

The Future is Electric

Part I

by John P. Ringquist

Editor's Note: This is Part I of a two-part article. Part II will be published in the fall 2024 edition.

The U.S. government has known of the importance of rare earths and their impact on national security for decades, but recent technology and national policy changes accelerated competition between the U.S. and China for economic dominance in many strategic fields including green energy, artificial intelligence, microprocessors, and metallurgy. Foreign relations developments, including global power competition and attempts to push back against Chinese export restrictions or outright bans, reveal the current state of U.S. rare earth production and refining capability and the dominant position that China enjoys in these fields. Chinese rare earth and strategic metals supply chain dominance threatens U.S. national security and that of many U.S. allies across the world. China is increasingly using commercial coercion to seize concessions and intimidate rivals while also chasing prestige as it reveals U.S. supply chain weakness. These practices go beyond denying technology and resources and into the realm of economic warfare because of the potential impact on U.S. and allied equipment and systems at a time when the U.S. and allies are supporting Ukraine and Taiwan with systems that are heavily reliant on rare earths and strategic metals.

Chinese export prohibitions on technology, minerals, and expertise, which began in mid-2023 and peaked at the end of 2023, have the potential to impact U.S. and allied defense equipment including some of the most advanced stealth and electronic warfare systems. Rare earths are a group of seventeen elements: lanthanum, cerium, praseodymium, neodymium, promethium, samarium,

Lieutenant Colonel John P. Ringquist, Ph.D., is an Army Engineer, Foreign Area Officer and an instructor at the Command and General Staff School at Fort Leavenworth, Kansas. His research focuses on contemporary military affairs, technology, and African security affairs. He has written articles on counterinsurgency, the intersection of climate, technology, and security, and the African American soldiers of the Kansas-raised 79th United States Colored Infantry Regiment in the Civil War West. His duty assignments frequently have involved working with allies, foreign military partners, and U.S. government interagency partners to draft and advocate the kinds of logistics and security agreements cited in this article.

europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, scandium, and yttrium. These elements are used for many of the most advanced military systems and China leads the world in the mining and processing of these materials, a reflection of the supply chain dominance that China enjoyed in 2016 when the USGAO published a report on the process.¹ China's dominance has continued into present day.

In 2023, in response to perceived challenges from the U.S. and other nations, China banned the export of technology for making rare earth metals and magnets and separating rare earths. These bans combined with earlier restrictions on exports on gallium, germanium, and graphite threaten to impact global business sectors from aerospace to artificial intelligence as a result.² Economics and supply chains are major factors that affect national security, and one that most

Electrification of the U.S. Army force cannot reliably occur while the U.S. is unable to secure its rare earths, strategic metals, and lithium supply chains.

militaries cannot directly affect through non-violent means. The DoD's future is increasingly tied to new materials and novel applications that were the stuff of science fiction a decade ago. Strengthening supply chain security and ensuring access to strategic minerals and technologies takes an interagency approach that the DoD can bolster through security agreements, but also through programs that leverage relations with allies to achieve shared defense, acquisitions, and Defense Industrial Base (DIB) investment goals.

A quick survey of the potential DoD systems that are vulnerable to supply chain disruptions shows that it is a threat that cuts across many U.S. domestic production sectors. Our existing

supply chains are overly dependent on foreign supply sources, including foreign companies that extract resources in the U.S. and re-export them back after processing. Offshoring has weakened U.S. companies' ability to compete, disincentivized companies from working with the DoD, and driven sectors of our economy to atrophy from lack of investment and research and development funding. The U.S. lacks the domestic industrial base to meet all internal requirements for rare earth processing within a 100% domestic supply chain, but the U.S. is working to identify new sources for minerals and rare earths products, create new alliances that share supply chain risks, and supporting these changes with new legislation and funding that will increase the ability of the U.S. Defense Industrial Base to meet the DoD and allies' future requirements. Allied and interagency action can defeat Chinese economic coercion.

The U.S. Army is part of the DoD affected by China's dominance of world supply chains for rare earths, strategic metals, and lithium for electric vehicle batteries. The U.S. Army's plans for gradual electrification of its entire force by 2050 are contingent on access to batteries, technology for improved battery charging and service life, and continued research and development for battery technologies, including reclamation/reuse. Electrification of the U.S. Army force cannot reliably occur while the U.S. is unable to secure its rare earths, strategic metals, and lithium supply chains. After those supply chains are secure and manufacturing is prepared to support U.S. and partner needs, the U.S. Army can proceed with converting wheeled vehicle fleets and the U.S. can bring in old and new allies as partners in the U.S. Defense Industrial Base.

Domestic Supply and Production

The DoD's rare earths and strategic metals supply chain security is weak, threatened by a Chinese dominance of the world's

rare earths markets and finished rare earths products. U.S. neglect of domestic rare earths mining and production capabilities, minimal magnet production facilities, and overreliance on Chinese exports of rare earth products jeopardizes the DoD supply chain. China's ban on rare earth extraction and separation technologies announced on December 21, 2023 jeopardizes the production of the DoD's most advanced systems and sensors. The ban will impact U.S. national security for years to come despite alliances with other countries that also export the seventeen metals that collectively comprise the rare earth elements. Rare earth elements are essential for military technologies affecting everything from missiles to communications.³ The Chinese bans on exports are strategic and affect many countries besides the U.S. The U.S. has been preparing for such a move by China, but it takes time to make up the Defense Industrial Base manufacturing that can meet domestic and international needs. This is where the 2023 Defense Industrial Base Strategy requirements for diversified sources of supply, increased domestic production and enhanced partner engagement in our domestic industrial base help mitigate insecurity in the U.S. supply chain. The situation in 2024 has slowly begun to change because of efforts over the past three years to strengthen the U.S. rare earths supply chain and guarantee access to strategic metals and minerals. However, as of 2024, U.S. production is limited to a single mine as new ones are opened, a single processor for rare earths as new plants are constructed, single battery maker due to the DoD inability to create economies of scale for manufacturers, a single nickel mine because the demand for electric vehicle batteries was unanticipated or manufacturers assumed supplies would be easily accessible. Today's shortages and supply chain insecurity is the result of past efforts to save money and offshore business moves to China.

The U.S. supply chain's weakness was

decades in the making. Previous decades of U.S. trade and economic policies that sought to bring China into the global economy led to the U.S. investing in businesses or processes that promised lower costs and minimal U.S. domestic environmental disruption. China's imports of U.S. rare earths and the U.S. relying on China for refining ore disincentivized U.S. domestic industry and led to offshoring that made the U.S. dependent on rare earth finished products from China instead of domestically refining it.⁴ The U.S. dependence on China created unforeseen

China's ban on rare earth extraction and separation technologies announced on December 21, 2023 jeopardizes the production of the DoD's most advanced systems and sensors.

chains of cause and effect for U.S. military industry when previously secure supplies became subject to arbitrary restrictions. In 2021 Chinese restrictions on rare earth exports (specifically magnets) were linked to trying to determine their impact on F-35 production.⁵ The Chinese efforts had the potential to slow production by preventing the manufacture or installation of key parts that give the F-35 its long-range sensors and enable it to engage enemies at maximum range. Modern technology requires a full suite of components that together make up the whole system.

The impact of rare earth shortages, especially certain varieties, can best be understood within the context of two examples: gallium and germanium. The former is used for radar, communications, satellites, and LEDs and the latter for night vision devices and satellite imagery sensors. Domestic U.S. defense contractors can find alternate sources and have reserves, but the supply chain is endangered by China's punitive trade practices

and the dominant Chinese position in the world's rare earths supply chain.⁶ China has the ability through supply chain dominance to undercut competitors, manipulate bids for mining rights and deny access to alternate material competitors through additional policy tools such as loans, development projects unrelated to mining, and economies of scale for production.

The U.S. has only a single rare earth mine in full-scale operation at Mountain Pass, California.

The U.S. supply chain vulnerability affects more than the U.S. due to the number of allies that also operate F-35 variants. When we also consider the potential impact on other weapons systems and sensors, Chinese rare earth dominance is a major defense and security threat. Securing the rare earth supply chain is necessary for the U.S. military across the spectrum of systems. In addition to the F-35 Lightning II, rare earth magnets are vital to U.S. submarines, UAVs, aircraft electronic systems, radar, Tomahawk missiles, smart bombs. The amounts of rare earth elements required for each system vary from, “900 pounds for a F-35 to 9,200 for a Virginia class submarine.” Factor in night vision devices, range finders, lasers, optics, and fiber optics systems and the potential vulnerability to these systems is evident.⁷ Then, add in the potential impact on allies through joint weapons and sensors programs with the U.S., and Chinese bans are not simply an economic weapon to push back against U.S. initiatives in the U.S.-China trade war, but also a way to impede strategic military systems production and repair while China proceeds with its own military advances.

The U.S. supply chain weaknesses are further complicated by China's dominance over the world's refining and production processes to include operating numerous mines outside of

China that China uses to meet internal needs. The U.S. faces a situation with its domestic rare earths mining and processing that China has exploited for decades as rare earth mining expanded in China and contracted in the U.S. The U.S. has only a single rare earth mine in full-scale operation at Mountain Pass, California.⁸ China, rather than exhaust its rare earth deposits, is content to control the supply chain by dominating the refining and production process at home, while importing ore from elsewhere.⁹ This strategy exhausts deposits outside of China and forces countries where mining take place to bear environmental costs of rare earths mining. China has built redundant domestic capacity for production and technical expertise and retains rare earths deposits to sustain domestic operations. Should access to some foreign deposits be denied, China's relationship with Russia and partners in the “Belt and Road Initiative” that spans the globe will likely ensure the flows to China continue unabated.

Given the potential for economic coercion and policy impacts, the United States and partners like Japan have tried to reduce their reliance on Chinese sources since 2010, but the process has been delayed by cost, environmental issues, and lack of domestic capacity. Further, securing U.S. supply chains and developing domestic refining processes was slowed by the global impact of COVID-19, another unanticipated security threat.¹⁰ The DoD must anticipate future advancements in military systems development as new technologies and civilian demand for rare earths and strategic metals, lithium for electric vehicle batteries, and chemicals vital to alternative energy technology increase across the world.

The DoD needs to examine new ways to prioritize its strategic needs and those of its partners across the U.S. whole-of-government and work closely with other U.S. government agencies to establish the necessary agreements to sustain those needs. The key to securing the

U.S. Defense Industrial Base and its supply chain is interagency cooperation. Interagency cooperation creates the agreements that ensure foreign partners are engaged and join the U.S. Defense Industrial Base (U.S. Department of State) the protective screen that blocks cyberattacks and insider threats (U.S. Department of Justice); reciprocal financial agreements that make resource sharing profitable for all parties (Departments of State and Commerce), and internal resource evaluation for exploitation (U.S. Department of the Interior).

Industrial base revitalization lies in securing and diversifying rare earth and strategic metals supply chains in parallel with effective domestic logistical, production, and innovation capacity. The DoD alone cannot achieve that change. Apart from rare earth magnets and the systems that need them to operate, the DoD must consider how the burgeoning field of artificial intelligence (AI) will affect future warfare because AI will need microprocessors that require rare earth. The U.S. leads the field but could lose its edge if denied the vital rare earths and strategic metals necessary for chip manufacture. However, there is hope for defense requirements and revitalization of the Defense Industrial Base. The same factories that drive green futures (GF) and electric vehicles (EV) also could drive military equipment requirements through innovative dual development strategies. However, before the Defense Industrial Base can start to produce materiel and systems that serve the needs of the DoD and foreign partners, the supply chain must be secured.

Developing and Sustaining Supply Chains

In the wake of Chinese rare earths and strategic minerals bans, it is vital that the United States revitalize its industrial base. The ground-breaking 2024 National Defense Industrial Strategy specifically identifies the need to consider supply chain protection from

disruptions, building redundancy, adding capacity, increasing support for industrial innovation, and shielding the strategic minerals and rare earths supply chain from international disruptions.¹¹ It is through interagency action and concerted policies that the National Defense Industrial Strategy will achieve its goals. The National Defense Industrial Strategy's opening page recognizes "...sustained collaboration and cooperation between the entire U.S. government, private industry, and our Allies and partners abroad," is vital to integrated deterrence and that, "by aligning policies, investments, and activities inside and outside the Department in a manner that is tailored to specific competitors, our industrial ecosystem can strengthen deterrence to maximum effect."¹²

Industrial base revitalization lies in securing and diversifying rare earth and strategic metals supply chains...

The National Defense Industrial Base Strategy's fifty-nine pages acknowledge the urgency for interagency action particularly for initiatives in foreign military sales, intellectual property, and cyberdefense. Creating international partnerships will strengthen overlapping strategies to energize the U.S. Defense Industrial Base. Diplomacy and agreements reinforce U.S. government policy and strategic imperatives with the allies that share the goals of the U.S. However, before the U.S. can bring old and new partners into its Defense Industrial Base, it must be built and resourced so that diplomacy has a tether to which to bind future agreements.

The DoD has actively responded to Chinese efforts to restrict rare earth materials by considering how to ensure domestic producers can be brought into agreements with the DoD and increase mining, processing, and finishing of rare earths and magnets. The DoD has

historically offered little incentive for civilian companies to dedicate much production space to DoD needs because the requirements were considered economically nonviable. In 2023 that situation changed with China's ban of exports. The DoD in September 2023, working through the Office of the Assistant Secretary of Defense for Industrial Base Policy through its Manufacturing Capability Expansion and Investment Prioritization (MCIEP) office established a program to create a permanent rare earth magnet production capability. The need for a reliable source for rare earth magnets in advanced technology is too strong to allow production to lapse.¹³ There were earlier efforts to supply the rare earth supply chain in 2021 were codified in Executive Order 14017 (E.O.), *America's Supply Chains*, and in 2022 the White House announced plans to increase domestic refining capacity for rare earths.¹⁴ These two initiatives provided notice of interest but as the National Defense Industrial Strategy notes, civilian production must be incentivized and DoD competition against U.S. commercial entities is difficult when commercial companies order products on scales that dwarf DoD requirements.

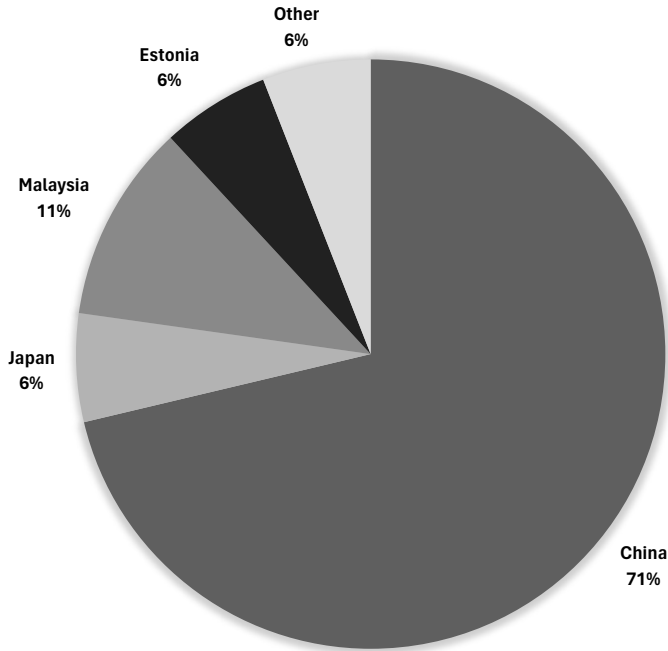
Domestic refining capacity for DoD purposes pales in comparison to the need for civilian rare earth products. But the National Defense Industrial Strategy goes farther than past strategies and acts by recognizing that the DoD should try to tap into civilian manufacturing demand, especially for solar and electric vehicle applications will ensure that future defense industry requirements can be met in tandem with commercial needs.¹⁵ The competition for resources will intensify in the future as the world seeks to transition to electrical vehicles and alternative energy. Demand for rare earths may rise to three to seven times current demand and lithium demand forty-fold. U.S. demands, according to the U.S. Department of Energy are projected to quadruple by 2050. This is in

the context of a world where currently there are fewer than ten rare earth magnet manufacturers outside of China, and only one in production in the U.S.¹⁶

This initiative will be hampered by the U.S. lack of industry elements that China has in abundance: the sheer number of labs, universities that specialize in metallurgy, and the thousands of metallurgists that graduate every year add to China's pool of expertise and research and development base for its industrial and defense industry base.¹⁷ China currently has an advantage but that lead is under threat as the U.S. government and the DoD specifically are bolstering funding to Defense Industrial Base companies. The U.S. government also seeks to rebuild the National Defense Stockpile and incentivize companies into supplying DoD and foreign partners' defense requirements.

The greatest potential for supply diversification lies in the processing phase utilizing material mined in the U.S. and potential new trade partners. A search of dozens of online data bases and industry sources identifies Brazil, Estonia, India, Australia, Malaysia, Japan, and the Philippines as sources for rare earths not readily available in the U.S. Working with these countries could help break China's monopoly and reduce collective risk. The U.S. has deposits containing most of rare earths, but environmental laws and industrial production capacity are limiting factors.

Imbedded in the FY 2024 National Defense Authorization Act were key provisions identifying rare earth elements that have been sourced through supply chains from China and replacing them.¹⁹ The stockpile, while managed by the Defense Logistics Agency, is funded by the Treasury Department and includes essential defense minerals and metals including titanium, tungsten, and cobalt.²⁰ Although the National Defense Stockpile is not directly in the supply chain, maintaining its viability and replenishing its depleted mineral resources is one part of the



Rare Earth Compounds and Metals Foreign Origins (2019-2022)

Potential Future Partners	Rare Earth Material	Purpose
Australia - Gadolinium Thailand- Lanthanum	Gadolinium, Lanthanum	Night Vision Devices and camera lenses
Malaysia	Erbium	fiber optic signal amplification
Brazil, India, Australia	Thulium, Europium	Optics, X-rays, coatings
Australia	Cerium and Dysprosium	Rare earth magnets
Promethium is formed from Neodymium	Promethium	Research and testing
Philippines - Scandium Brazil, India, Australia - Samarium	Scandium, Samarium	Aerospace alloys
India, Australia, Brazil	Terbium	Sonar, high temperature operations, data recording
India, Australia, Brazil	Ytterbium	Hardened ceramics and armor
India, Australia, Brazil	Holmium	Sensor calibration
India, Australia, Brazil	Lutetium	lenses, sonar

Figure 1. Potential for Supply Diversification¹⁸

securing and restoring independence of the DoD supply chain.

DoD efforts to secure the rare earth supply chain since 2020 have included a spectrum of investments in Defense Industrial Base companies, large and small, to create domestic rare earths supply chains even while working with China to meet DoD needs. Prior to the 2023 Chinese bans, the DoD awarded more than \$400 million to companies and programs to establish domestic rare earth supply chains. Under the Office of the Assistant Secretary of Defense for Industrial Base Policy, the Manufacturing Capability Expansion, and Investment Program (MCEIP) directorate leads the DoD five-year rare earth investment strategy that includes establishing critical nodes for sourcing, separation, processing, metallization, alloying, and magnet manufacturing. The MCEIP has funded Lynas USA, LLC, Noveon Magnetics, TDA Magnetics, and E-VAC Magnetics, thereby ensuring the U.S. domestic rare earth supply

The rare earths and gases that are vital for advanced defense system components are already in the U.S., but redundancy is critical...

chain for the DoD by the target date of 2027.²¹ Lynas USA is also part of the National Defense Industrial Strategy to use domestic and allied production to meet DoD needs.²² Rare earths magnets are one of the supply chain insecurities that are being addressed with new initiatives. Another point of concern for an increasingly electrified military and U.S. domestic needs are the domestic nickel supplies that need replacement quickly in a world where lithium battery production for EVs requires nickel.

Strategic metals are another area where recent DoD investment is keeping domestic production open and U.S. government is

restoring depleted strategic stockpiles. Through funds obtained via the Additional Ukraine Supplemental Appropriations Act, the DoD invested over \$20 million under Defense Production Act (DPA) Title III authorities to ensure nickel production through 2027 at the only nickel mine in the U.S..²³ This delays the urgency of the need for the U.S. to find additional supplies through allies Canada, Indonesia, Philippines, and Australia. Nickel is one resource that the U.S. will need to ensure supplies are available for commercial and DoD needs, not only for EVs but also the U.S. Army planned fleet electrification.

The DoD is also able to ensure supply chain redundancy through efforts to find new methods of processing rare earth and other minerals, or methods to create alternatives to industry standards (e.g., sodium batteries for lithium). Innovation, research, and development to find different methods to extract rare earths than how China does at present will enable the U.S. to circumvent any future Chinese attempts to impact the U.S. supply chain through bans on chemicals, machines, or diplomatic pressure on U.S. material suppliers vulnerable to Chinese coercion. The Department of Defense started funding this effort with some domestic companies, among them Ucore Rare Metals.²⁴ Finding and pursuing alternatives also gives options should the accepted chemical processing and finishing processes be determined environmentally risky or the companies subjected to unforecasted materials shortages. Further, when we examine the process for creating the necessary microprocessors for AI computer chips the U.S. has an immense reservoir of helium that will aid the domestic manufacturing process and reduce reliance on foreign manufacturers.²⁵ The rare earths and gases that are vital for advanced defense system components are already in the U.S., but redundancy is critical, as is protection for the industry that manufactures military systems that

could be critically impacted by a cyber-attack or loss of domestic infrastructure affected by a natural disaster. The world is turning to electric solutions including EV and the DoD is no exception. The effort is ongoing, but a combination of factors may prevent full evolution of the DoD fleet. Supply and demand, resource constraints, and clandestine efforts to prevent DoD systems evolution threaten the DoD supply chain's security.

Conclusion

The U.S. DoD and the U.S. Defense Industrial Base are at a stage where the competing demands of international, domestic, and industrial sectors are creating new security challenges for future systems and force development. Creating strong and secured supply chains will require the DoD to work with other U.S. government agencies to communicate current and future needs, especially as the National Defense Industrial Base Strategy is implemented with new international partners that may not want to confine alliances to defense issues, but may seek to include DoD equities in agreements or treaties that involve commercial ventures to protect energy supplies, prevent illegal fishing, or forestall climate change. The U.S. government interagency process, the “whole-of-government” approach that allows the U.S. to offer partners many areas of cooperation, is what makes the U.S. international negotiating position strong relative to competitors.

The future for the DoD and the world at large is electric, and the need to secure the base materials to create the batteries, computer chips, rare earth magnets, and supercomputers can only be met through cooperative ventures that ensure multiple partners and nations share risk by creating a supply chain of many links including redundant ones. China will not allow this to occur without interference, and as the rare earths and other bans show, China has no compunction against using economic coercion to force political concessions. China also utilizes instruments of national power – diplomatic, informational, military, economic, financial, intelligence, and law enforcement (DIME-FIL) – to force decisions and shape emerging technology sectors to its favor. Diplomatically China has challenged the west with its “Belt and Road Initiative” and tempting development offers. China has employed information warfare to sway public opinion and undercut alliances. Militarily, China has intimidated and coerced countries that could ally with the west and the U.S. especially those in the South China Sea. Economically, China has demonstrated the will to flex economic muscle to depress foreign domestic industrial sectors such as U.S. rare earth miners and producers. China actively conducts espionage by employing hackers to gain access to information and cut years or even decades off research and development. China even sets up clandestine police stations in other countries to maintain control over expatriate citizens. These factors all endanger the DoD supply chain, especially in tandem with China's military build-up of naval, missile, cyber, and electronic warfare forces. I will discuss these threats further in Part II of this article series where I will discuss how China uses messaging campaigns, cyber operations, and foreign policy pressure to destabilize U.S. supply chains. **IAJ**

Notes

1 US Government General Accountability Office, Report to Congressional Committees GAO-16-161: Rare Earth Materials: Developing a Comprehensive Approach Could Help DOD Better Manage National Security Risks in the Supply Chain, 2016, Figure 2: Generalized Rare Earth Materials Supply Chain for Metal Components, gao.gov/assets/gao-16-161.pdf

- 2 “China to Halt Export of Rare-Earth Tech, Imperiling EV Materials,” Bloomberg, December 21, 2023, <https://www.detroitnews.com/story/business/autos/2023/12/21/china-to-halt-export-of-rare-earth-tech-imperiling-ev-materials/71999088007/>
- 3 Gracelin Baskaran, “What China’s Ban on Rare Earths Processing Technology Exports Means,” (Washington, D.C.: Center for Strategic and International Studies, 2024), <https://www.csis.org/analysis/what-chinas-ban-rare-earths-processing-technology-exports-means>
- 4 Shunsuje Tabeta, “China bans Exports of Rare-Earth Magnet Technologies,” Nikkei Asia, December 21, 2023, <https://asia.nikkei.com/Economy/Trade/China-bans-exports-of-rare-earth-magnet-technologies>
- 5 Monish Tourangban, “What the US National Defense Industrial Strategy Means for the IndoPacific,” The Diplomat, February 21, 2024, <https://thediplomat.com/2024/02/what-the-us-national-defense-industrial-strategy-means-for-the-indo-pacific/>
- 6 “Pentagon has Strategic Germanium Stockpile but no Gallium Reserves,” Reuters, July 6, 2023, <https://www.reuters.com/markets/commodities/pentagon-has-strategic-germanium-stockpile-no-gallium-reserves-2023-07-06>
- 7 C. Todd Lopez, “DOD Looks to Establish ‘Mine-to-Magnet’ Supply Chain for Rare Earth Materials,” DOD News, March 11, 2024, <https://www.defense.gov/News/News-Stories/Article/Article/3700059/dod-looks-to-establish-mine-to-magnet-supply-chain-for-rare-earth-materials/#:~:text=Since%202020%2C%20DOD%20has%20awarded%20more%20than%20%2024439,those%20refined%20materials%20into%20metals%20and%20then%20magnets>
- 8 “2024 Mountain Pass Materials Facts,” <https://mpmaterials.com/about/>
- 9 Ibid.
- 10 Sarah Godek, “Why China’s Export Controls on Germanium and Gallium May Not Be Effective,” (Washington, D.C.: The Stimson Center, 2023), <https://www.stimson.org/2023/why-chinas-export-controls-on-germanium-and-gallium-may-not-be-effective/>
- 11 US Department of Defense, National Defense Industrial Strategy, December 16, 2023, https://www.dau.edu/sites/default/files/2024-2/2023%20NDIS_FINAL%20FOR%20PUBLICATION%201_0.pdf
- 12 Ibid.
- 13 U.S. Department of Defense, Department of Defense Enters an Agreement to Expand Domestic Manufacturing to Strengthen U.S. Supply Chains for Rare Earth Magnets, September 19, 2023, <https://www.defense.gov/News/Releases/Release/Article/3529874/departement-of-defense-enters-an-agreement-to-expand-domestic-manufacturing-to-s/>
- 14 The White House, Fact Sheet: Securing a Made in America Supply Chain for Critical Minerals, February 22, 2022, <https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/22/fact-sheet-securing-a-made-in-america-supply-chain-for-critical-minerals/>
- 15 Mikayla Easley, “SPECIAL REPORT: U.S. Begins Forging Rare Earth Supply Chain,” National Defense Magazine, February 10, 2023, <https://www.nationaldefensemagazine.org/articles/2023/2/10/us-begins-forging-rare-earth-supply-chain>
- 16 Mureji Fatunde, “The Race to Produce Rare Earth Elements,” Technology Review, January 5, 2024, <https://www.technologyreview.com/2024/01/05/1084791/rare-earth-materials-clean-energy>

- 17 “Vietnam’s Rare Earth Sector on the Rise,” Voice of America, November 30, 2023, <https://www.voanews.com/a/vietnam-s-rare-earth-sector-on-the-rise-/7378282.html>
- 18 Daniel J. Cordier, Mineral Commodity Summaries 2024, <https://www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information>
- 19 John Jacobs and Danny Broberg, “What’s in the FY 2024 NDAA for Critical Minerals?” (Washington, D.C.: Bipartisan Policy Center, 2023), <https://bipartisanpolicy.org/blog/whats-in-the-fy2024-ndaa-for-critical-minerals/>
- 20 Bryant Harris, “Congress and Pentagon seek to shore up strategic mineral stockpile dominated by China,” Defense News, May 23, 2023, <https://www.defensenews.com/congress/2022/05/23/congress-and-pentagon-look-to-shore-up-strategic-mineral-stockpile-dominated-by-china/>
- 21 C. Todd Lopez, “DOD Looks to Establish ‘Mine-to-Magnet’ Supply Chain for Rare Earth Materials.”
- 22 “DOD Awards Key Contract for Domestic Heavy Rare Earth Separation Capability,” Business Defense, September 19, 2023, <https://www.businessdefense.gov/news/2023/DoD-Awards-Key-Contract-for-Domestic-Heavy-Rare-Earth-Separation-Capability.html>
- 23 U.S. Department of Defense, “Department of Defense Enters an Agreement to Strengthen the U.S. Supply Chain for Nickel Production,” Defense.gov, September 12, 2023, <https://www.defense.gov/News/Releases/Release/Article/3522652/department-of-defense-enters-an-agreement-to-strengthen-the-us-supply-chain-for/>
- 24 Siyi Liu and Dominique Patton, “China Bans Export of Rare Earths Processing Tech over National Security,” Reuters, December 22, 2022, <https://www.reuters.com/markets/commodities/china-bans-export-rare-earths-processing-technologies-2023-12-21/>
- 25 Sasha Pare, “Scientists just discovered a massive reservoir of helium beneath Minnesota,” Live Science, March 7, 2024, <https://www.livescience.com/planet-earth/geology/scientists-just-discovered-a-massive-reservoir-of-helium-beneath-minnesota>