (DPA) Title III, was utilized to establish a new beryllium plant to ensure our nation had a dependable source of beryllium.

The new facility produces high-purity beryllium at an approximate rate of 160,000 pounds per year. This quality of beryllium is used in numerous DoD applications where there no other viable substitute is available. Beryllium is an extremely light weight material that is used for weight driven airborne heat-sink applications. Some uses of beryllium include metal alloys used in electrical connectors; optics, clad metals, alloys used in navigation systems, braking systems, camera and other sensors; enhancement of semiconductors used in smart phones, tablets, computers, and other electrical devices; inorganic chemical phosphors used in LED lighting; inorganic chemicals in ink used for printing of currency making it harder to create counterfeit currency world wide; thin film deposition used in medical testing, devices and technology; and unique combinations of material can be used for electric and hybrid cars and medical implant devices such as pacemakers.

United Steelworkers Union, Pittsburgh Pa

We traveled to the United Steelworkers Union in Pittsburgh, Pennsylvania. The purpose of this travel was to better understand the impact unions can have on the workforce including areas where the government's need for particular skillset are and could be affected. We met with VP of the Union and several other Senior Leaders within the organization. The United steelworkers union is the largest union in North America. They have over 1.2 million members and retirees. Some of their member base are stationed at the Newport News Virginia shipyard, and Redford Army Ammunition Plant.

During our visit, we were educated on how they bargain, what the laws provide once the Union is certified for a particular group of individuals, and how bargaining over things that would violate the law is not permitted. We learned that a good union is there for their workers when they are alive but a better union is there when the workers are not. Their Washington DC office is primarily focused on policy and they work with Congress and a wide spectrum of agencies. The United Steelworkers Union worked with Materion to develop a worker health and safety standard around beryllium. They currently have a blue/green alliance and they believe in environmental protection as well. Metals is about 30% of their business. Some of their challenges include, but are not limited to:

- Metal price cyclicality,
- Declining ore grades,
- Limited mine life of any mines and projects,
- Stripping requirement and business cycle,
- Capital intensity and comments of new mining equipment,
- Training and apprenticeship programs,
- Natural resource companies hostile to unions.

Climax/Henderson Mine, Colorado

We traveled to Colorado to explore the Climax Henderson Mine operation to gain a better understanding of the mining industry for molybdenum (moly), copper, and gold. While there we engaged with their new President, the Director of Operations, the General Manager, and several others in Senior Management. During our visit we toured the Henderson mine. Henderson is a subterranean mine that is approximately a mile below the surface. The Climax mine is an open pit mine. These mines began 100 years ago and has since won the Army/Navy Excellence Award?????. They are currently the world's largest moly producer and are vertically integrated from "mine to market". They have both primary and by products. Primary is moly, by products are copper and gold. What is mined in Colorado is the primary product of Moly.

They are a subsidiary of Freeport McMoRan and produced about 74 million pounds of Moly in 2017 and is the second largest power user in the state of Colorado. Their production of Moly is based on an end customer because it is not a commodity like copper. Therefore, they only mine it when they have a customer that wants to buy it. When output is reduced, the life of the mine is extended. When moly steel is used for bridges and roads it adds about 1/3 of additional life to the structure.

Some of moly's uses are for construction steels, stainless steels, high speed steels, and space aircrafts because of the high temperature sustainment. Some of the applications are buildings, chemical plants, oil and gas refineries, power plants, and oil rigs. Some chemical applications are catalyst, sinter, lubricants, water treatments, pigments and smoke suppressants. It can also be found in flat panel displays, lighting, and furnaces.

Hazen Research, Inc.

Located in Golden, Colorado, we traveled to Hazen Research Laboratories to understand how research laboratories contribute to the cutting edge technologies and developments while using rare earths, critical, and strategic materials. Hazen Research Laboratories is an Employee Stock Ownership Plan (ESOP) corporation that has about 1,200 clients of which 60% are mine related. During our visit we were shown mineral processing, thermal processing (in a smelter), and some projects involving coal and uranium. We also learned that they specialize in the "how" or design criteria for environmental clean up projects. Hazen worked closely with the Environmental Protection Agency (EPA) on a mercury clean up project and the EPA adopted their recommendations and practices. From their perspective, the price of metals need to go up so that more companies will want to process more products and contribute to the economy.

Resource Capital Funds

Resource Capital Funds (RCF) is located in Denver Colorado and is a Private Equity Investment Firm specializing in the mining industry. We visited them to understand the investment side of the mining industry, what challenges they face, how much investment does it generally take to get a mine operational and producing and what risks are involved. Currently their focus for investment is nickel, copper, gold and zinc and they have a global presence in Denver, Perth, New York, Toronto, and Santiago. After 10 years of investing they return the investment back to the investor and about 90% of their investors are in North America. RCF look for environmental, social and global (ESG) investments and they believe land access can be one of the biggest challenges in the mining industry.

Colorado Department of Natural Resources, Division of Reclamation and Mining Safety

We visited the Colorado Department of Natural Resources, Division of Reclamation and Mining Safety. Our meeting was to better understanding in areas such as, their administration, their duties, their permitting process and and the beneficial uses of reclaimed sites. The briefing we received allowed for a greater depth of knowledge into their statutory history and their regulatory authorities. We discussed the *Hard Rock Act and Constructive Materials Act* which are the two acts they adhere to and we were informed of the duties of the Board and Office, the role of the Mineral Staff Authority, the financial warranty involved for reclamation of a mine, construction materials permitting process and the Colorado Mined Land Reclamation Act.

During this visit we also met with the Department of Public and Health. We received insight on the Quartz Hill Reclamation Case Study and the purpose of the Superfund (CERCLA). The Superfund Legislation was passed in 1980 and was a tax create to assist with environmental cleanups. The CERCLA tax expired in 1996, however, the fund continues to operate with reduced funding. Another briefing was given to educate us of the Mining Authorities and Evolution of Minerals Management. We were informed about when the first mining act was passed in 1866 through 2005 when the Energy Policy Act was implemented. Finally, we discussed National Environmental Policy Act (NEPA) and the environment analysis and decision making process.

Colorado Mining Association (CMA)

During our time in Colorado we met with the President of the Colorado Mining Association. The CMA has a 19 member Board of Directors and represents all the mining companies doing business in the state of Colorado. The purpose of the Board is to advocate for public policy issues and promote the interest of the industry from the local perspective. We learned about the socially economic challenges their local communities are experiencing and while there we discussed the differences between coal mines, aggregate mines, and hard rock mines. The CMA are staunch defenders of coal because 50% of the state's energy relies on coal. We also had the opportunity to discuss the 2015 Gold King Mine disaster where a tailings spillage (540 tons) caused the Animas River and San Juan River to run orange for several weeks. This provided the chance to engage in a Good Samaritan Law dialog.

NioCorp

Our final meeting during our Colorado travel couplet was with NioCorp, currently a junior mining company. NioCorp is seeking investments of over \$1.5 billion for the opening of a underground niobium, scandium and titanium dioxide mine. We learned about scandium's properties, uses and how it can be important to our National Security.

Albemarle Corporation, Silver Peak NV Operations

We visited the Albemarle Corporation, Silver Peak Operations located in Nevada. There we met with the Operation Managers and the Productivity Engineer. We had an interest in this mining operation because the Silver Peak Lithium Mine is the only lithium mining operation in North America. Globally, Albemarle Corporation has roughly 4,500 employees and specializes in both hard rock and brine mining of Lithium. This particular operation specializes in brine mining. Prior to 1981 lithium was a leasable mineral and after 1981 became locatable.

We learned about the lithium extraction process which is basically done by drilling wells and pumping them into evaporation pools. The lithium they produce is contained within the groundwater. It is then pumped into large evaporation pools and within a 12 to 18 month timeframe the brine becomes lithium concentrate and transferred to the factory for processing into lithium carbonate. The lithium carbonate is shipped to their Kings Mountain facility for further production. The by products of this process are magnesium hydroxide, salt and calcium sulfate. The plant's has the capacity of 7,000 tons per year, however the equipment is quite dated and will need to be addressed in the future.

Mountain Pass Mine, Southeast California

During our visit to the Mountain Pass Mine located in Southeast California we engaged with the CEO, the Operations Manager, and two of their geologists. We had an interest in visiting this mining operation because it is America's only rare earth mine. In 2015 the owners of Mountain Pass, Molycorp, filed bankruptcy and the mine remained idle until the December, 2017 when it was brought back online. MP Materials is now the new owner of Mountain Pass Mine, however there is some concern about MP Materials relying on the Chinese mining giant Shenghe Resources Holding Co for financial and technical support.

The facility is currently 2200 acres and they have approximately 40 agencies involved in the "Project Phoenix". The land is currently patented/private land and they mostly engage with state and local officials, not the Federal Government so much. MP Materials currently has 170-190 air permits which covers anything that generates dust, vapor or gas. These air permits do not include any land permits, plant permits and the like. In the upcoming years, MP Materials must invest in a new roaster because the roaster is further away than it needs to be and was built in 1962. To replace the old roaster, they must apply for new permits but have determined all the new cost would make the facility more economically viable. Mountain Pass is currently in talks with the Defense Logistics Agency to see if the DoD has any interest in contracting with MP Materials.

Materion Natural Resources Utah Mine and Mill

During our visit to Materion Natural Resources, Utah Mine and Mill we met with the President of Operations, the Technical and Quality Advisor, and several other operational employees. We have an interest in this mine because this is the only beryllium processing plant within the United States. Here at this plant they have to move about two tons of rock to get about a pound of beryllium. This facility mines bertrandite ore which is .25 percent beryllium and creates about 18.5% beryllium hydroxide. While receiving our briefing, we learned about the bertrandite process and toured the facility to physically experience the process. Here at this mine/mill bertrandite is their bread and butter.

We learned that in 2000 Materion bought beryllium ingots from DLA and that was about a 10 year supply. In 2011 the DoD stockpile was going to run out of Beryllium. At that time Materion had a \$10 million per year business and was facing a \$100 million investment. Materion received \$70 million in Title III money and invested \$30 million themselves. That money was invested in Materion's Pebble Plant in Ohio.

We also discussed whether Materion could meet the demand of a surge should one arise. They believe that the initial surge would not be the main problem, maintaining a surge would be the bigger issue. Other interesting facts we learned during our visit included:

- Beryllium is located in the volcanic tuff beds,
- Materion owns the surface rights but lease the mineral rights,
- They must pay a royalty to Utah public schools,
- They have about 75 years of reserves,
- They would like to have smaller pits so they do not need to have so much inventory sitting around. This would also make the processing faster.

Rio Tinto Kennecott

We visited the Rio Tinto Kennecott Bingham Canyon Mine and mining operation located just outside of Salt Lake City, Utah. Rio Tinto Kennecott is a wholly owned subsidiary of Rio Tinto and is a fully integrated mine. At this site we had the opportunity to meet with the Director of Finance, the Director of Logistics, the Communications Director and the Human Resources Business Partner for the Mining Group. Our interest in this facility was because it produces some of the materials used in so many of our everyday products as well as many of our weapon systems.

This mine has a very rich ore body has been in production for 110 years. It is a strong economic contributor that strives to be a valuable partner to the community. Bingham Canyon's Mining Operation includes copper, molybdenum, gold, silver, and sulphuric acid. The facility at Bingham Canyon includes an open pit mine, Copperton Concentrator, Garfield Smelter, refinery, power plant and production facility. We had the opportunity to tour the entire facility and learn about the economics and viability of this mining operation. Rio Tinto has applied for Rapid Innovation Funding (RIF) through DLA for the processing of uranium. If this two year R&D project is successful, the DoD could have a domestic source for uranium.

Utah Governor’s Office of Energy Development – Utah Science Technology and Research Initiative

While in Utah, we visited the Utah Governor’s Office of Energy Development. We wanted to engage with Utah’s state government to learn more about their mining initiatives as a state government, their views of the mining permitting process all the way through to the opening of the mine and how are they planning for future initiatives. Utah was just deemed the most “Diverse Economy” in the country, up from number 3. Our meeting began by speaking with a former ICAF (now Eisenhower School) student. We were briefed about how she is currently using what she learned from her ICAF experience to drive her current initiatives. For example, she has adopted the Asher Overholt Model into her career planning and it has proven to be effective for her.

We learned that the Utah Science Technology and Research is similar to the DARPA agency but at the state level. Their mission is to build and diversify a robust innovation ecosystem in the state of Utah. Currently they are focusing on areas where there is market gaps (where private industry is not addressing) and they are targeting areas of:

- Aerospace automation,
- Robotics,
- Big Data and Cyber Systems,
- Energy Clean Technology, and
- Life Sciences.

From a research perspective, an interesting initiative they have is how they target the “Valley of Death” and work on getting the innovation to market. This state agency currently offers competitive grants and has an innovation center where they have public/private and Federal partnerships. At this center, individuals can work on reverse engineering development when necessary to bridge the gap when necessary.

Lieutenant Governor Cox joined our meeting, where we were able to have open, honest dialogue about his strategic leadership and his views on topics such as private/public partnerships. We were also able to engage his perspective on government seeking private partners that can do it better than we can.

US Department of Interior, Bureau of Land Management

The Bureau of Land Management (BLM) regulates mine plans with Utah. It does not explore for minerals and currently has 24,000 mining claims in Utah. Although the BLM does not explore for minerals, it works to manage those that do find viable deposits. The BLM stood up a task force to evaluate permitting for:

- 1 or 2 centralized oil/gas leasing teams,
- Streamline NEPA processing using document referencing,
- EIS processing in 3 years is the minimum and 7 is the normal timeframe (13 – 18 months processing is the goal),

- FOIA requests, responses to appeals and litigation,
- Master Leasing Plan.

The BLM is currently experiencing staffing issues while trying to complete such tasks. They currently have 535 vacancies and are not certain when they can fill them which places a concern on the timing of:

- Completed applications,
- Briefings (both up and down the chain)
- Responses to appeals to litigation (reactions to administration drives litigation from one entities to another,
- Administration Procedures Act which allows 6 years for appeal
- Service First — authorized by Congress, and
- Joint Management Areas — one SES who can force coordination.

International Travel

Expomin, Santiago Chile

We were interested in this particular event to gain a better understanding of all the technology involved in the mining process. Currently, on its 15th year, EXPOMIN gathers all players in the sector and attracts the largest group of world-class local and international supply companies, creating the perfect setting for interaction between suppliers, professionals and executives that represent the entire value chain of the mining industry. The Expo focuses on products like exploration mining and geological mining, drilling and blasting, treatment and disposal, waste mining, earthwork, excavation, leveling, transportation and logistics and the metallurgical processes.

Albemarle, Santiago Chile

During our international travel we visited Albemarle located in Santiago, Chile. We met with a member of the Board of Directors and a representative from their Santiago office. We learned that cooper is the main mining in the country (taxes, education, main contributor to economy) but lithium has become the new “darling”. No where near the contributor as copper but it definitely appears to be their next viable economic resource. While lithium is unique in Chile, the purity of the ore and the process in high desert in north and it is much less labor intensive. With brine the waiting period is just about 18 months for sun to do its work. There are no likely viable sources that is better suited as the lightest metal. If weight and size do not matter, then you may have other sources. Lithium is used mainly with electric vehicles which is its main demand (quantity of lithium). All others uses are minute phones, tablets, electronics.

Albemarle's focus:

- Dedicated to extraction and processing of brine (carbonate and chloride). Brine is their raw material,

- Innovative committed to its environment and part f one of the most lithium producers in the world,
 - 75% of their product goes to Asia to produce batteries,
- Developers of the lithium industry in Chile and CORFO. More than 37 yrs experience,
- Sustainable business that protects the country's natural resources generating benefits for stakeholders,
- At Plantar La Nedra they have 312 workers but by 2020 they will be 700+,
- Plants Salar de Atacama 208 workers; will expand to 450 workers in 2020,
- Santiago will stay about 50 employees,
- Sustainable/agreements (community engagement)
- Shared value/associativity (relations through universities),
- Albemarle is not a battery producer, they just provide the raw material for the batteries. They are the resource. The value add here in country (turning brine into chloride etc.). Turning it into batteries, they will have to partner with others. To date there has not been much interest in doing this.
- Economic model is privatization and the state has an interest in taxes and royalties.

Who will supply the new lithium demand?

- By 2020 they will be at 31%; 2006 it was 52%,
- Australia does not produce carbonate. They are now investing to create hydro carbonate plant,

Albemarle has a new basic agreement with CORFO that consists of some of the following:

- 25% reserve of production of entities of specialized products chosen by CORFO,
- Development of Technology,
- Increase in production capacity,
- Indigenous communities are participants in the company's benefits (3.5% of annual sales),
- Contributions to the state for \$2.7billion,
- Annual contribution of \$12 million for innovation and development,
- Preferential prices of up to 25% of national production to national manufacturers,
- Extension of contract 27 years from 2017 or consumption of quota,
- New quota of metallic lithium (262,132 tons),
- All information is public information/very transparent.

Efficiency quota that is based on sustainability

- 2017 Chilean environmental authorities approved lithium yield optimization project for the Salar de Atacama operation
- Efforts in securing sustainability.

Mining process summary

- Pumping brine — Atacama Salar .2% concentration—after 18 months in the sun it becomes 6% concentration. The brine is very very good here. For example in Bolivia the concentration is 0.08,

- 58% efficiency,
- Transport from Solar to Negra where they remove magnesium (considered waste). Potassium is their byproducts and for potash,
- From LaNegra the process is carried out and value add to the lithium according to the requirements of each client,
- State owns the mining land, Atacama (CORFO),
- Final product:
 - technical grade lithium carbonate
 - Battery grade lithium carbonate
 - Lithium chloride.

They are doing a lot of drilling exploration right now. New permitting will allow 442 liters per second with water rights of 23.5 liters per second. 442 liters per second is their production goal and so it will not affect the hydrological balance. To do this, they need new well areas. They have operational wells and explorational wells. They hope at the end, the explorational wells become operational. SQM has rights to pump 1,700 per second. With water rights of 450 liters per second. For one year of operation 650 MW of power is needed for brine concentration. If another source would be used it causes more CO₂ emissions. SQM produces 2 million tons of potash vs. 135,000 tons of potash that Albemarle produces. Once they have the final brine, they need to remove magnesium and calcium to have a more pure lithium carbonate. They have moved from a two step process to a one step process. This process has only one filtration step. They can use the lithium carbonate to produce lithium chloride.

COCHILCO

During our visit in Chile, we met with an analyst at COCHILCO. COCHILCO is the Chilean Copper Commission. The Chilean government will not step in and claim certain companies as their own. Some facts about the Chilean economy is:

- Mining is 10% GDP,
- Poverty is about 11.7% of population,
- 13.1 people have access to internet,
- 26.5 million cellphones,
- 23,194 gross per capita. Their gross per capita has doubled.

Mining is their main economic activity (Cu, Re, Mo, Ag, Au, Y, Li) and they mine 30% of the world's copper and have most known reserves in the world. Followed by Australia and Peru. Chile has RE which is 52% world's reserves and 57% world's copper production. Mo is 16% world reserves; Ag 6th producer, 14% world reserves; Li 2nd after Australia and 53% world's reserves, 35% world production; Y 24% world's reserves, 66% world's production. Over 90% of export comes from copper. What the importance of mining for Chile? 10.1%. Not including trade, transportation, and tourism in this number. Therefore, they are essentially a mining country.

Every year they spend millions of dollars in exploration to ensure the deposits are there. It is very difficult for them to find mega large deposits of copper because most of those deposits

have already been explored. No new deposits have been found in the last decade. Everything they know about they are exploring. They still have large deposits they are currently exploring. There are no restrictions for a foreigner to come here and explore the deposit. If they can get the permits and funding to do so, but 2/3 of copper production comes from private mining. Chile produced 5.5 million tons of copper in the world. They protect the price of copper but they are also very interested in what the Chinese government is doing. They are following them very closely. They follow their main variables and rely on China for production. Copper because it is standardized and can be used to obtain financial credit. For example, if they want to build a building, they will give copper credit so they can build.

The 4 cycles of copper consist the Industrial Revolution, Industry in the US, Industry in Japan, and now the growth of China. What is different about this? China is starting to concentrate the world's minerals. They say that the Chinese will not keep growing, but it has now grown bigger than 50% of world's demand. The Chinese are the largest importer of Chilean products. The US is the second largest. So they care about these two economies. They expect with the electrical cars demand, demand to go up two fold. But it will also affect demand growth, at a slower rate. This will cause companies to adjust their demand growth. Smaller margins are going to drive the prices of copper up and there are certain restrictions that are causing the prices from dropping too low. One of the problems that Chile has is a productivity problem. That is because the price was too high. But when the prices dropped, the price was focused on the cost. The only way to increase production, is to focus on new production technologies that will cause the price to slowly go down temporarily. For example, autonomous trucks are cheaper in labor costs.

The United States currency policy with the new tax law that they passed in December will cause the deficient to go up the copper price to go down. They must know the future price of copper so that they can know if their project investments will be worth it. They try to predict copper prices but it is all just speculation. Because China uses up 50% of the world's copper, especially in the real estate sector, if their demand for real estate goes down, that will effect the price of copper.

Some of the Geopolitical conflicts from the past four months that are affecting the price of copper is the China and US tariffs. These tariffs are making it harder to predict the price of copper. The US interest rate is going up so they are hoping the US dollar value will go up. The state is very important in terms of the fraction of investment. In 2018 they will reach almost 6 million in copper production. Approximately 1/3 of copper production is recycled in China however, this is going down. Restrictions (environmental) are coming into because of the China's pollution. The imports for scrap have dropped 90% because they are so hard to refine and because they are so pollutant. Therefore, companies will have to clean scraps before melting them.

China, EU, US, Japan is 70% of the world's copper demand. The world market for refined copper is in a decline right now so there is a balance they have to do. Chile is a mining country although it is thought as being an agricultural country. They can keep taxes low because of their copper mining. Foreign investment system is very transparent. The mining possession is granted by the courts not the government. The only restrictions is following all the regulations.

There currently is not much room for new companies to come because it has already been explored and developed. Mining affects all the other sectors such as, tourism, manufacturing, transportation, but these sectors do not effect the mining industry. It does not work in reverse. Chile is not in a situation to produce the final products. For example, cell phones, radiators, electronics, and batteries just to name a few. They are not there and will not be able to get there. China seems to be reaching their top demand for copper. The copper demand is relying on Asia overall. For example, Taiwan may increase their demand, but they will never reach the demand of China.

How are COCHICO analysis used by the government?

The main role is to advise the state regarding copper investment. They are in constant communicating with the mining industry. They are public. So when the state decides to legislate on a mining copper issues, they advise on that matter. Then the state can then decide which way to go. They are/were about 99% copper and now they are looking at Lithium. They do studies/analysis and provide recommendations. Lithium is designated as a strategic material but there is some uncertainty as to how that happened. The last time they went through their process of determining something strategic was in the 1970's and therefore no one really knows how this happened and was determined strategic.

CODELCO

At CODELCO we had the opportunity to meet with the Vice President. CODELCO is a state owned enterprise that produces 1.74 million tons of copper each year. The newest development they are pursuing is to preserve their reserves over the next 40 years. The master plan of sustainability is to anticipate the market tendencies. The tendencies are more transparency of environmental to natural resources, natives, water, human rights, labor rights. Their first priority is to preserve the health and safety of their people. Master Plan over the next 20 years sustains around 1.74 million tons per year. An investment project of \$4 billion per year is the budget assigned by the government to them. This is accomplished by open leasing, both domestic and internationally. CODELCO has their own labor force of 17,000 workers in eight divisions and other people are contractors—40,000 (on top of the 17,000). Last year they had a copper price of a little over \$3. There is a demand to have more of a surplus. Minister of Interiors will take their recommendation and approve and tell them what to do with the money.

CODELCO is the largest copper mining company in the country. From 2014 to present they have been given \$4 billion per year for development. In the north they have an open pit and a totally automated underground mine. Because of the location, they operate a plant 1500 miles away. Currently they recruit from Universities and Tech Schools for talent entrance to the mining industry. They help to define the curriculum to meet the future demand they foresee within their mining industry. The needs have been given to the tech schools and universities. They also have a very strong union. They just finished reorganizing the refinery and reorganizing the workforce.

Permits

To gain approval for a project by COCHICO and the mining ministry, CODELCO has to have the environmental impact approval first. It takes about tow – three years to obtain the

environmental impact and cost about \$12-\$15 million just to study. It requires approval of the indigenous people/community and the environmental industry must also approve. CODELCO has 28,000 commitments. Every single project has to go through this process. If they want to modify it, they must submit the modification for approval. Currently they are exploring a \$50 million project in Ecuador because it appears to be a very attractive reserve there.

If there is a workforce strike, it is CODELCO's problem. The workforce does have the right and power to strike and they use that power at times. Within the last 4 years, they have had 18 or 20 days of strike within one of their operations. In the event of a strike, the government would not intervene and it remains the problem of CODELCO. The workers are very well taken of and they receive productivity bonuses.

The state mandates CODELCOs to explore the reserve they have but CODELCO does not have the talent to explore the lithium reserves. They are building a business model to explore lithium. Re in the economic community of CODELCO it is very small. But they are exploring it as a byproduct. It is the same for gold and silver.

CORFO

CORFO is currently working on several innovation initiatives for the larger mining sector. They provide warranties for loans relating to mining technologies and also negotiate all of the lithium contracts for the state of Chile. CORFO receives royalties from these contracts that support CORFO's Solar Mining Technology Institute.

Resource Capital Funds, Santiago Chile

Resource Capital Funds is a mining market focused investment company that is focused on copper and lithium. Their Santiago location operates very closely in theory to all their other offices. They are particularly keen on the future market for the electric vehicles. They believe that the larger Latin America can produce more minerals than they currently, a market lightly tapped from their perspective.

Geoscience of Australia

We visited the Geoscience of Australia to engage in discussion about how they are similar and different from our USGS. We were also in search of what processes they have better streamlined than the US and could we utilize this information to possibly streamline our processes. We also in search of how much investment is being done in recycling and substitution to avoid potential National Security risks. We met with the Acting Branch Head, a Critical Commodities Analyst, a representative from the Department of Industry Innovation and Science, and a representative from ???(Dr. Anthony Budd—need to find out what agency was with)

While there we learned that the Geoscience of Australia is a Federal Government Agency that is similar to our USGS. They give advice and have their own budget (\$195 million

currently). They have their own laboratories and their organizational structure consists of a CEO and five divisions. Unlike the USGS they focus on six key areas:

- Securing water resources,
- Managing marine jurisdiction,
- Providing fundamental geographic info,
- Ensuring community safety,
- Maintaining geoscience knowledge and capability,
- Building Australia's wealth.

Their research division is to attract investment, build and map and identify carbon dioxide stored safely. The role of their Energy Systems Branch is to understand geological controls petroleum, map and characterize, collect data and sample acquisitions, analyze and interpret data. Their National Geoscience Repository is responsible for the Petroleum and Green House Gas and Storage Act of 2006 and the Resource Advice and Promotion Branch is responsible for:

- Resource promotion — Australian Minerals promotion
- Petroleum Resource Assessment
- CO2CRC
- Provide Technical advice but not policy advice
- Key stakeholders
 - Dept. of industry, innovation and science
 - Foreign investment review board
 - Dept. of the environment

The Mineral Systems Branch consists of five sections:

- Geophysical Acq. & processing
- Onshore seismic and magneto telluric
- Geochronology and stratigraphy
- Mineral potential of Australia—Nickel, copper and pg's' Salt Lake lithium, they don't update these projects annually because they are very expensive, but they do the Annual report similar to our USGS
- Regional geology and drilling

Some challenges and opportunities they have is to detect mineral systems and follow up with the 2012 National Mineral and International Strategy. This strategy consists of three key elements—lower technology risk, the exploration and investment plan and uncover new initiatives.

Geoscience of Australia also has a minerals program. This program consists of a Government Directive to build Australia's wealth and attract investment. To achieve this, they must understand structure, evolution and mineral resources of Australian continent. They are also tasked with helping to map out thickness and cover. They are currently engaging in a geological survey collaboration that include nine programs such as the AusLAMP Program. In

Australia, states and territories collect the exploration data which is then made public. They currently have a MOU with the US and they also collaborate with India, Finland.

Department of Industry, Innovation and Science

During our visit in Australia we met with a representative from the Department of Industry, Innovation, and Science. The purpose of our visit was to learn how the Australian Government interacts with industry and how they approach new innovative technologies. They are responsible for the Business the National Business Simplification Initiative Program where they offer grants, assistance & other support for small business. They are responsible for Australia's Innovation and Science 2030 Strategic Plan and 2030 Resources Taskforce. The agencies they work with for science specific topics include CSIRO & ANSTO and the Office of Chief Scientist, Geoscience Australia. Talking directly with the US Department of Interiors occurs frequently to make the alliances between Australia and US. The Department of Industry, Innovation, and Science has four pillars of investment that encourage investment, harness capability, protect environment by adding more depth around the application process, and supporting communities—community buy in is required prior to granting a permit. Their agency places a large focus on encouraging partnerships between companies, communities, academics and research institutions.

Latin America, Japan, China and the US are the main players they have partnerships with. They work closely with small to medium companies to explore what opportunities are available. Additional areas of responsibilities the Agency has is providing contributions to:

- Monetary and tax policy
- National law (health and safety)
- Security and defense,
- Immigration,
- International regulation,
- and FDI approval.

Currently at the federal level, they have control of offshore permitting, but onshore approval lies with the state. They also work closely with ALCAIN and have off take agreements. Business must have off take agreements for approval. We learned that Australia has a Defense Export Facility but nothing like the Defense Production Act. They have an existing MOU with USGS and are looking forward to the August 2018 report. They talk directly with the US Dept. of Interiors to make the alliances between Australia and US. Would the Australian Gov't subsidize any companies or processes for strategic materials. He wasn't sure but would take the question up and answer it for us.

Mineral Council of Australia

The Mineral Council of Australia represents the mining industry sector in areas such as trade, fiscal policy, energy policy, and the geophysical realm. Generally, the larger mining companies are represented by the Mineral Council. Coal is a large part of their membership. During our visit we learned that the permitting process takes an extended period of time similar

to ours here in the US. Permitting has become more expensive and more individuals have the ability to pause the permitting process. For example an individual can live in Melbourne, Australia and submit a concern for a potential mining company in Karratha, Australia applying for a permit. Actions like these stall the permitting approval process.

Copper, coal, REE have a much more challenging permitting process. Going through the courts to uphold certain mining can be quite a lot of time. It took 4 years for a REE company to get permits and they have not started yet. The industry is seeking consistent environmental standards so they can follow. Australia is behind the US in caring about space and there is no significant emphasis placed on recycling. There is a driving concern that the stockholding of oil is to be 90 days but they only have 40 day reserve.

They more are concerned with trade, company tax, trade tariffs, free trade disruption. They want to talk about bigger issues.

Australian Department of Defence

During our visit to the Australian of Defence we were able to meet with the Assistant Secretary of the Defense Industry, and the Assistant Secretary of Critical Infrastructure and Foreign Investments. Australia has the 12th largest defense budget in the world. They currently have 30,000 in their Defence Industry. Their Defence is really about the workforce and capabilities driven by the need to be competitive. The Australian DoD has a large amount of ship building expertise and the next generation of submarines will be doubled—the largest project they have ever had. Their DoD has a good land force capability but they are seeing a decline in their automotive capability. The US is their largest export Defence market. They currently face the question of how to stay ahead of the Chinese and Russians similar to the US and want to ensure they have secure supply chains, reduced supply risk and a national technological industrial base. The DoD does not worry much about strategic materials/minerals with the industrial base because it is far down the supply chain. If the US identifies a capability vulnerability, it will become a capability vulnerability for them as well. They are not focused on strategic material/minerals and therefore the report released in August 2018 will help them gain a better understanding of whether or not to place these materials as a strategic focus. Within their Defence Export Strategy there are five strategic areas that are moreso a plan but also a plan to plan beyond those five areas.

Australia does not subsidize mining and the Government believes in free and open markets and the government would not interfere where odds and services should be sold. The banking industry is one of the largest for the Australian economy and it is the strength of the Australian Financial Sector that underpin the country. From a mining perspective, they have companies poking to process in ways that can be done in Australia, but they need a definite market for those end products before investing in those processes.

They are currently looking for long term agreements with the US because they cannot use rare earths as a commodity. If the US needs to have an alternative supply (other than China), long term agreements with Australia would help bridge that gap. The US may want to consider bringing US companies to Australia so that the Chinese have a smaller footprint in Australia. We also learned that when considering foreign investments, they must understand the baseline risk and then some other areas of risk are highlighted, such as:

- Supply chain, agriculture issues,
- Protective security issues are in place,
- C critical infrastructure risks,
- They look at the 3rd or 4th step back to see how the investment effects the Defence,
- Emerging technologies and capabilities and the break in those area,
- Aggregation and having the ability to influence the supply and competition, and
- Protecting customer privacy (from a Healthcare perspective)

ANSTO (Australian Nuclear Science and Technology Organization)

ANSTO Minerals an Australian Government Organization that specializing in mining consulting. ANSTO is similar in nature to Hazen Research Laboratories. It has approximately 60 employees consisting of geological and mineralogical specialists, chemists, chemical engineers and process engineers that produce final product. Their primarily focused on metallurgy, mineralogy and also mine development. Their main customers 80% Australian based and 70% of work is done for new deposits & development of those deposits. ANSTO focuses on Technology Evaluation/Development bad how do they do it the most technological and economical.

ANSTO reinvest about 10% of their own income into their own technologies, R&D and future opportunities. These investments range from lab scale (testing, etc.) through demonstration scale. They generally will begin with a small scale first, then medium, finally large scale demonstrations. If they do not have specific customers for projects, they look at the economic viability of it before getting started. Who could use their research and who would be interested. Occasionally get asked for input regarding permitting, radioactivity and how to work through it and to understand human exposure. They can provide a lot of real world scenarios because they have completed a lot of handling radio activity and examined the risk. They consult with Department. of Public Affairs to gather advice of how to work with specific countries..

ANSTO provides internships and utilize the universities if they needed to produce in a surge capacity. They try to obtain their “brain” power as much as possible to ensure they have expansion capacity.

Alkane Resources, LTD

Alkane Resources, LTD is an Australian mining company. They have successfully helped to develop, construct, and operate two mines—Peak Hill and Tomingley, They are considered a small junior company that has a very good relationship with the community because of the jobs they provide and the ability to safely mine within a populated area. They were recently recognized for shortening the permitting process that took about eight year as from start to finish. The start was the time they engaged a consultant about water research to the end result of obtaining a permit. Generally, it can take 10-15 years to go from discovery to production. ALKANE was able to lessen this process to 8 years for their product because they accelerated the process and kept working and reworking different environmental scenarios until they could not test it anymore without changing the end product. This technique helped shorten the timeline

but that is not a guarantee that process will work all the time.. They completed an environmental impact study within 3 years — start to finish. They were able to focus a lot of resources at it (about \$10 million). They also had an overarching consulting firm overseeing the project. They are seeing the permitting process become more complex and convoluted due to compliance because every department is increasing their compliance.

Department of Mining Industry — New South Wales Government

The Department of Mining Industry for New South Wales focuses on leading the economic department for the state. Growing and driving business and investment is their key focus. Their workforce consist of key account manager that have specific industry experience. They partner with all levels of government included in the Federal, State, and Local arenas. They operate from the principles of mining regulations to help drive their client consultations. They walk their clients through the permitting processes both above and below ground. Geological Survey of NSW give tools to help with the exploration process. This tool is given away and is an open source. They maintain live core samples and mining companies have to report core samples. Any reports that are five years old or more will go online for public view. Purpose is to encourage new investment into NSW. They are also looking for companies to find new ways to perform exploration so that it improves and accelerates the process. NSW is beginning to see forward capabilities and looking at forward processing (processing to the point where its ready for use). The government is investing this processing through grants. There is an incentive where they fund up to \$200k into ground exploration because they are trying to get into the higher dollar value space.

CFMEU Mining and Energy (Union)

CFMEU, similar to United Steel Workers Union, is a Mining and Energy Union with a large history. They receive a royalty from the coal mining that is being produced and own 5% of the mine. They are associated with major super funds that supplies their pension. They conduct a workers compensation program and are representatives for workers at mining companies such as, Rio Tinto and Glen Corp. They currently have about 40,000 employees and have approximately 130 members in Australia. Being a member is not a requirement and they experience some problems with “free riding” from non-member.

More recently they engaged in the concern of liquid fuel security. This is where Australia is to keep a 90-day supply of fuel on hand but they currently have about a 40-45 day reserve. Australia has not completed a liquid fuel assessment since prior to 9/11. They were concerned when Rio Tinto was almost taken over by a chinese owned company and would have controlled one of the world’s largest copper markets and iron ore markets.

Automation/technologies is a growing concern because it is beginning to have significant impact the on employment numbers in mining industry. Hard rock mining is more susceptible to automation than coal mining. Automation will happen in coal mining slower than hard rock mining. Automation is now on their radar because in long-term there will be less and less jobs in mining. Mining is a significant part of their GDP but only 2% of the workforce is in mining. With automation, they have to be sure that the communities do not get left behind with no jobs

while the companies continue with their social license to operate. The mining companies will get less and less community support if the jobs do not come to the area.

Appendix B - Mapping Campaign Plan

Section 1. US security and economic prosperity are tied to critical minerals mined, processed, and imported to the United States. This reliance on foreign-sourced critical materials has rendered the United States' economy and military vulnerable to adverse foreign government action, natural disaster, and other supply chain disruptions. Currently, in the United States Geological Survey's 139 years history, less than 50 percent of the nation has been mapped to a level of detail necessary for today's critical minerals challenge. To overcome this challenge a resource informed plan has been developed to provide a comprehensive topographical, geological, and geophysical mapping survey database of the 50 United States and Puerto Rico. The desired end state of the mapping survey database is to consolidate all that is known with regards to critical minerals and increase private sector domestic exploration and production. Through critical mineral independence our leadership in technological innovation will be preserved, jobs will be created, national security and the balance of trade will be improved, and the technological superiority and readiness of our Armed Forces will be enhanced; which are among the United States' most significant consumers of critical minerals.

Sec. 2. Mapping Lead. The United States Department of the Interior, through the United States Geological Survey, will be the lead agency within the Federal Government responsible for the planning and execution of the national mapping strategy as well as the collection, consolidation, availability, and maintenance of mapping data obtained. The United States Geological Survey will coordinate with the following organizations to execute the mapping survey mandate established by Executive Order 13817, December 20, 2017 (Federal Register, Volume 82, Number 246), and protect information gathered to the extent permitted by law and subject to the appropriate limitations for purposes of privacy and security of corporate proprietary information:

- (a) United States Environmental Protection Agency.
- (b) United States Forrest Service.
- (c) Bureau of Indian Affairs.
- (d) Bureau of Land Management.
- (e) Bureau of Safety and Environmental Enforcement.
- (f) National Park Service.
- (g) Office of Surface Mining Reclamation and Enforcement.
- (h) United States Fish and Wildlife Services.
- (i) Geological Survey offices of the 50 United States and Puerto Rico.

- (j) Association of American State Geologists.
- (k) Universities conducting topographical, geological, and geophysical mapping surveys in the 50 United States and Puerto Rico willing to participate.
- (l) Private sector companies conducting mining operations in the 50 United States and Puerto Rico willing to participate.

Sec. 3. Mapping Funding. Congress should fund the United States Geological Survey an additional \$50 million per year for 10 years to be used specifically for the accomplishment of the critical minerals mapping survey. This funding should supplant mapping appropriations identified within the National Geologic Mapping Act of 1992 or subsequent National Geological Reauthorization Acts signed in to law in 1997, 1999, and 2009. Funds appropriated for mapping surveys should be separate and distinct from the United States Geological Survey's annual operating budget.

- (a) The United States Geological Survey should utilize the funding increase identified in Section 3, Mapping Funding, for the additional manning to coordinate, manage, and conduct nation-wide mapping surveys; analyze and interpret mapping survey data; and upgrade databases as well as the information to be contained within the databases in order to provide miners and producers with the most advanced topographic, geologic, and geophysical data available.
- (b) Should funding for the mapping survey become limited the United States Geological Survey will prioritize mapping survey efforts in the United States and Puerto Rico based upon the recommendations provided by the National Cooperative Geological Mapping Program described in Section 4(c). The National Cooperative Geological Mapping Program should prioritize their recommendations based upon the geological and critical mineral areas least known to the most known in accordance with the geological and critical mineral baseline established in Section 4(a). Additionally, within these areas, the National Cooperative Geological Mapping Program will prioritize their recommended mapping survey efforts on those minerals identified within the Draft List of Critical Minerals published on February 16, 2018 (Federal Register, Volume 83, Number 33). Mapping survey efforts should be prioritized in the following order:

- (i) Federal lands.
- (ii) State lands.

Sec. 4. Mapping Survey Methodology. The United States Geological Survey will develop a mapping survey strategy of the 50 United States and Puerto Rico. The ultimate outcome of the nation-wide mapping survey is to develop a comprehensive mapping survey database identifying new sources of critical minerals and refining sources of critical mineral resources already known through the topographical, geological, and geophysical mapping of our Nation. An annual report detailing mapping survey activities accomplished, results of mapping survey activities

accomplished, and an accounting of funds from the previous calendar year along with the planned mapping survey activities, expected mapping survey results, and funding plan for the current calendar year will be produced by the United States Geological Survey no later than the first business day of the calendar year and provided to the Secretary, United States Department of the Interior for the duration of the mapping program. A four-tiered approach should be utilized to accomplish this task:

- (a) The United States Geological Survey will establish a geological and critical mineral baseline for the United States and Puerto Rico. Actions required to build the geological and critical mineral baseline may be accomplished concurrently with the additional actions identified within this section but should be accomplished no later than 2 years from program implication. Developing a baseline is essential because it provides a foundational starting point for the program, identifies what critical minerals the United States already possesses, where the Defense Industrial Base may obtain critical materials for current and future requirements, and acts as a reference point for targeted mapping surveys should funding levels require mapping survey efforts to be prioritized as defined in Section 3(b). The geological and critical mineral baseline should contain the following prioritized list and be made available as defined in Section 4(d):
 - (i) An analysis of the 50 United States and Puerto Rico to identify geological formations most likely to contain critical materials.
 - (ii) A current and historical listing of all critical minerals and geological assessments conducted and collected by the United States Geological Survey.
 - (iii) A current and historical listing of all critical minerals and geological assessments conducted and collected by the geological survey offices of the 50 United States and Puerto Rico.
 - (iv) A current and historical listing of all critical minerals and geological assessments conducted and collected by universities on lands within the 50 United States and Puerto Rico.
 - (v) A current and historical listing of all critical minerals and geological assessments conducted and collected by private sector mining companies on lands within the 50 United States and Puerto Rico willing to participate in the mapping program with the understanding their information will only be accessible outside of the United States Geological Survey to the extent permitted by law and subject to the appropriate limitations for purposes of privacy and security of corporate proprietary information.
 - (vi) A current and historical listing of all critical minerals and geological assessments conducted and collected by universities on lands within the 50 United States and Puerto Rico.

- (vii) A list of historical tailings on lands within the 50 United States and Puerto Rico in order to identify potential sources of recoverable critical materials.
- (b) The mapping survey will identify areas containing previously undiscovered deposits of critical materials and refine the known deposits of critical materials in order to determine what the United States already possesses and to highlight where the Defense Industrial Base may obtain critical materials for current and future requirements. Initial United States Geological Survey efforts will be focused in the mineral rich states of the western United States due to the large amount of federal lands and already known deposits (identified in the United States Geological Survey's Mineral Commodity Summaries 2018) before expanding to the remaining states in the Nation. The comprehensive mapping survey strategy should be a multi-tiered approach consisting of the following prioritized survey methods:
- (i) A geophysics survey of the 50 United States and Puerto Rico consisting of magnetic, gravity, and electrical data in order to discover, define, and / or refine individual and multi-parameter physical properties (magnetization, density, and electrical conductivity) and map major crustal boundaries, conduits, and prospective domains that underlie mineral deposits of strategic importance.
 - (ii) Hyperspectral remote sensing conducted by space-based as well as aircraft-based platforms in order to characterize surficial materials, geology, and minerals; identify and map surface minerals in poorly illuminated, steep, and vegetated terrain; and have the ability to integrate with geochemical, and geophysical studies through the United States Geological Survey's USGS Mineral Deposit Database described in Section 4(d) in order to discover and / or refine the geologic footprint of select deposits.
 - (iii) Field geology studies with the express purpose of validating and refining all geophysical surveys, hyperspectral surveys, as well as all current and historical listings previously identified within Section 4(a).
- (c) Costs associated with conducting the mapping survey requirements identified within Section 4(b) will require a collaborative effort between the United States Geological Survey, geological survey offices of the 50 United States and Puerto Rico, the Association of American State Geologists, universities willing to participate, and private sector mining companies willing to participate. The United States Geological Survey should utilize the National Cooperative Geologic Mapping Program as a baseline and build upon it to ensure appropriated funds are efficiently executed in order to improve topographical, geological, and geophysical mapping in the United States and Puerto Rico. Components of the National Cooperative Geologic Mapping Program should include:
- (i) The Federal Geological Mapping Component (FEDMAP). FEDMAP will better the understanding of earth sciences, produce geological maps, regional

geological analyses, multidimensional geological models and will incorporate the geophysics surveys and hyperspectral sensing data into their programs in order to better identify critical minerals, aid in the mitigation of natural hazards, ground and surface water management, land-use management, effective management of natural resources, environmental protection and management, and resource extraction. A United States Geological Survey-led Federal Review Panel consisting of federal, state, private sector mining companies, and university partners will manage strategic priorities, as set by the United States Geological Survey, and annual planning efforts to efficiently complete the FEDMAP mission and discover, define, and / or refine critical mineral deposits within the 50 United States and Puerto Rico.

- (ii) The State Geological Survey Mapping Program Component (STATEMAP). STATEMAP will award grants annually on a competitive basis to the 50 United States and Puerto Rico where each federal dollar will be matched by a state dollar. The geologic mapping the National Cooperative Geologic Mapping Program funds through STATEMAP is determined by the geologic mapping priorities State Mapping Advisory Committees set. Grant requests should be prioritized on primarily discovering and / or refining what is known for critical mineral deposits in accordance with United States Geological Survey strategic priorities and then on areas considered to be vital to the welfare of individual states. The STATEMAP Panel evaluates the proposed STATEMAP projects and their alignment with National Cooperative Geologic Mapping Program priorities.
- (iii) The University Geological Mapping Component (EDMAP). EDMAP will award grants annually on a competitive basis to universities within the 50 United States and Puerto Rico where each federal dollar will be matched by a university dollar. Requests for grants will be sent to the National Cooperative Geologic Mapping Program and evaluated by the National EDMAP Evaluation Panel. Grant requests should be prioritized on primarily discovering and / or refining what is known for critical mineral deposits in accordance with United States Geological Survey strategic priorities and then on areas considered to be vital to the individual universities.
- (iv) The Private Sector Mining Component (MINEMAP). MINEMAP will award grants annually on a competitive basis to private sector mining companies operating within the 50 United States and Puerto Rico where each federal dollar will be matched by a private sector mining company dollar. Requests for grants will be sent to the National Cooperative Geologic Mapping Program and a United States Geological Survey Review Panel strictly consisting of United States Geological Survey personnel will evaluate the requests. Grant requests should be prioritized on primarily discovering and / or refining what is known for critical mineral deposits in accordance with United States Geological Survey strategic priorities. Additionally, this component will be conducted with the understanding private sector mining

companies are “for profit” entities and this is a joint United States-private sector venture aimed at reducing or eliminating the Nation’s reliance on foreign-procured critical minerals. As such, the United States Geological Survey will ensure critical mineral-related data collected will only be accessible outside of the United States Geological Survey to the extent permitted by law and subject to the appropriate limitations for purposes of privacy and security of corporate proprietary information.

(d) A key component of Executive Order 13817 is for the consolidated and collected data defined in Section 4, Mapping Survey Methodology, to be electronically accessible. The requirement for accessibility derives from the needs of federal and state-level governments as well as private sector mining companies and universities of the 50 United States and Puerto Rico to have the most comprehensive data available, aid state and local governments with their geological requirements, and ultimately reduce the United States’ reliance on foreign-sourced critical materials. The United States Geological Survey will build upon and modernize its existing USGS Mineral Deposit Database and ensure:

- (i) The database continues to be the Nation’s focal point for the collection and dissemination of mineral resource information used by federal, state and local governments, private sector mining companies, and the public.
- (ii) The database will include information on geology, production, resources, history, and development status.
- (iii) All historical information defined in Section 4(a) will be refined as necessary and formatted to a common standard in order to facilitate equal accessibility and functionality for all database users.
- (iv) Results of topographical, geological, and geophysical mapping surveys shared by private sector mining companies will only be accessible outside of the United States Geological Survey to the extent permitted by law and subject to the appropriate limitations for purposes of privacy and security of corporate proprietary information.

Sec. 5. Potential Mapping Impediments. The possibility exists for there to be obstacles with the implication of the mapping survey program. Two potential impediments have been identified:

- (a) Challenges from the Public, Federally Recognized American Indian and Alaska Native Tribes, and Private Organizations.
 - (i) American citizens, American Indian and Alaskan Native Tribes, and private organizations could believe the United States Geological Survey mapping efforts would be the first step in a process to open mining operations on their lands or in close proximity to population centers and environmentally sensitive areas as well as being a source of pollution. The United States

Geological Survey should take the following actions to mitigate this potential mapping impediment:

- a. Ensure the mapping survey plan is transparent through an increase in community relations and public outreach efforts for the duration of the program.
- b. Receive the expressed permission of tribal governments before any mapping survey activities are conducted on federally recognized American Indian and Alaska Native tribal lands.
- c. Omit mapping survey activities from populated areas, environmentally sensitive areas, lands deemed to be national treasures, and regions containing infrastructure (agricultural, energy, transportation) where mapping would have limited utility.

(b) Funding.

- (i) The United States Geological Survey will manage the mapping survey program and efforts in accordance with the prioritizations described within this annex should funding levels fall below those identified in Section 3, Mapping Funding.

analysis/portable-analysis-material-id/portable-mining-exploration-solutions/portable-minerology-rare-earth-element-analysis.html

^{xvi} Ames Laboratory, - Critical Materials Institute develops new acid-free magnet recycling process, 5-September-2017, Last accessed 11-May-2018, <https://www.ameslab.gov/news/news-releases/critical-materials-institute-develops-new-acid-free-magnet-recycling-process>

^{xvii} Australian Nuclear Science and Technology Organisation – *Waste as a resource when using selective separation* – Last accessed 9-May-2018, http://www.ansto.gov.au/AboutANSTO/MediaCentre/News/ACSTEST_040680

^{xviii} US Environmental Protection Agency - *Fact Sheet: Good Samaritan Administrative Tools* - <https://www.epa.gov/enforcement/fact-sheet-good-samaritan-administrative-tools>

^{xix} “National Security Strategy of the United States of America,” December 2017, pg. 2, <https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf>.

^{xx} We note that this effort has historical antecedents, including President Harry Truman’s Point Four Program and activities subsumed under the Joint Industrial Mobilization Committee.

^{xxi} According to Statista (<https://www.statista.com/statistics/272708/top-10-mining-companies-worldwide-based-on-net-income/>), in 2017, the largest mining companies by revenue included Brazil’s Vale, Rio Tinto (UK/Australia), China Shenhua Energy, BHP Billiton (Australia/UK), Polyus (Russia), Anglo American (UK), Arch Coal (US), Coal India (India), Barrick Gold Corp. (Canada), and NMDC (India).

^{xxii} “Interior Seeks Public Comment on Draft List of 35 Minerals Deemed Critical to US National Security and the Economy,” US Department of the Interior, February 16, 2018, <https://www.doi.gov/pressreleases/interior-seeks-public-comment-draft-list-35-minerals-deemed-critical-us-national>. Bolded minerals were designated as critical.

^{xxiii} Geological Survey of Canada, <http://www.nrcan.gc.ca/earth-sciences/science/geology/gsc/17100>.

^{xxiv} Geological Survey of Canada, “Strategic Plan 2013-2018,” pg. 10, http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/293/293638/gid_293638.pdf

^{xxv} US Department of the Interior, US Geological Survey, “Mineral Commodity Summaries 2017” pg. 6, <https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf>.

^{xxvi} McGill Research Group Investigating, “Canadian Mining in Latin America,” <http://micla.ca/countries/mexico/>.

^{xxvii} David Ljunggren and Anthony Esposito, “Negotiators Fail to Reach NAFTA Deal, Trump Launches New Attack,” *Reuters*, May 11, 2018, <https://www.reuters.com/article/us-trade-nafta/negotiators-fail-to-reach-nafta-deal-trump-launches-new-attack-idUSKBN1C1P5>.

^{xxviii} “Interior Seeks Public Comment on Draft List of 35 Minerals Deemed Critical to US National Security and the Economy,” US Department of the Interior, February 16, 2018, <https://www.doi.gov/pressreleases/interior-seeks-public-comment-draft-list-35-minerals-deemed-critical-us-national>.

^{xxix} CIA World Factbook, entry on Australia, data as of 2016
<https://www.cia.gov/library/Publications/the-world-factbook/geos/as.html>

^{xxx} Alan Boyd, “China Dangles Trade Threat Over Australia,” *Asia Times*, January 3, 2018, <http://www.atimes.com/article/china-dangles-trade-threat-australia/>.

^{xxxi} The existing Bureau of Energy and Natural Resources (ENR) currently performs this function in the similar field of energy security and related issues.

^{xxxii} For example, these efforts are consistent with ongoing US efforts to mitigate conflict in Democratic Republic of the Congo, the world’s leading producer of cobalt. It is unlikely the US Government will engage in large-scale lending or quasi-state funding of infrastructure projects in developing countries in exchange for long-term resource commitments--such as employed by China and to a lesser extent Japan.

^{xxxiii} “Defense Production Act: Foreign Involvement and Materials Qualification in the Title III Program,” US General Accounting Office, GAO/NSIAD-94-74, March 14, 1994, <https://www.gao.gov/assets/220/219410.pdf>. This report highlighted US dependence on foreign sources for critical defense materials and analyzed foreign participation in projects undertaken since the DPA’s reactivation in 1985 and found that four of six projects had some foreign involvement.

^{xxxiv} According to the website managed by the Council on Environmental Quality (CEQ):

CEQ publishes surveys on NEPA litigation on an annual basis. These surveys identify the number of cases involving a NEPA based cause of action, Federal agencies that were identified as a lead defendant, general information on plaintiffs, general information on why litigation was pursued, and the outcomes of the cases decided during the year.

Each year, Federal agencies conduct hundreds of EISs, tens of thousands of EAs and hundreds of thousands of CEs. The amount of litigation on these NEPA analyses is comparatively small. Since 2001, fewer than 175 NEPA cases were filed each year - with less than 100 filed in 2007, 2009, 2010, and 2011.

<https://ceq.doe.gov/ceq-reports/litigation.html> (2013's litigation survey is the most recent one posted to the website.)

^{xxxv} STRATMAT commends a report commissioned by the US Council for Environmental Quality and prepared by a group of enterprising students at Stanford Law School, focused on the effects of litigation trends - actual and perceived. The students' insight and incisive recommendations merit careful consideration. Stanford Law School, "Comments and Recommendations on NEPA Reform for the White House Council on Environmental Quality," <https://www-cdn.law.stanford.edu/wp-content/uploads/2015/04/NEPA-Submittal-to-CEQ-FINAL-5.pdf>