AMERICAN FOREIGN POLICY COUNCIL

DEFENSE TECHNOLOGY PROGRAM BRIEF

Breaking China's Stranglehold on the U.S. Rare Earth Elements Supply Chain

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BRIEFING HIGHLIGHTS

The U.S. has become dependent on China for some of the most crucial materials in high technology production: rare earth elements. As of 2019, China produced 62% of rare earth materials globally, while the U.S. only produced 12.2%. REEs are used in the manufacture of missile and aircraft guidance and control systems, advanced optics technologies, radar, sophisticated smart or guided weapons, and telecommunications.

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China may use REEs for political gain. In 2010, after a Chinese fishing boat collided with two Japanese coast guard vessels near the disputed Senkaku Islands, it imposed an embargo on rare earth materials to Japan because the Chinese boat captain had been detained and scheduled to face trial there.

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There is now a broad understanding that there are available ways to increase U.S. supplies of rare earth materials. Domestically, the U.S. can develop its own resources and find ways to mine and extract rare earth elements without dangerous ecological and environmental damage. The U.S. can also form consortiums with allies and dependable partners to stockpile or develop rare earth material sources. At the same time, the U.S. can take a lesson from China and seek to develop foreign sources of rare earth elements of its own.

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The Administration's efforts must incorporate cooperation with and input from industry, environmental and natural resource protection groups. Congress, meanwhile, must follow up on its prior legislative efforts to focus on developing the capacity in the U.S. to safely mine and refine rare earth elements, cooperate with allies and partners to break China's stranglehold on the rare earth supply chain, and ensure that the Executive Branch follows up on its reports with concrete action.

In historical terms, the United States has been caught off guard by China's dominance of the rare earth industry. Over the years, the U.S. has become dependent on a potential adversary for some of the most crucial materials in high technology production: rare earth elements. Rare earths are a collection of 17 elements that include: scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.[1] These elements may one day soon become as essential to the U.S. as oil. They are important in producing a range of technological products, including cellular telephones, computer hard drives, and medical imaging equipment, as well as green technology like electric vehicle motors and wind turbines.[2] In scientific circles in China, rare earth materials are considered a "trump card" of national policy due to the country's dominance in industrial production.[3]

In the realm of military technology, rare earths are used in the manufacture of missile and aircraft guidance and control systems, advanced optics technologies, radar, sophisticated smart or guided weapons, and telecommunications.[4] Rare earth elements are present around the world; as one writer has put it, "rare earths are not so rare."[5] The problem, rather, is production and refining capacity; as of 2019, China produced 62 percent of rare earth materials globally, while the U.S. only produced 12.2%. Myanmar, in third place globally, produced 10.3%.[6] The U.S., in other words, is now nearly completely dependent on China for rare earth element extraction and refinement.

This was not always the case. From the 1960s through the 1980s, the U.S. was the world leader in rare earth element production, most of which came from the Mountain Pass Mine in California. By the early 1990s, however, weaker labor and environmental laws allowed China to begin to satisfy the demand for rare earth elements. Twenty-five years later, the U.S. "imported all of the rare earth elements" it required, "mostly from China."[7]

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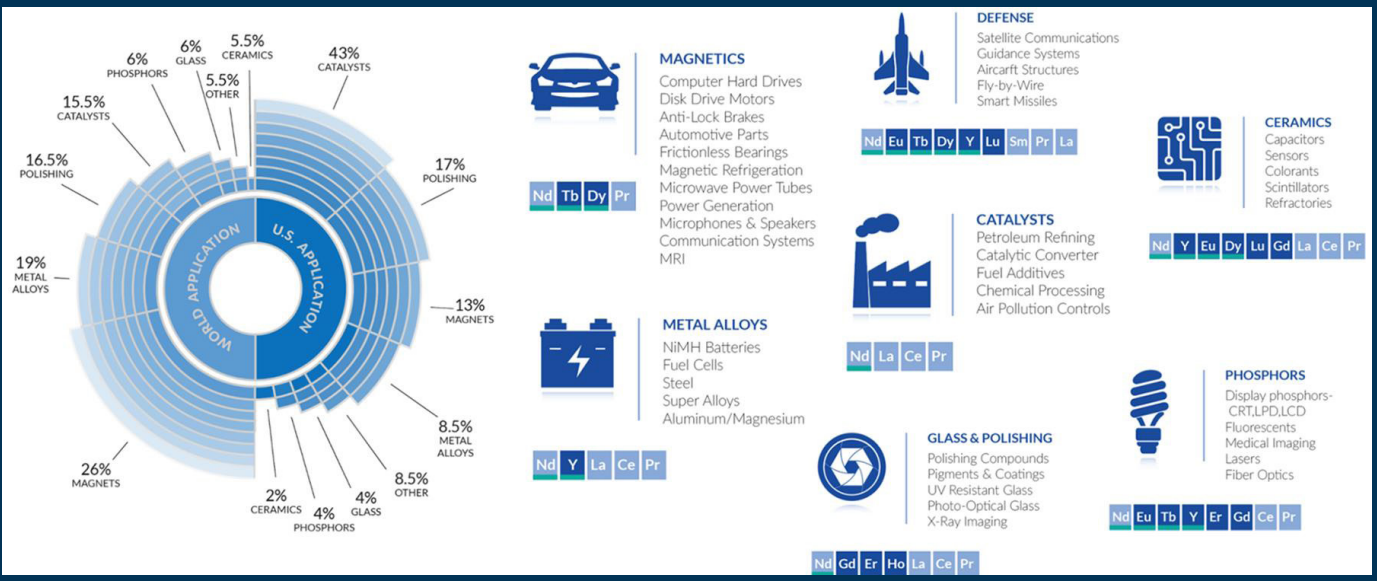
FIGURE 1: GLOBAL DEMAND AND DOMESTIC CONSUMPTION OF REE



Source: Brandon Tracy, "An Overview of Rare Earth Elements and Related Issues for Congress," Congressional Research Service, CRS Report R46618, November 24, 2020; National Energy Technology Laboratory (NETL), "REE-CM Program," https://www.netl.doe.gov/coal/rare-earth-elements/program-overview/background.
Notes: The figure provides examples of uses and sectors. Source and year of data is not given in original. Light blue shaded elements are LREE; dark-blue shaded elements are HREE; green underscores denote "critical REE," as defined by NETL.

China, for its part, is not afraid to use these metals for political gain. China shocked the world's rare earth-using nations when, in 2010, after a Chinese fishing boat collided with two Japanese coast guard vessels near the disputed Senkaku Islands, it imposed an embargo on rare earth materials to Japan because the Chinese boat captain had been detained and scheduled to face trial there.[8] (The case is detailed in full below). The incident caused a great deal of soul-searching in the United States, given that U.S. production had gradually shifted to China. The People's Republic of China, of course, denies that it would use its dominance over rare earth materials as leverage in trade disputes or against the United States.[9]

CHINA'S STRATEGIC PLANS FOR RARE EARTH ELEMENTS

Although China controls less than 40% of the world's REE deposits,[10] it has over time increased its global proportion of supply by subsidizing the relocation of companies involved in the rare earths supply chain to China and through the acquisition of foreign firms. In 1995, Chinese state investors acquired Magnequench, a unit of General Motors, and in 2001 moved the company to Tianjin, China. Doing so meant that the U.S. Department of Defense lost its sole supplier of special magnets used to manufacture U.S. Hellfire missiles.[11]

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The PRC government, meanwhile, as part of Communist Party General Secretary Xi Jinping's "One Belt One Road (一带一路) Initiative," (BRI for short) has strategically catalogued where along the BRI it can develop and secure rare earth elements.[12] China can use the BRI to leverage global deposits and refinement sites of rare earth elements to maintain its hold on the rare earths market.

As one PRC chemical industry publication put it, "the countries along the 'Belt and Road' are rich in mineral resources, have relatively low levels of geological work, good mineralization conditions, and great potential for prospecting. In particular, uranium, copper, aluminum, lead, zinc, nickel, iron and other mineral

resources are abundant, and new technology minerals such as rare, rare earth, and rare earths."[13] This planning is part of the broader strategic effort by China to secure steady supplies of critical minerals. In doing so, the PRC is able to harness state power on demand and put banks, private companies, state owned enterprises, provinces and locales in the business of developing these resources.[14]

Yet some in China clearly recognize that the entire matter of rare earth resources requires a "comprehensive national strategy," not industry-by-industry or province-by-province approaches. Wu Gang, Secretary of the PLA Commission for Discipline Inspection, suggested in 2018 that China develop a national rare earth resource stockpile system and concurrently "improve the management of resource reserves, establish a rare earth resource storage base, and promulgate a rare earth resource protection law."[15]

THE JAPAN CASE

The 2010 incident with Japan touched off concerns in the U.S. about the prevailing dependence on China for processed rare earth materials. On September 7, 2010, a Chinese trawler in the area of the Senkaku Islands collided with two Japanese Coast Guard patrol ships.[16] The Senkaku Islands, which Japan claims, are also claimed by China (which calls them the Diaoyu Islands); Taiwan, as the Republic of China, has also claimed them.[17] Japan's government arrested the trawler captain and intended to put him on trial.

The arrest of the trawler captain elicited a major diplomatic protest from China, as well as riots in Tianjin, Shanghai and a number of other Chinese cities with a presence of Japanese companies of citizens.[18] In the authors' view, these demonstrations were likely orchestrated and controlled by PRC authorities in order to intimidate the Japanese government, as it is exceedingly difficult to engage in large-scale protests in China. Demonstrations also took place in Taiwan over the detention of the Chinese trawler captain.

Some in the U.S. had already become alarmed over the state of access to rare earth minerals.[19] However, the PRC's decision to impose an embargo on rare earth exports to Japan in apparent retaliation for Japan's actions increased those concerns significantly, and fueled new fears about U.S. dependence.[20] Ultimately, the PRC embargo had the effect of prompting other nations to diversify their sources of rare earth elements, and hurt exports of Japanese products from China's factories.[21]

The PRC is monitoring how the U.S. responds to its control of rare earth supply chains. In 2017, the Communist Party newspaper Reference News carried an article quoting then-Chairman of the Joint Chiefs of Staff Gen. Joseph Dunford as saying that the "United States' defense industrial base is becoming 'more and more fragile,' which has a long-term impact on the state of military readiness. Rare earth elements are vital to the United States' ability to launch and win wars, but the U.S. government's actions on this issue are hesitating."[22] Subsequently, General Secretary Xi Jinping provided a subtle reminder about China's domination of the rare earth industry with his 2019 visit to a mine in Jiangxi Province.[23]

Today, U.S. industry, the military services, the Executive Branch and Congress are learning lessons that should have been obvious earlier, when the PRC used rare earth elements as a weapon against Japan. First, the United States needs to know the supply chains for the production of vital products. Second, the U.S. cannot depend on a single source for vital materials. And third, it cannot put its industrial base at the mercy of an increasingly arrogant and hostile potential enemy.

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AMERICA'S DEPENDENCE ON RARE EARTH ELEMENTS

A sobering set of facts from the Congressional Research Service show just how vital rare earth elements are to America's national defense. "[E]ach SSN-774 Virginia-class submarine would require approximately 9,200 pounds of rare earth materials, each DDG-51 Aegis destroyer would require approximately 5,200 pounds of these materials, and each F-35 Lightning II aircraft

FIGURE 2: RARE EARTH ELEMENTS IN WEAPON SYSTEMS

ELEMENTS	TECHNOLOGY	FUNCTION/ APPLICATION	SELECTED EXAMPLES
Nd, Pr, Sm, Dy, Tb *Neodynium, Praseodymium, Samarium, Dysprosium, Terbium*	Compact/ Powerful Permanent Magnets	Guidance & Control Electric Motors and Actuators	Tomahawk Cruise Missile, Smart Bombs, Joint Direct Attack Munitions, Joint Air to Ground Fin Actuator, Predator Unmanned Aircraft
Numerous	Energy Storage/ Density Amplification	Electronic Warfare, Directed Energy Weapons	Jamming Devices, Electromagnetic Railgun, Ni Metal Hydride Battery, Area Denial System, Long Range Accoustic Device and Area Denial Systems loaded on "Stryker" vehicle
Y, Eu, Tb *Yttrium, Europium, Terbium*	Amplification of Energy and Resolution	Targeting and Weapons	Laser Targeting, Air Based Lasers, Laser Avenger (counter-IED's), SaberShot Photonic Disrupter, FCS Vehicle with Laser Weapon
Nd, Pr, Sm, Dy, Tb *Neodynium, Praseodymium, Samarium, Dysprosium, Terbium*	Compact/ Powerful Permanent Magnets	Electric Drive Motors	CHPS Future Combat, Integrated Starter Generator, Hub Mounted Electric Traction Drive, Zumwalt DDG 1000, Joint Strike Fighter and More Electric Aircraft
Nd, Y, La, Lu, Eu *Neodynium, Yttrium, Lanthanum, Lutetium, Emporium*	Amplification, enhanced resolution of signals	Radar, Sonar, Radiation, and Chemical Detection	Sonar Transducers, Radar, Enhanced λ Ray Radiation Detection, Mulitpurpose Integrated Chemical Agent Alarm (MICAD)

Source: Compiled from content in Valerie Bailey Grasso, "Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress," Congressional Research Service, *CRS Report* R41744, December 23, 2013

would require approximately 920 pounds of these materials," a 2013 CRS report detailed.[24] In U.S. Department of Defense production, "rare earth materials are used in fin actuators in missile guidance and control systems, controlling the direction of the missile; disk drive motors installed in aircraft, tanks, missile systems, and command and control centers; lasers for enemy mine detection, interrogators, underwater mines, and countermeasures; and satellite communications, radar, and guidance and control systems," electronic warfare systems; targeting for weapon systems; sensors; and communication systems.[25]

ASSOCIATED PROBLEMS

While acquisition of rare earth elements is critical to maintaining technical and industrial independence from China, the mining of these resources is not without major costs. Similar to oil, rare earth deposits must be in a location and quantity that is cost effective to extract. While rare earth elements are distributed widely across Earth's crust, there are few deposits which are economically feasible to extract. Some of the most promising deposits are located in southwestern Nevada, southwestern Montana, northeastern Wyoming, central Colorado, southeastern Nebraska, eastern Missouri, western Virginia, northeastern New York, and southeastern Alaska.[26]

In the U.S. today, although other mines are under development, the Mountain Pass Mine in San Bernardino County, California is the only operational rare earth metals mine. It produces about 10 percent of all rare-earth concentrate, from which the metals are extracted; yet "the mine does not process its own materials—nor does any other U.S. firm."[27] Instead, the extracted materials are shipped to China for processing.

In 2020, President Donald Trump issued an Executive Order (EO) designed to address this U.S. vulnerability.[28] It identified 35 minerals "essential to the economy and national security of the United States." It also directed agencies to identify supply chains vulnerable to disruption and that serve "an essential function in the manufacture of products" needed for U.S. national Security.[29] While President Trump left office before all of these steps were accomplished, President Biden subse-

FIGURE 3: WORLD MINE PRODUCTION AND RESERVES

COUNTRIES	MINE PRODUCTION		RESERVES
	2019	2020	
United States	28,000	38,000	1,500,000
Australia	20,000	17,000	4,100,000
Brazil	710	1,000	21,000,000
Burma	25,000	30,000	NA
Burundi	200	500	NA
Canada	---	---	830,000
China	132,000	140,000	44,000,000
Greenland	---	---	1,500,000
India	2,900	3,000	6,900,000
Madagascar	4,000	8,000	NA
Russia	2,700	2,700	12,000,000
South Africa	---	---	790,000
Tanzania	---	---	890,000
Thailand	1,900	2,000	NA
Vietnam	1,300	1,000	22,000,000
Other countries	66	100	310,000
World Total (rounded)	**220,000**	**240,000**	**120,000,000**

Source: U.S. Geological Survey, Mineral Commodity Summaries, January 2021
Notes: Reserves for Brazil and the United States were revised based on information from Government and Industry reports.

quently continued the policy in a new Executive Order, described below.

Sources of pollution will be similarly difficult to offset or eliminate as the nation moves toward addressing its supply chain problems. Mining causes a wide variety of environmental concerns including pollution to air, water and land. Mining processes cause increased air particulates that contribute to and exacerbate respiratory conditions, release greenhouse gases more potent than carbon dioxide, and contribute to acid rain. Mines generally require sludge or slurry ponds that contain toxic waste—and such waste has completely destroyed over 2,000 water sources in Appalachia alone. Lastly, mines can make land unusable for any other purpose, decrease biodiversity, and contaminate surrounding soil.[30]

WASHINGTON TAKES AIM AT THE VULNERABILITY

In recent years, both Congress and the Executive Branch have taken a number of noteworthy measures to mitigate the current U.S. vulnerability relating to access to rare earth elements.

In the previous Congress, a number of legislative measures were introduced in an effort to address the current state of rare earth element supplies in the United States. Congressmen Paul Gosar (R-AZ-4th) and Michael Waltz (R-FL-6th), for instance, introduced an act "to promote the domestic exploration, research, development, and processing of critical minerals to ensure the economic and national security of the United States, and for other purposes.[31] Other legislative actions were also floated.[32] And although none of these bills were enacted into law in their entirety, some relevant provisions were included in the 2021National Defense Authorization Act,[33] which:

- requires the Secretary of Energy to implement an R&D program on advanced separation technologies for rare earth elements (REE) and related mitigation of public health and environmental impacts;"[34]
- establishes a robust critical mineral supply chain;
- requires the Executive Branch to create a list of critical minerals, which include rare earth elements, and update that list every three years;
- requires the United States Geological Survey (USGS) to conduct resource assessments of rare earth elements and make the findings available to the public;
- requires the Departments of Interior and Agri-

culture to publish notices in the Federal Register of critical minerals;
- establishes a research and developments program on "production, recycling, and alternatives to critical minerals" under the direction of the Secretary of Energy;
- directs the Secretary of Energy and Director of the Energy Information Administration to develop tools to better forecast rare earth elements markets; and;
- requires the Director of National Intelligence to study and report on mineral investments in China and to make recommendations on designation of critical minerals.[35]

In a similar vein, in December 2017, four months after the PRC chemical industry published its plans to develop sources of critical minerals,[36] President Trump issued Executive Order 13817 to address what many observers saw as a U.S. strategic vulnerability. The premise of the Order was that the U.S. reliance on imports of critical minerals, which include rare earth elements, makes it vulnerable to "adverse foreign government action, natural disaster, and other events that can disrupt supply of these key minerals."[37]

EO 13187 directed the Secretary of the Interior to coordinate with the Secretary of Defense and consult across government departments to publish a list of critical minerals no later than 60 days from the December 20, 2017 order. The U.S. Geological Survey published a draft list of 35 critical minerals[38] on February 16, 2018.[39] The order also made it government policy to 1) "identify new sources of critical minerals;" 2) invigorate the supply chain through developing means for "exploration, mining, concentration, separation, alloying, recycling, and reprocessing critical minerals;" 3) provide miners producers with "electronic access to the most advanced topographic, geologic, and geophysical data within U.S. territory to the extent permitted by law;" and 4) streamline the "leasing and permitting processes to expedite exploration, production, processing, reprocessing, recycling, and domestic refining of critical minerals."

That Executive Order was updated by President Trump in the last days of his term. The update specifically addressed China as an adversary:

> Our dependence on one country, the People's Republic of China (China), for multiple critical minerals is particularly concerning. The United States now imports 80 percent of its rare earth elements directly from China, with portions of the remainder indirectly sourced from China through other countries. In the 1980s, the United States produced more of these elements than any other country in the world, but China used aggressive economic practices to strategically flood the global market for rare earth elements and displace its competitors. Since gaining this advantage, China has exploited its position in the rare earth elements market by coercing industries that rely on these elements to locate their facilities, intellectual property, and technology in China.[40]

President Trump used the International Emergency Economic Powers Act (IEEPA) to require that the Secretary of Interior "inform the President of the state of the threat posed by our Nation's reliance on critical minerals, in processed or unprocessed form, from foreign adversaries and recommend any additional actions necessary to address that threat" every 60 days.

A little over a month after taking office, President Biden issued his own Executive Order 14017, essentially continuing the actions authorized by President Trump.[41] Among other things, the new Order directed the U.S. government interagency to conduct a review of U.S. supply chain risks within 100 days in order to ensure "resilient, diverse, and secure supply chains."[42]

THE WAY FORWARD

Within the Washington Beltway, there is now a broad understanding that there are available ways to increase our supplies of rare earth materials. Domestically, the U.S. can develop its own resources and find ways to mine and extract rare earth elements without dangerous ecological and environmental damage. The U.S. can also form consortiums with allies and dependable partners to stockpile or develop rare earth material sources. At the same time, the U.S. can take a lesson from China and seek to develop foreign sources of rare earth elements of its own.

One future domestic source is Round Top, a "polymetallic deposit in southwestern Texas, about 138 km from El Paso, owned by Texas Mineral Resources… which contains 16 of 17 rare earths—all 11 heavy rare earths and five light rare earths—and importantly all

five rare earth elements required for making permanent magnets."[43] Processing for rare earth elements and minerals from Round Top is carried out at a "pilot plant" in Colorado, a joint venture between USA Rare Earth and Texas Mineral Resources Corp. to separate 26 recoverable elements for industry.[44] At the same time, Congress has realized that there may be ways to extract rare earths from coal and coal byproducts, and has passed legislation to explore and enable such processes.[45]

Beyond the United States, a number of options are also available. For instance, Greenland is home to a major rare earth elements mine that has been the focus of Chinese development in recent years.[46] However, a snap election in the country has tabled the acquisition—for now—over environmental concerns. Nevertheless, Greenland has other mines that the United States might be able to acquire under the proper condition; given that the country has the seventh-largest reserves of rare earths globally, it represents a place where the U.S. or European allies could potentially develop rare earth capabilities (if the projects were designed to be environmentally friendly and allay local concerns).

Japan also has the potential to become an important source of rare earth materials in the future, although extraction there may present problems because the country's significant deposits are in its far eastern territorial waters. Underwater mining is a difficult process, so the discovery—while significant—may take some time to exploit.[47] The Japanese government it working to reduce its dependence on China and improve its own mining and refining capacity.[48]

In Latin America, Brazil holds major global deposits of rare earth elements.[49] There are opportunities available for Brazilian mining companies to extract rare earths, and these can fit into a strategy to reduce dependence on China for rare earth materials. One can, for instance, envision creating a trilateral rare earths relationship between the U.S., Brazil, and Japan that allows the U.S. to defend against potential future Chinese threats of a rare earths embargo.

Australia has some of the highest percentages of existing rare earth element mining operations, after China. One mining industry publication points out that the Mount Weld mine, which is administered by Lynas Corp., is one of "only two significant primary rare earth mines owned by Western companies and operated outside China."[50] Lynas' Mount Weld mine is especially important given the fact that Canberra is having its own problems with China, and the PRC has "slowed or stopped imports of Australian cotton and coal" imposed tariffs on Australian barley, banned beef from five major Australian producers, and imposed tariffs on Australian wines.[51] To diversify its markets and reduce its dependence on China, Australia has turned to Japan, India, and the U.S.[52] This pivot makes Australia an attractive destination for rare earth elements—one that the U.S. and its partners in the "Quad" alliance are positioned to exploit.[53]

The Biden administration has now taken the first steps to addressing America's critical vulnerability to China's control of the global rare earths market. The new Administration's Executive Order maps out a "whole of government" approach to solving the rare earth elements supply chain problem.[54]

Government alone, however, cannot solve the problem. The Administration's efforts must incorporate cooperation with and input from industry, environmental and natural resource protection groups. All of these actors will shape how the U.S. addresses these issues. Congress, meanwhile, must follow up on its prior legislative efforts to focus on developing the capacity in the U.S. to safely mine and refine rare earth elements, cooperate with allies and partners to break China's stranglehold on the rare earth supply chain, and ensure that the Executive Branch follows up on its reports with concrete action.

The problem is urgent. China's control of the supply of usable, refined rare earth elements undermines U.S. security and that of its allies. And, at the moment, the U.S. does not have a strategic plan or vision to assure its own technological and national security success in this arena. Yet there is now a broad realization across government and among the American public that the U.S. economy and national security cannot be placed in a stranglehold by the People's Republic of China. That realization, in turn, is at long last generating the requisite political will for measures that are needed to secure the U.S. rare earth supply chain in the years ahead.

ENDNOTES

1. Lee Levkowitz and Nathan Beauchamp-Mustafaga, *China's Rare Earths Industry and its Role in the International Market* (Washington, DC: U.S.-China Economic and Security Review Commission, November 3, 2010), https://www.uscc.gov/sites/default/files/Research/RareEarthsBackgrounderFINAL.pdf.
2. Xie Kaifei, "What makes the rare earth trump card (是

什么成就了稀土这张王牌)," *Science and Technology Daily* (科技日报), June 6, 2019, http://www.xinhuanet.com/tech/2019-06/06/c_1124588710.htm.
3. Ibid.
4. Peter Grier, "Rare-Earth Uncertainty," *Air Force Magazine*, December 21, 2017, https://www.airforcemag.com/article/rare-earth-uncertainty/.
5. Felix K. Chang, "Digging Deeper: Rare Earth Metals and the U.S.-China Trade War," Foreign Policy Research Institute, June 21, 2019, https://www.fpri.org/article/2019/06/digging-deeper-rare-earth-metals-and-the-u-s-china-trade-war/.
6. Government of Canada, "Rare Earth Elements Facts," n.d., https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522.
7. Senate Republican Policy Committee, "Protecting America's Supply of Rare Earth Elements," March 11, 2020, https://www.rpc.senate.gov/policy-papers/protecting-americas-supply-of-rare-earth-elements.
8. Dean Cheng, Nicolas Loris and Klon Kitchen, "China Is a Paper Tiger on Rare Earth Minerals," Heritage Foundation Report, June 13, 2019 https://www.heritage.org/asia/report/china-paper-tiger-rare-earth-minerals.
9. "The relevant person in charge of the National Development and Reform Commission answers reporters' questions on the development of the rare earth industry (国家发展改革委有关负责人就稀土产业发展相关问题答记者问)," *PLA Daily*, May 29, 2019, 4.
10. David L. An, "Critical Rare Earths, National Security, and U.S.-China Interactions" (Santa Monica: Rand Corporation, 2015), https://www.rand.org/pubs/rgs_dissertations/RGSD337.html.
11. Ibid.
12. "Overview of the Reserves and Production Capacity of Major Mineral Resources in the 'One Belt One Road' Initiative (一带一路"主要矿产资源储量及产能概况)," *ChemNet*, August 8, 2017, http://news.chemnet.com/detail-2455363.html.
13. Ibid.
14. See Nadège Rolland, "A Concise Guide to the Belt and Road Initiative," National Bureau of Asian Research, April 11, 2019, https://www.nbr.org/publication/a-guide-to-the-belt-and-road-initiative/; Meg Rithmire, Testimony before the U.S.-China Economic and Security Review Commission, March 19, 2021, https://www.uscc.gov/sites/default/files/2021-03/Meg_Rithmire_Testimony.pdf; Anne Stevenson-Yang, Testimony before the U.S.-China Economic and Security Review Commission, March 19, 2021, https://www.uscc.gov/sites/default/files/2021-03/Anne_Stevenson-Yang_Testimony.pdf.
15. Zou Weirong, "Member Wu Gang-Step up the formulation of a rare earth resource protection strategy (吴刚委员— —加紧制定稀土资源保护战略)," *PLA Daily*, June 8, 2018, http://www.xinhuanet.com/mil/2018-03/16/c_129830534.htm.
16. Justin McCurry, "Japan-China row escalates over fishing boat collision," *The Guardian*, September 9, 2010, https://www.theguardian.com/world/2010/sep/09/japan-china-fishing-boat-collision; "Boat collisions spark Japan-China diplomatic row," *BBC News*, September 8, 2010, https://www.bbc.com/news/world-asia-pacific-11225522.
17. Carol Chen, "Should Taiwan Claim Sovereignty Over the Senkakus?," *The Taiwan Times*, July 23, 2020, https://thetaiwantimes.com/should-taiwan-claim-sovereignty-over-the-senkakus/.
18. McCurry, "Japan-China row escalates over fishing boat collision."
19. Committee on Science and Technology, House of Representatives, "Hearing: Rare Earth Minerals and 21st Century Industry," March 16, 2010, https://www.globalsecurity.org/military/library/congress/2010_hr/Hearing_Charter.pdf; (accessed March 14, 2021); Stephen Freiman, Testimony before the House Committee on Science and Technology Subcommittee on Investigations and Oversight, March 16, 2010, https://www.globalsecurity.org/military/library/congress/2010_hr/Freiman_Testimony.pdf.
20. Keith Bradsher, "China Bans Rare Earth Exports to Japan Amid Tension," *CNBC*, September 23, 2010, https://www.cnbc.com/id/39318826; Felix K. Chang, "Digging Deeper: Rare Earth Metals and the U.S.-China Trade War," Foreign Policy research Institute, June 21, 2019, https://www.fpri.org/article/2019/06/digging-deeper-rare-earth-metals-and-the-u-s-china-trade-war/.
21. Cary Huang, "China's ban on rare earths didn't work on Japan and won't work in the trade war with the US," *South China Morning Post*, June 5, 2019, https://www.scmp.com/comment/opinion/article/3012994/chinas-ban-rare-earths-didnt-work-japan-and-wont-work-trade-war-us.
22. U.S. media say China holds the Achilles heel of the U.S. military and affects U.S. strategic security (美媒称中国手握美军致命弱点 影响美国战略安全), Reference News, October 13, 2017, http://mil.news.sina.com.cn/china/2017-10-13/doc-ifymvece1877131.shtml.
23. "The relevant person in charge of the National Development and Reform Commission answers reporters' questions on the development of the rare earth industry," PLA Daily.
24. Valerie Bailey Grasso, "Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress," Congressional Research Service Report, September 17, 2013, 4, https://apps.dtic.mil/dtic/tr/fulltext/u2/a590410.pdf.
25. Hobart M. King, "REE - Rare Earth Elements and their Uses," geology.com, n.d., https://geology.com/articles/rare-earth-elements/; See also Grasso, "Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress," 9-11.
26. B.S. Van Gosen, P.L. Verplanck and Poul Emsbo, "Rare earth element mineral deposits in the United States," *U.S. Geological Survey Circular* 1454, 2019, 16, https://doi.org/10.3133/cir1454.
27. Alyk Russell Kenlan, "Rare Elements of Security," *Air Force Magazine*, November 1, 2020, https://www.airforce-

mag.com/article/rare-elements-of-security/.

28. White House, *Executive Order on Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries*, September 30, 2020, https://www.federalregister.gov/documents/2020/10/05/2020-22064/addressing-the-threat-to-the-domestic-supply-chain-from-reliance-on-critical-minerals-from-foreign.
29. Ibid.
30. Paul R. Epstein et al., "Full Cost Accounting for the Life Cycle of Coal," *Annals of the New York Academy of Sciences* 1219, no. 1 (2011), 73–98, https://doi.org/10.1111/j.1749-6632.2010.05890.x.
31. 116th Congress, H.R.7061 - American Critical Mineral Exploration and Innovation Act of 2020, introduced May 28, 2020, https://www.congress.gov/bill/116th-congress/house-bill/7061/text; the submission by Congressman Waltz (R-FL) and Congressman Gosar (R-AZ) can be found at https://republicans-science.house.gov/sites/republicans.science.house.gov/files/american_critical_minerals_exploration_and_innovation_act.pdf.
32. Brandon S. Tracy, "An Overview of Rare Earth Elements and Related Issues for Congress," Congressional Research Service Report, November 24, 2020, https://crsreports.congress.gov/product/pdf/R/R46618.
33. 116th Congress, H.R.6395 - *National Defense Authorization Act for Fiscal Year 2021*, PL 116-283, introduced March 26, 2020, https://www.congress.gov/bill/116th-congress/house-bill/6395#:~:text=William%20M.%20%28Mac%29%20Thornberry%20National%20Defense%20Authorization%20Act,authority%2C%20which%20is%20provided%20in%20subsequent%20appropriations%20legislation. See Sec, 848, Sec. 849, Sec 852 (accessed March 24, 2021). See also NioCorp Developments, Ltd., "U.S. House of Representatives Approves Defense Bill That Highlights Growing Urgency for the U.S. to Produce More of its Own Critical Minerals, Including Niobium," July 23, 2020, https://www.prnewswire.com/news-releases/us-house-of-representatives-approves-defense-bill-that-highlights-growing-urgency-for-the-us-to-produce-more-of-its-own-critical-minerals-including-niobium-301098780.html.
34. "The Consolidated Appropriations Act Overhauls US Energy Policy," *Thompson Reuters Practical Law*, January 13, 2021, https://uk.practicallaw.thomsonreuters.com/w-029-1544?originationContext=knowHow&transitionType=KnowHowItem&contextData=(sc.DocLink)&-firstPage=true.
35. Ibid.
36. "Overview of the Reserves and Production Capacity of Major Mineral Resources in the 'One Belt One Road' Initiative (一带一路"主要矿产资源储量及产能概况), *Chemnet*.
37. White House, *Executive Order 13817—A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals*, December 20, 2017, https://www.presidency.ucsb.edu/documents/executive-order-13817-federal-strategy-ensure-secure-and-reliable-supplies-critical.
38. The full list of critical minerals includes: Aluminum (bauxite), used in almost all sectors of the economy; Antimony, used in batteries and flame retardants; Arsenic, used in lumber preservatives, pesticides, and semi-conductors; Barite, used in cement and petroleum industries; Beryllium, used as an alloying agent in aerospace and defense industries; Bismuth, used in medical and atomic research; Cesium, used in research and development; Chromium, used primarily in stainless steel and other alloys; Cobalt, used in rechargeable batteries and superalloys; Fluorspar, used in the manufacture of aluminum, gasoline, and uranium fuel; Gallium, used for integrated circuits and optical devices like LEDs; Germanium, used for fiber optics and night vision applications; Graphite (natural), used for lubricants, batteries, and fuel cells; Hafnium, used for nuclear control rods, alloys, and high-temperature ceramics; Helium, used for MRIs, lifting agent, and research; Indium, mostly used in LCD screens; Lithium, used primarily for batteries; Magnesium, used in furnace linings for manufacturing steel and ceramics; Manganese, used in steelmaking; Niobium, used mostly in steel alloys; Platinum group metals, used for catalytic agents; Potash, primarily used as a fertilizer; Rare earth elements group, primarily used in batteries and electronics; Rhenium, used for lead-free gasoline and superalloys; Rubidium, used for research and development in electronics; Scandium, used for alloys and fuel cells; Strontium, used for pyrotechnics and ceramic magnets; Tantalum, used in electronic components, mostly capacitors; Tellurium, used in steelmaking and solar cells; Tin, used as protective coatings and alloys for steel; Titanium, overwhelmingly used as a white pigment or metal alloys; Tungsten, primarily used to make wear-resistant metals; Uranium, mostly used for nuclear fuel; Vanadium, primarily used for titanium alloys; and Zirconium, used in the high-temperature ceramics industries.
39. "Final List of Critical Minerals 2018: A Notice by the Interior Department," *Federal Register*, May 18, 2018, https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018. The USGS February list can be found at https://www.usgs.gov/news/interior-releases-2018-s-final-list-35-minerals-deemed-critical-us-national-security-and.
40. *Executive Order 13953—Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries.*
41. *Executive Order 14017 - Executive Order on America's Supply Chains.*
42. Ibid., sections 1-3.
43. Mandy Mayfield, "Rare Earth Processing Plant Opens in Colorado," *National Defense*, July 16, 2020, https://www.nationaldefensemagazine.org/articles/2020/7/16/rare-earth-processing-plant-opens-in-colorado#:~:text=The%20facility%2C%20which%20is%20based,U.S.%20government's%20critical%20minerals%20list; See also Trish Saywell, "USA Rare Earth outlines domestic mine-to-magnet strategy," *The Northern Miner*, January 7, 2021,

https://www.northernminer.com/news/usa-rare-earth-outlines-mine-to-magnet-strategy-in-us/1003826738/.
44. Ibid.
45. 116th Congress, *Rare Earth Element Advanced Coal Technologies Act*, S. Rep. 116-74, August 16, 2019, https://www.govinfo.gov/content/pkg/CRPT-116srpt74/html/CRPT-116srpt74.htm.
46. Yaseo Takeuchi, " Greenland says no to China-backed rare earth mine in election," *Asia Nikkei*, April 8, 2021, https://asia.nikkei.com/Business/Markets/Commodities/Greenland-says-no-to-China-backed-rare-earth-mine-in-election; Stacy Meichtry and Drew Hinshaw, "China's Greenland Ambitions Run Into Local Politics, U.S. Influence," *Wall Street Journal*, April 8, 2021, https://www.wsj.com/articles/chinas-rare-earths-quest-upends-greenlands-government-11617807839.
47. Jeremy Berke, "Japan Just Found a Huge Rare-Earth Mineral Deposit That Can Supply The World For Centuries," sciencealert.com, April 16, 2018, https://www.sciencealert.com/japan-just-found-a-semi-infinite-deposit-of-rare-earth-minerals.
48. Julian Ryall, "Japan moves to secure rare earths to reduce dependence on China," *MSN News*, August 17, 2020, https://www.msn.com/en-sg/news/world/japan-moves-to-secure-rare-earths-to-reduce-dependence-on-china/ar-BB183qbq.
49. "Global Rare Earth Metals Market SWOT Analysis, Key Indicators, Forecast 2027," *KSU Sentinel*, February 17, 2021, https://ksusentinel.com/2021/02/17/global-rare-earth-metals-market-swot-analysis-key-indicators-forecast-2027-lynas-corporation-ltd-molycorp-2/.
50. Saywell, "USA Rare Earth outlines domestic mine-to-magnet strategy."
51. Prashant Mehra, "China trade pressure sends Australia 'wake-up call' to diversify," *Nikkei Asia*, October 26, 2020, https://asia.nikkei.com/Economy/Trade/China-trade-pressure-sends-Australia-wake-up-call-to-diversify; Sybilla Gross and Shuping Niu, "China Sets Duties on Australia Wine for 5 Years as Ties Sour," *Bloomberg*, March 26, 2021 https://www.bloomberg.com/news/articles/2021-03-26/china-s-tariffs-on-australian-wine-to-last-5-years-as-ties-sour.
52. Ibid.
53. Jeff Smith, "The Return of the Indo-Pacific Quad," *The National Interest*, July 26, 2018, https://nationalinterest.org/feature/return-indo-pacific-quad-26891#:~:text=The%20Quad%20has%20also%20found%20common%20ground%20on,again%20for%20a%20second%20time%20in%20April%202018.
54. *Executive Order 14017 - Executive Order on America's Supply Chains.*

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