

MARCH 2021

THE

 **Geopolitics**

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AUTHOR

Jane Nakano

A Report of the CSIS Energy Security and Climate Change Program

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The Geopolitics of Critical Minerals Supply Chains

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Acknowledgments

The author would like to thank CSIS colleagues Sarah Ladislaw and Nikos Tsafos for feedback and Ian Barlow for graphics assistance. The author would also like to thank Brandon Tracy of the U.S. Congressional Research Service and Marco Giuli of the Brussels School of Governance for reviewing a draft.

This report was made possible by the generous support of the Japan External Trade Organization.

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Introduction

Confronted with the rising threat of climate change, many governments around the world have launched efforts to electrify their energy system while decarbonizing their electric power supply. This trend has led to an increased demand for non-carbon-emitting sources of electricity and energy storage technologies, and in turn has grown the demand for these technologies' component minerals and materials. According to a World Bank study, the demand for component minerals for electric storage batteries—such as aluminum, cobalt, lithium, manganese, and nickel—could rise by more than 450 percent by 2050 if clean energy technology is deployed at a level consistent with the Paris Climate Agreement goal of keeping the rise in atmospheric temperature to no more than 2 degrees Celsius.¹

Clean energy technology components have different degrees of reliance on a range of minerals, which in turn have different criticality profiles informed by factors such as price volatility and the stability of the supplier country. Rare-earth elements, such as neodymium, dysprosium and praseodymium, are key ingredients of permanent magnets (powerful magnets that do not lose their magnetic fields), which are used in high-performance wind turbines.² Borates, gallium, germanium, and indium are also important ingredients in solar photovoltaics (PV), while cobalt and lithium are required for the lithium-ion batteries used in electric vehicles (EVs). Although these minerals are available globally, some are highly concentrated in a few countries. For example, about half the global supply of cobalt comes from the Democratic Republic of the Congo (DRC); over 80 percent of the global supply of lithium comes from Australia, Chile, and Argentina; and 60 percent of the global supply of manganese comes from South Africa, China, and Australia.³ Most notably, over 85 percent of the global supply of rare-earth elements comes from China.

Supply chain security for the minerals and materials needed in clean energy technologies has become a strategic issue, not only because it could affect the pace of clean energy technology deployment around

the world but also because clean energy technology has become the latest frontier for the geoeconomic rivalries sparked by China's competitive manufacturing sector. No longer a simple mineral producer or component assembler, China is emerging as a higher-value manufacturer that requires a growing volume of the minerals and metals that are considered key to clean energy technology manufacturing. This development has increased the pressure for other major economies dependent on mineral imports to secure their critical minerals supply chains.

An equally important factor is that China appears to recognize the strength of its critical minerals supply chains as geopolitical leverage. For example, during one of the heightened phases of the U.S.-China trade war in 2019, President Xi Jinping of China and his top trade negotiator toured a rare-earth processing facility in Jiangxi Province, which is known for its rare-earth wealth. The visit was widely interpreted as a reminder to the United States that China has leverage over the rare-earth supply chains, bringing back the memory of China's embargo on rare-earth exports to Japan, which occurred over a territorial dispute in the fall of 2010. Additionally, Xi Jinping's call in April 2020 for the need to enhance global supply chains' dependence on China and "develop powerful retaliation and deterrence capabilities against supply cut-offs by foreign parties" has only fueled concern among Western policymakers that heavy economic dependence on China for something as critical as rare-earth minerals may translate into a vulnerability that can be exploited by China in the event of a clash between China and the West.⁴

Furthermore, the Covid-19 pandemic has exposed fragility in the global supply chains for not only pharmaceuticals and crucial medical supplies but also some critical minerals. For instance, the transport of cobalt produced in the Democratic Republic of the Congo was delayed in South Africa for months following the South African government's imposition of a strict lockdown in the second quarter of 2020.⁵

A confluence of these developments has elevated the strategic importance of securing critical minerals supply chains, especially to a group of economies that are home to innovators and manufacturers. Some governments have modernized or expanded existing strategies to address the challenge, while others have outlined action plans or articulated their perspectives on only specific portions of the supply chains. The author identified a select set of economies whose approach to the security of critical minerals supply chains is likely to be consequential in terms of geopolitics. Through a literature survey and interviews, the author reviewed the statuses of these economies' critical minerals supply chains as well as their strategies to address the supply security concern. This report illuminates the key economic, security, and geopolitical factors behind the recent evolution of these economies' strategies and their approaches to the security of critical minerals supply chains.

Key observations include:

- The security of critical minerals supply chains is a strategic issue, in light of the expected exponential demand growth led by clean energy technology deployment around the world.
- Sustained political commitment to technological innovation is essential to managing the growing competition over resources and clean energy manufacturing value chains.
- China's development of midstream and downstream capacities has turned it from a supplier of raw minerals and materials to a key consumer of them. China's commanding position along critical minerals supply chains is a key factor that shapes other economies' strategic responses.

- Different economies are motivated by different concerns reflecting the heterogeneity in their resource endowment profiles and industrial structures. The United States appears most concerned about import dependence that can be exploited geopolitically, while the European Union and Japan appear primarily concerned with the effects of supply disruptions on their industrial competitiveness.
- Recent efforts to strengthen critical minerals supply chains include the United States' development of midstream capacities, the European Union's orchestrated support for its battery sector, and Japan's stockpile modernization and resource development abroad.
- Competition over critical minerals supplies is also rising between import-dependent economies. Such competition could hinder effective international partnerships that might otherwise mitigate existing risks to supply chains.

The Chinese Dominance of the Global Critical Minerals Supply Chains

China has become a dominant stakeholder in the global supply chains for critical minerals and clean energy goods. In solar PV manufacturing (which broadly consists of the manufacturing of polysilicon, ingots, wafers, cells, and modules), China is home to over 90 percent of the world's wafer manufacturing capacity, and Chinese companies—regardless of factory location—own two-thirds of the global polysilicon manufacturing capacity and 72 percent of the global module manufacturing capacity.⁶ In lithium-ion battery manufacturing, China has a majority of processing capacity for key components (such as cathodes, anodes, separators, and electrolytes), as well as almost 80 percent of global battery cell manufacturing capacity.⁷ Although less dominant, China still has a strong presence in the wind turbine value chain: it is home to about half of total manufacturing plants for nacelles, blades, wind towers, turbine generators, and gearboxes.⁸

China's emergence as a major force along the clean energy technology value chain is partly the result of their resource wealth, as China is home to roughly one-third of global rare-earth reserves. However, this emergence also represents the culmination of long-term industrial policy, China's capacity to execute it, and advantages derived from a lag in extractive industry regulations.⁹

Where it lacks access to resources, China has invested in mining projects abroad. For example, since nearly 60 percent of cobalt ore comes from the DRC, Chinese enterprises invest in cobalt mines and participate in cobalt smelting projects there to secure stable access to cobalt resources.¹⁰ China has come to account for 72 percent of the global cobalt refining capacity.¹¹ The consumption of cobalt by China—where approximately three-quarters of supply is used in lithium battery manufacturing—is forecast to almost double between 2017 and 2023.¹² Also, while China is only one of five countries that produce lithium (another key mineral for lithium-ion battery production), it accounts for roughly 60 percent of global lithium refining capacity.¹³ China also leads the rest of the world in its capacity to

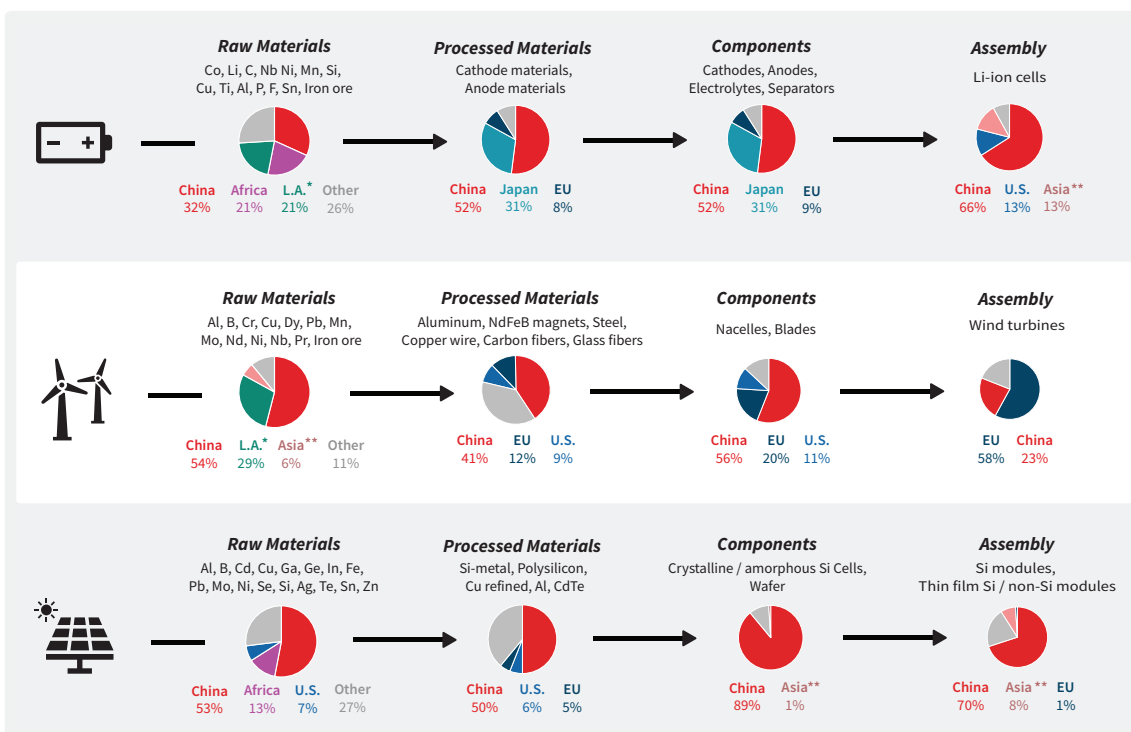
process these refined materials into components, mainly cathodes (producing 52 percent of the global cathode supply), anodes (78 percent), separators (66 percent), and electrolytes (62 percent).¹⁴ In 2018, for the first time in over three decades, China became a net importer of at least seven rare earths, as domestic output declined due to a government crackdown on illegal production.¹⁵

China’s recognition of the strategic value of non-fuel minerals and their industrial applications dates back at least to the seventh National Five-Year Plan for Rare Earth Industry (1986–1990), which made it a priority to “develop research and production of advanced rare-earth applications and new materials (e.g., permanent magnets and lasers) for domestic consumption and export.”¹⁶ The Chinese government spurred the development of midstream and downstream sectors through investment policies that allowed foreign investment in rare-earth smelting with the import of advanced technologies and machinery and encouraged foreign investment and joint ventures in producing advanced products downstream—all while prohibiting foreign investment and joint ventures in the mining sector.¹⁷

State-sponsored investment in research and development took off early in China. By 1985, there were more than 300 research institutes and university research centers in China working on research projects related to rare-earth mining, smelting, and applications.¹⁸ China has filed more rare-earth patents than the rest of the world combined.¹⁹ Low-cost minerals and supply of materials attracted many foreign firms to relocate to China, a situation that not only afforded these firms access to the growing Chinese market but also benefitted the Chinese by enhancing China’s downstream manufacturing capacity through technology transfer.

Clean Energy Mineral Supply Chains and Top Global Suppliers

Batteries, Wind, and Solar PV



* Latin America
** Excluding China and Japan

Source: Created by Ian Barlow based on data from European Commission, *Critical materials for strategic technologies and sectors in the EU - a foresight study*, 2020 (Brussels: European Commission, 2020).

China has also employed export and production quotas. From 1999 to 2014, China imposed an annual export quota. The export quota system was structured to favor firms that could create high additional value.²⁰ Moreover, in 2006, China introduced production quotas on rare-earth concentrates, with the stated goal of controlling total production and illegal mining. These actions caused a spike in rare-earth prices, given China's strong position in the global supply. China's export restrictions continued until 2014 when a World Trade Organization (WTO) dispute settlement panel agreed with the United States, European Union, and Japan that China's export duties and export quotas on rare earths, tungsten, and molybdenum constituted a breach of WTO rules.²¹

More recently, the Chinese government identified “new materials,” such as permanent magnets, to be among the 10 industries targeted for government support under the *Made in China 2025* initiative. This industrial initiative, released in 2015, aims to upgrade China's manufacturing capacity by 2025 through focused allocation of resources, such as beneficial regulations, tax incentives, and financing by public banks.²² The development of the new materials industry is seen as a foundation for the successful development of Chinese manufacturing capacity in nine other industries, such as EVs, new information technology, and aerospace.²³ China's heavy focus on expanding its technology innovation capacity is likely to continue until at least 2035—a year identified by the Chinese Communist Party's Central Committee in October 2020 to be when China becomes the global technology leader.²⁴

Since the Chinese government has been promoting domestic downstream industry, the country's consumption of rare-earth minerals has been on the rise. Between 2004 and 2014, China's consumption of rare-earth minerals grew at an average annual rate of 7.5 percent, while the rare-earth mineral consumption of the rest of the world decreased by 3.8 percent, raising China's share of the global consumption from 43 to 70 percent.²⁵ Moreover, China's production of rare-earth end-use products grew by about 70 percent between 2005 and 2015; by 2015, domestic consumption accounted for over 80 percent of the domestic production of rare earths.²⁶

In order to better position itself to weather potential supply disruptions, China's National Mineral Resource Plan for 2016–2020 called for establishing a range of capabilities, including a warning mechanism for the rare-earth industry to safeguard its supply chains against various causes of potential disruptions and a more systematic demand and supply analysis on mineral products.²⁷ More recently, in October 2020, China passed an export-control law that would restrict exports of controlled items to protect China's interest and security. Although the government has not elaborated or clarified which items and technologies will fall under this law, rare earths are among the strong suspects.²⁸ Furthermore, in early January 2021, China introduced draft legislation to “reinforce the protection of its rare earth resources” and “strengthen full industrial chain regulation” by strengthening the approval process for mining and processing projects, as well as the rare-earth trade.²⁹ In reporting this proposal, the state-run *China Daily* noted that China considers rare-earth elements to be “prized resources” with “irreplaceable significance for the upgrade of traditional industries, and the development of emerging industries.”³⁰ These developments may also reflect China's unease that the United States and other major economies are beginning to seriously address their current vulnerability with regards to critical minerals supply chains.

Securing the Critical Minerals Supply Chains

Various Strategies and Policy Steps

A confluence of factors—including growing competition over critical mineral supplies and clean energy manufacturing, fragility in the global supply chains, and rising competition from China—has led a few economies to review the state of their critical minerals supply chains in recent years. Several of them have updated their strategies, expanded policy tools to address the challenge, or introduced action plans to improve or preserve the security of critical minerals supply chains.

For example, India is noteworthy for its growing political focus on developing clean energy manufacturing capacity. A 2016 report released by India’s Department of Science and Technology presented an assessment of the effects the security of critical minerals supply may have on India’s manufacturing sector, given the growing gap between the rising demand for technology-enabled products and its domestic manufacturing capacity.³¹ India has been striving to grow its clean energy manufacturing base, as exemplified by the *Make in India* program. This industrial initiative, combined with goals to grow the installed capacity of renewable energy from about 90 gigawatts (GW) currently to 450 GW and fully electrify the mobility sector by 2030, seems to be driving India’s interest in developing relationships with resource-rich economies to secure access to critical minerals.³² For example, India concluded a memorandum of understanding (MOU) with Australia in June 2020 to secure supplies of critical minerals from Australia.³³

Australia is another major stakeholder in the global supply chains for critical minerals. Australia is rich in energy and natural resources, including many critical minerals, and home to some of the top companies in global mining. The Australian government seeks to leverage ongoing efforts at the state and territory levels, such as Western Australia’s initiative to capitalize on local minerals for the lithium-ion battery industry and New South Wales’s effort to attract investment in metals and rare-earth resources.³⁴ In 2019, the Australian government issued its Critical Minerals Strategy

in an effort to strengthen its mining and processing capacities by promoting investment and incentivizing innovation.³⁵

While the universe of economies seeking to enhance their competitiveness along the critical minerals supply chain is growing, this report focuses on the United States, the European Union, and Japan, evaluating the similarities, differences, and evolution of their respective critical minerals strategies.

Table 1: Comparing the Strategies/Responses

	United States	European Union	Japan
Term Used in Strategic Documents	Critical minerals.	Critical and raw materials.	Rare metals.
Key Interests/Considerations	Defense requirements; economic security; industrial competitiveness. No specific focus on clean energy sector.	Industrial competitiveness in clean energy sector. Political commitment to climate neutrality.	Industrial competitiveness.
Research and Innovation Focus	Domestic resource survey capacity; separation and processing; substitute development; recycling technologies.	Separation and processing; substitute development; recycling technologies.	Substitute development; recycling technologies.
International Cooperation Focus	Cooperation is alliance-oriented. The tone is confrontational against China.	Cooperation within and near the European Union is important.	Trade and investment with resource-rich countries. Funding to resource-rich developing countries for capacity building.
Domestic Land Access Issue Focus	Permitting.	Permitting.	Not applicable.
Workforce Issue Focus	Extractive industry workers and processing expertise.	Extractive industry workers and processing expertise.	Expertise in substitution and recycling technology researchers.
Critical Minerals List	35 entries on the list. No regularly scheduled criticality assessments. Updates per the White House. The most recent list was published in 2019.	30 entries on the list. Regularly scheduled criticality assessments, every three years. The most recent list was published in 2020.	34 entries on the list. No regularly scheduled criticality assessments. METI updated the list sometime since 2014.
Stockpile	For DOD use, managed by the DLA. ³⁶	None at the EU or EU member nation level. ³⁷	Stockpiling since 1983, for industry use; national (70%) and private industry stocks (30%) both managed by JOGMEC.

Note: These country strategy characteristics are relative and dynamic, and they are not to be viewed as comprehensive.

United States

Status of U.S. Supply Chains

The United States has a wealth of mineral resources and a strong tradition of mining. In fact, the United States was once the global leader in the production of the rare-earth minerals key to the high-performance magnets needed in clean energy technologies. From the mid-1960s through the 1980s, the Mountain Pass mine in California was the largest source of rare-earth oxides in the world. In addition to Mountain Pass, CA, other identified rare-earth deposits include Bokan Mountain, AK; Bear Lodge, WY; Round Top, TX; and Elk Creek, NE.³⁸

However, U.S. presence in the upstream and midstream of critical minerals supply chains is severely limited today. Several decades of globalization, where countries have sought greater economic benefits from closer integration of supply chains and trade, have led the United States to move much of its manufacturing base abroad. These forces of globalization, together with U.S. policymakers' decisions to prioritize domestic environmental protection over import-dependence concerns, have shifted the extraction and production of some key minerals, such as rare earths, outside of U.S. borders.³⁹ By 2000, the United States had become almost entirely dependent on overseas imports—particularly from China—for separated rare-earth oxides.

The Chinese rare-earth embargo of 2010 and the resultant volatility of rare-earth prices sharpened the U.S. focus on critical minerals supply chain security, as well as on the geopolitical consequences of unchecked dependency on a single source for these mineral and material supplies. By then, the sole U.S. rare-earth mining project at Mountain Pass had become dormant.⁴⁰ The subsequent decade saw limited progress in reducing dependency. For example, Molycorp reopened its Mountain Pass mine in 2012, but in the face of price declines due to the ample Chinese supply of many of the rare-

earth elements, its operation became economically unsustainable, resulting in bankruptcy in 2015.⁴¹ While Mountain Pass has resumed operation under its new owner, MP Materials, all the rare-earth concentrates from the Mountain Pass are currently exported for separation and processing, as the United States lacks the domestic capability to separate rare-earth concentrates into rare-earth ores and process them into rare-earth metals at a commercial scale.⁴² From 2015 to 2018, Chinese supplies accounted for 80 percent of U.S. imports of rare-earth compounds and metals; additionally, U.S. imports from other countries are largely derived from Chinese rare-earth inputs.⁴³

A decade after China's rare-earth embargo, however, U.S. momentum to address critical minerals supply chain challenges is on the rise. Recent industry undertakings to reactivate domestic supply chains include attempts by MP Materials and Lynas to establish processing capabilities for light rare-earth elements in California and Texas, respectively, both of which are recipients of a Defense Production Act Title III technology investment agreement.⁴⁴ Several separation and processing projects are also under development, including in Bokan Mountain in Alaska and Wheat Ridge, Colorado.⁴⁵

There also are domestic developments further along the clean energy technology value chain. For example, Nevada has become home to Tesla's Gigafactory battery plant, soon to be followed by another Tesla battery factory in Texas.⁴⁶ More plants to manufacture batteries for EVs are planned for Georgia, New York, North Carolina, and Ohio.⁴⁷

U.S. IDENTIFICATION OF CRITICAL MINERALS

The U.S. Geological Survey has decades of expertise in tracking domestic mineral resource assessments, but the first mineral supply chains assessment work specific to clean energy applications was issued by the Department of Energy (DOE) in 2010. The DOE's 2010 and 2011 *Critical Materials Strategy* reports provided the findings from their criticality assessment on rare earths and other elements needed for various energy applications, including the identification of critical minerals—14 minerals in the 2010 report and 16 minerals in the 2011 report.

Under Executive Order (EO) 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," issued in 2017, critical minerals are currently defined as:

- (i) a non-fuel mineral or mineral material essential to the economic and national security of the United States, (ii) the supply chains of which is vulnerable to disruption, and (iii) that 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.

Per this definition, in May 2018, the U.S. government released a list of 33 minerals and two mineral groups—platinum group metals and rare-earth elements—that are deemed critical and warned that of the 35 entries, the United States relied on import for more than half of the annual consumption of 31. Moreover, the United States lacks any domestic production (and thus is completely import-reliant) for 14 of them.

U.S. Strategy and Responses

The availability of minerals has been an important issue for U.S. policymakers for decades, but until the turn of the twenty-first century, it was mainly in the context of their value for defense applications. This has rapidly changed in recent years. The supply of critical minerals has emerged as a major economic security issue, which in turn has become a national security concern. This shift emanated from a combination of growing U.S. import dependence and the market-distorting effects of Chinese mineral export practices in the late-2000s.

2010 was a pivotal year for U.S. policymakers. In March, the Obama administration's White House Office of Science and Technology Policy (OSTP) began convening the Interagency Working Group on Critical and Strategic Minerals Supply Chains to promote supply diversification, mitigate the long-term risks associated with a dependence on critical minerals, establish federal R&D priorities, promote environmentally sustainable mining, and prepare a next-generation workforce.⁴⁸ Also in 2010, the National Science and Technology Council's Committee on Environment, Natural Resources, and Sustainability chartered the Subcommittee on Critical and Strategic Mineral Supply Chains to develop advice and provide assistance on policies, plans, and procedures for mitigating mineral risks.⁴⁹

In December 2010, shortly after the Chinese embargo of rare-earth element exports to Japan in October 2010, the DOE issued its first-ever strategic document focused on the role of critical minerals and materials in the clean energy economy, *Critical Materials Strategy*. The 2010 strategy pointed to the potential growth in global consumption of critical materials commensurate with the expansion of clean energy technology deployment in the future and stressed the importance of global supply chain diversification, substitute materials development, and greater research into the recycling and reuse of materials.⁵⁰ In addition to material supply and demand projection, the DOE undertook a review of the supply chains for four components in clean energy technologies and presented areas for action by U.S. federal agencies, including but not limited to those under DOE jurisdiction (e.g., research and development). This inaugural work was quickly followed by the 2011 *Critical Materials Strategy*, with updates in areas such as criticality assessments and market and technology analyses.

Moreover, the DOE's 2015 *Quadrennial Technology Review*, which examined the status of energy-related science and technology with medium-term commercialization potential, included a critical material technology assessment that reported on key trends affecting material criticality for clean energy components, such as permanent magnets for wind turbines and EVs. The DOE also outlined its R&D goals and pathways for advancing its critical material technology work.⁵¹

The major U.S. government effort to assess the national security of critical minerals supply chains under the Trump administration began with EO 13817, issued in December 2017. The document's key concern was the United States' heavy import reliance for critical minerals, and it focused on various current technological, technical, regulatory, and legal limitations to the increase of domestic mineral production. In response to EO 13817, the National Science and Technology Council's Subcommittee on Critical Minerals prepared *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals* (hereafter referred to as the *Federal Strategy*), which was then released by the U.S. Department of Commerce in June 2019. The strategy presented "6 Calls to Action, 24 goals, and 61 recommendations" in pursuit of the following objectives⁵²:

. . . improve the ability of the advanced technology, industrial, and defense manufacturing sectors that use critical minerals to adapt to emerging mineral criticality issues; reduce risks for American businesses that rely on critical minerals; create a favorable U.S. business climate for production facilities at different stages of critical mineral supply chains; and support the economic security and national defense of the United States; all of which will reduce the Nation’s vulnerability to critical mineral supply disruptions.

The types of issues covered under the “6 Calls to Action” were wide-ranging and included research, development, and deployment (RD&D); supply chains and the manufacturing base; international trade and cooperation; domestic resource assessment and upstream regulation; and workforce availability and capacity. The strategy largely reflected the Trump administration’s general view that economic security was national security, although it also underscored the benefit of international cooperation. Analogous to the strong energy interdependence among North American economies, the United States has close trading relationships with Canada and Mexico in critical minerals. For example, the strategy noted that “Canada and Mexico supply all or part of U.S. consumption for many critical minerals.”⁵³ It also called for establishing policy consultation as well as R&D cooperation with like-minded economies—such as Canada, Australia, the European Union, and Japan. Interestingly, one of most notable multilateral endeavors under the Trump administration relative to critical minerals supply chains was the Energy Resource Governance Initiative (ERGI), even though the *Federal Strategy* did not specifically mention resource governance challenges. Launched in June 2019, the ERGI shed light on the key linkages between demand for critical minerals, growth of renewable power generation and battery technologies, and resource management and sector governance capacity-building in resource-rich countries around the world.⁵⁴ Its membership has expanded to include Australia and the Philippines in the Asia-Pacific; Argentina, Brazil, and Peru in Central and South America; and Botswana, the DRC, Namibia, and Zambia in Africa.⁵⁵

Meanwhile, the *Federal Strategy* itself was notably silent on the growing global attention on these minerals and their contribution to energy transition. Given that climate mitigation is likely the most significant and dynamic demand multiplier for clean energy technology component minerals, the role of critical minerals in the ongoing energy transition merited a much clearer recognition. However, the introductory section merely noted that the minerals are used in “electricity generation, storage and transmission systems.”⁵⁶ In contrast, both “national security” and “national defense” appeared over a dozen times throughout the *Federal Strategy*, underscoring its prominence as a consideration in the U.S. government assessment of its supply chain’s vulnerability and response formulation.

Also, per EO 13817, the DOE issued “Critical Minerals Rare Earths Supply Chain: A Situational White Paper” in April 2020. This placed a primary focus on the status of industry along the upstream and midstream of the supply chains and underscored the alignment between the focus of EO 13817 and ongoing DOE activities to diversify supply of critical materials (e.g., increasing domestic production, separations, and processing). Additionally, the white paper also offered suggestions on how the U.S. effort to diversify supply could be augmented.⁵⁷

The 2017 executive order was followed by EO 13953 in September 2020, “Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries.” This executive order adopted a starkly sharper tone on the role of China in the global supply chains for critical minerals. For example, the 2017

executive order did not once mention China, and the resultant *Federal Strategy* referenced China only under 1 of its 24 goals (alluding to its 2010 rare-earth export embargo as an example of the risk of heavy dependence on China).⁵⁸ In contrast, under EO 13953, President Trump declared a “national emergency” to deal with the threat to the U.S. economy and national security emanating from the country’s dependency on China for these minerals. The order suggested the use of tariffs or quotas as potential remedies and directed agencies to examine potential authorities and prepare agency-specific plans to improve the supply chains.⁵⁹

In response to the 2020 executive order, the DOE released *Critical Minerals and Materials* in January 2021.⁶⁰ The document complemented the white paper from a year earlier by providing greater information on the DOE’s ongoing R&D work in the areas of diversifying supply chains, developing critical mineral substitutes, and improving reuse and recycling. For example, the DOE has made key investments in efforts to produce rare-earth elements from sources such as coal and coal byproducts and in developing new magnet alloys and new phosphor materials to reduce rare-earth elements requirements. In the area of reuse and recycling, DOE efforts have advanced the disassembly and recovery of rare-earth magnets from hard disk drives, for example.⁶¹ In laying out their R&D objectives under detailed categories of goals, the DOE underscored how the R&D ecosystem can contribute to solving a host of challenges. National laboratories working on the critical minerals supply chains include the National Energy Technology Laboratory, the Critical Materials Institute (led by Ames Laboratory), and the ReCell Lithium Battery Recycling R&D Center at Argonne National Laboratory. Also, the Advanced Research Projects Agency-Energy (ARPA-E) has awarded projects related to improving the recovery of critical minerals to advance the reuse and recycle objective.⁶²

The inauguration of the Biden administration likely ushers in a unique alignment of policy priorities and considerations that could yield a more comprehensive strategy on critical minerals supply chains for the United States. First and foremost, climate change mitigation is the top administration priority. The Biden administration seeks to deliver on its mid-century carbon neutrality commitment through the accelerated deployment of clean energy technologies across industries, for example by ridding the power sector of carbon sources by 2035 and by massively electrifying the transportation sector. A month after the inauguration, the Biden administration issued EO 14017, “Executive Order on America’s Supply Chains” and called for an immediate review of vulnerabilities in the supply chains for critical minerals and high-capacity batteries, including electric vehicle batteries.⁶³ Identifying climate mitigation as a key driver for clean energy technology deployment, the administration underscored the linkage between the supply chain security and the U.S. ability to accelerate its leadership of clean energy technologies.⁶⁴

The administration may also roll out measures to hold China accountable for its practices relative to minerals and materials that put U.S. companies at a disadvantage, as outlined in the Biden campaign plan to “rebuild U.S. supply chains and ensure the U.S. does not face future shortages of critical equipment,” in which key raw materials are noted.⁶⁵ This could be one of more immediate steps available to the administration, as other measures to strengthen the supply chains—such as upstream project developments and R&D endeavors—are more incremental in nature. The efficacy of pursuing a trade case, for example, would need to be weighed carefully against the risk of politically-motivated supply disruptions and their effects on U.S. supply chains when a pool of alternative suppliers—as well as the availability of substitutes—remains limited for some of the critical minerals.

Additionally, Secretary of Energy Jennifer Granholm remarked at her confirmation hearing in January 2021 that she “enthusiastically” supports the DOE’s role in critical minerals “for both jobs and energy security and supply chain security in the United States.” Her view clearly comports with the administration’s commitment to create jobs, as exemplified by the issuance of EO 14005, “Ensuring the Future is Made in All of America by All of America’s Workers.”⁶⁶ However, what is less clear is how and whether the effort to rebuild the manufacturing base for clean energy technology components will translate into revitalizing upstream job opportunities, especially because the same political force behind the deployment of clean energy technologies has generally been adverse to the extraction of hydrocarbon resources in the past.

European Union

Status of EU Supply Chains

The European Union consists of a variety of economies in terms of their resource endowments and industrial structures. Some of the EU member economies are mineral producers and suppliers. For example, Germany accounts for 8 percent of the global production of gallium (used in PV thin films), Finland accounts for 10 percent of the global production of germanium (used in multi-junction solar cells), Spain accounts for 31 percent of the global production of strontium (used in anode for solid oxide fuel cells), and France accounts for 49 percent of the global production of hafnium (used in super-alloys for space applications).⁶⁷ EU members also include major manufacturers of solar PV components, wind turbines, and EVs, such as Germany, Denmark, France, Italy, Spain, and Switzerland. In fact, Germany is home to some of the world's leading manufacturers of these clean energy components.

Europe's focus has traditionally been on the refining and manufacturing industries rather than the extractive industry.⁶⁸ A combination of limited understanding of resource availability within the European Union and economic and societal hurdles seems to have hampered upstream development, leading to the relative absence of the European Union from the upstream portion of global supply chains for many minerals.⁶⁹ This is clearly the case for the critical minerals supply for wind turbine technology and EV batteries. The European Union produces no more than 1 percent of the minerals that are needed for wind turbine technology (rare earths among them) or lithium-ion battery technology (e.g., cobalt, natural graphite, and lithium).⁷⁰ EU capacity is also limited in the processing phase for component minerals for wind turbines, PV cells and modules, and batteries, making up about 10 percent of the global supply for wind turbines and batteries and about 5 percent for PV cells and modules.⁷¹ EU manufacturing capacity for components for the three clean energy technologies is more

variable. While the European Union accounts for about 20 percent and 10 percent of the global total in wind turbine and battery component manufacturing, respectively, EU capacity is effectively absent in the PV component manufacturing phase.⁷²

EU IDENTIFICATION OF CRITICAL MINERALS

Since 2011, the European Commission has been issuing a list of critical and raw minerals every three years; the latest update was released in September 2020. The list expanded from 14 entries in 2011 to 20 in 2014, 27 in 2017, and 30 in 2020. The 30 entries consist of 27 minerals and three mineral groups: heavy and light rare-earth elements (counted separately) and platinum group metals.

The commission assessed 83 individual raw materials before finalizing the 2020 list, which was included in the *Critical Raw Materials Resilience*. The assessment work was led by the Ad hoc Working Group on Defining Critical Raw Materials, a sub-group of the Raw Materials Supply Group, which in turn is an expert group of the European Commission.

EU Strategy and Responses

The security of critical minerals supply chains formally became an EU agenda item in the late-2000s with the launch of the Raw Materials Initiative in 2008. The main aim of the Raw Materials Initiative was to ensure fair and sustainable supply of minerals and materials from global markets and to encourage efficient resource supply through recycling. The initiative emanated from growing recognition by EU member governments that the lack of an integrated policy response to market-distorting practices would limit the European Union's ability to secure raw materials at "fair and undistorted prices."⁷³ The European Commission argued that distortion of international trade in raw minerals and materials is arising from the industrial strategies of emerging economies—such as China, Russia, India, and South Africa—that aim to protect their resource base in order to generate advantages for their downstream industries.⁷⁴ Also notable in the Raw Materials Initiative was its clear recognition that minerals, such as rare earths and cobalt, are important for Europe's shift toward developing innovative "environmental-friendly [sic]" technologies and products.⁷⁵ In 2012, the commission established the European Innovation Partnership on Raw Materials to carry out the Raw Materials Initiative.

A decade later, the European Union sees secure and sustainable supply of critical minerals as an ongoing challenge which has risen in strategic importance as the European Union strives to deliver on the two inter-linked agendas of meeting its climate neutrality goal and preserving industrial competitiveness. Pursuing the robust deployment of clean energy technologies could exacerbate the current level of import-dependence for critical minerals and materials if the supply security issue is left unaddressed. This potential trade-off has become a disquieting issue for the European Union, which is already concerned that global competition for these resources has become fierce. *Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability*, issued in September 2020, is the European Union's most recent strategic document focusing on the supply security of critical minerals. Prepared by the Directorate-General for Internal Market, Industry, Entrepreneurship and Small-Medium Enterprises, *Critical Raw Materials Resilience* included a list of critical minerals and an action plan to increase the resilience of critical minerals supply chains for the European Union, with the following four aims⁷⁶:

- Develop resilient value chains for EU industrial ecosystems;
- Reduce dependency on primary critical raw materials through circular use of resources, sustainable products, and innovation;
- Strengthen the sustainable and responsible domestic sourcing and processing of raw materials in the European Union; and
- Diversify supply with sustainable and responsible sourcing from third countries, strengthening rules-based open trade in raw materials and removing distortions to international trade.

In clear recognition that the demand for clean energy technologies is the leading factor affecting its critical minerals demand and industrial competitiveness, the European Commission also released the *Critical Raw Materials for Strategic Technologies and Sectors in the EU – A Foresight Study* to accompany the *Resilience* document. The report not only provided the outlook for demand in minerals and materials in 2030 and 2050 but also detailed the risk analysis for the critical minerals supply chains per technologies and sectors that have strategic importance to the European Union. Among its 2050 outlook highlights are a 60-fold growth in lithium demand, a 15-fold growth in cobalt demand, and a 10-fold growth in demand for the rare earths used in permanent magnets.⁷⁷

Immediately following the release of *Critical Raw Materials Resilience*, in September 2020, the European Raw Materials Alliance was launched to identify barriers, opportunities, and investment cases to build capacity at all stages of the critical minerals value chain.⁷⁸ The establishment of this alliance was the first of 10 actions presented in *Critical Raw Materials Resilience*. The alliance will complement the ongoing EU work on the battery value chain being pursued through the European Battery Alliance, an initiative that was established by the European Commission in 2017 and supported by the European Investment Bank.

The EU strategy on the security of critical minerals supply chains has evolved to reflect emerging global challenges. First and foremost is climate change. The 2008 strategic document noted the linkage between the supply of critical minerals and the European Union’s drive to develop and innovate environmental-friendly technologies. In the 2020 version, climate change is a prominent focus, both as a key reason for the anticipated expansion of clean energy technology deployment (thus necessitating a secure supply of critical minerals) and as an issue on which the European Union seeks to become a global champion. Positioning itself to seize the economic and industrial opportunities that may arise from the required efforts of mitigating climate change effects, the mineral resilience strategy synergizes well with the European Union’s 2019 Green Deal. The sustainable use of natural resources, such as minerals for clean energy technologies, comports to one of the two key objectives of the Green Deal: to promote the efficient use of resources by moving to a circular economy.⁷⁹ For example, in order to underpin the sustainability and circularity of battery consumption, the European Commission decided in November 2020 to modernize EU legislation on batteries to facilitate their collection, repurposing, and recycling.⁸⁰

The shift in the global economic landscape—from one based on the neo-liberal notion of shared prosperity through greater integration of supply chains and trade to one that is more fragmented and inward-looking—is another key challenge that is shaping the European Union’s response to its critical minerals supply chain security. At the launch of the European Raw Materials Alliance, for example, Germany’s minister for economic affairs and energy noted the “growing international protectionism” on raw materials and remarked on the importance of supporting EU companies and stakeholders along the supply chain.⁸¹ This shift is the backdrop for both growing concern among policymakers over

minerals supply availability and the interest in greater intra-EU solutions to leverage complementarity among member economies with different supply chain capacities. Both the *Critical Raw Materials Resilience* and *A New Industrial Strategy for Europe*, another communication by the European Commission, released in March 2020, feature the notion of “strategic autonomy.”⁸² The term is nothing new in European politics, particularly on the issue of transatlantic diplomacy.⁸³ However, the concept has recently expanded to clearly include the notion of “reducing dependence on others for things [the European Union] need[s] the most,” such as critical minerals.⁸⁴ As the European Union seeks to enhance its upstream capacity and that of nearby countries, some new mining projects are under development, such as a lithium mining project in the Czech Republic and a lithium-borate project in Serbia.⁸⁵ Also, interest in nurturing its battery industry seems to be driving the European Union’s plan to roll out strict environmental and labor requirements for batteries, as this could protect the EU battery market from cheaper Asian imports.⁸⁶

There is one particular difference between the U.S. and EU strategic responses to the critical minerals supply chains challenge: China. In *Critical Raw Materials Resilience*, the European Commission articulates its concern that the European Union’s growing critical mineral demand may essentially mean replacing its existing import dependence for fossil fuels with the future import dependence for raw minerals and materials. However, unlike the U.S. response that has become increasingly antagonistic to China, the European Commission refrains from naming China as its chief competitor for critical mineral supplies and clean energy technology manufacturing. Nor does the European Union call out Chinese behavior as the primary cause for concern in the sound working of global supply chains. This difference in tone may reflect not only the intensifying geopolitical rivalry between the United States and China but also the strategic calculus for the European Union to preserve amicable economic ties with China. This is partly to hedge against the relative decline in U.S. geoeconomic influence and partly to not preempt the prospect for stronger and more balanced economic ties with China, as exemplified by multiyear efforts to conclude the EU-China Comprehensive Agreement on Investment.

The third major global challenge is the Covid-19 economic crisis. In fact, the European Commission specifically noted in *Critical Raw Materials Resilience* that the Covid-19 pandemic revealed “how fast and how deeply global supply chains can be disrupted.”⁸⁷ The EU economic recovery plan, issued in May 2020, identified critical minerals and materials as one of the areas where Europe needs to be more resilient in preparation for future shocks.⁸⁸ The pandemic-induced sense of vulnerability appears to have amplified the European Union’s interest in enhancing its “strategic autonomy” by increasing supply capacity within the European Union.⁸⁹ The EU Covid-19 recovery plan is thus seen as an enabler of enhanced resilience, as it relates to the critical minerals supply chains.

The European Union may rely more heavily on financing and trade rules to advance its interests in the global competition over green mineral supply chains. For example, the European Investment Bank (EIB) has recently adopted a new energy lending policy that would enable the bank to support projects related to the supply of critical raw materials needed for low-carbon technologies in the European Union. The European Union looks to the EIB to help de-risk such projects and attract more private investment, both within the European Union and in resource-rich third countries.⁹⁰ Additionally, viewing the integrated value chains as a “fundamental growth engine” and key for economic recovery, the European Commission’s communication on pandemic economic recovery has suggested a “trade policy review” to ensure the uninterrupted global flow of goods and services.⁹¹

Japan

Status of Japan's Supply Chains

Japan is a manufacturing economy that is significantly import-dependent for natural resources, including critical minerals. While a sizable indium mine used to exist in the northern island of Hokkaido, the mine ceased operation in 2006, making Japan entirely dependent on imports for indium supplies.⁹² Japan's presence is severely lacking in the upstream, but it does have a substantial rare-earth processing and manufacturing industry. For example, Japanese companies account for around 15 percent of annual global magnet production.⁹³ Specifically for the global market for high-performance NdFeB permanent magnets, three Japanese corporations—Hitachi Metals, Shin-Etsu Chemical, and TDK—had a 48 percent share as of the mid-2010s.⁹⁴ The Japanese capacity in the magnet industry stems from early inventions in the process and the acquisition of attendant intellectual property rights. Consequently, major manufacturers of sintered NdFeB magnets, including China and Germany, currently license the right to manufacture and sell these batteries from Hitachi.⁹⁵

JAPAN'S IDENTIFICATION OF CRITICAL MINERALS

Japan's first list of critical minerals was prepared by the Advisory Committee on Mining Industry in 1984, under the direction of the Ministry of International Trade and Industry (the predecessor of the current METI). The list appears to have stayed constant in the subsequent decades. For example, the same set of minerals appears in the 2014 METI document, where the minerals are considered critical and thus merit policy focus and financial support to address their supply chain security.

The list has been updated since 2014 to now include 32 critical minerals and two mineral groups—platinum group metals and rare-earth elements. Some minerals, such as palladium, have been removed, while others, such as fluorine and silicon metals, have been added since 2014.

Japan's Strategy and Responses

Viewing its economic security as almost synonymous to its national security, the Japanese government has long approached the security of critical minerals and materials supply chains as a top priority. Given the absence of domestic upstream capacity, Japan pursued securing its critical minerals supply chains through trade, investment in mining projects overseas, stockpiling, and R&D in substitutes and recycling technologies. The Ministry of Economy, Trade and Industry (METI) leads the policy work, while Japan Oil, Gas and Metals National Corporation (JOGMEC) is the key implementing actor. JOGMEC is affiliated with METI and has the statutory authority to make strategic investments abroad to enhance Japan's energy security.

As early as the mid-1980s, Japan was concerned with the supply shortages that may arise from the slow pace of upstream development around the world and the anticipated demand growth for the minerals required for high-tech goods. As a result, in 1983, the Japanese government began stockpiling seven minerals—including tungsten, cobalt, and vanadium, three of the minerals that are commonly identified as critical by the United States, the European Union, and Japan today.⁹⁶ However, determining that stockpiling is insufficient to mitigate longer-term risks to its critical minerals supply chains, the Japanese government also began to increase its focus on technology R&D.⁹⁷

Japanese policymakers have taken a more strategic approach to the security of critical minerals supply chains since the early-2000s. In July 2007, METI issued *Measures to Secure the Stable Supply of Rare Metals Going Forward*.⁹⁸ This underscored the importance of “resource diplomacy” to enhance access to overseas mining projects, in addition to the existing focus on mineral reuse, R&D on substitutes, and stockpiling.⁹⁹ In particular, the Japanese government decided in 2008 to augment its resource diplomacy capability through the use of foreign aid, public finance, and trade insurance.¹⁰⁰ In anticipation of future supply disruptions, Japan further introduced *Strategies to Secure Rare Metals* in 2009, where it clarified both its policy tools and focus areas around four key pillars: securing resources overseas, recycling, substitute development, and stockpiling.¹⁰¹ To date, overseas rare-earth development projects Japan initiated or entered into partnerships with a host country for include the Mount Weld project in Australia, the Don Pao project in Vietnam, and the Indian Rare Earth project in India, as well as the partnership with Lynas of Australia on a separation and purification plant in Malaysia.¹⁰²

For Japanese policymaking on critical minerals supply chains, 2010 was a pivotal year. In the aftermath of the Chinese embargo on rare-earth exports to Japan in the fall, the Japanese government grew alarmed with the potential exodus of Japanese midstream capacities to China, as

the Chinese government had introduced a 25 percent export tax and 17 percent value-added tax; there was no such tax obligations if the foreign company manufactured inside China using local rare earths and then exported.¹⁰³ In response, the Japanese government introduced measures, including 39 billion Japanese Yen package (\$3.9 billion when \$1=JPY100) to help Japanese firms cover the cost of building various capacities within Japan to mitigate the effects of material shortfalls.¹⁰⁴ The effectiveness of this particular measure may be mixed or muted, however, as several Japanese companies nonetheless moved permanent magnet manufacturing factories to China between 2014 and 2018.¹⁰⁵

Also, in the early-2010s, having become particularly sensitive to the sense of equity among resource-rich countries and the attendant rise in resource nationalism, Japan expanded its resource strategy to include a focus on contributing to the economic development of a resource-rich country by considering the provision of technical expertise in areas such as resource surveying, local irrigation systems, and human resource development.¹⁰⁶

In the area of R&D, one of Japan's key focuses has been on developing a production process that reduces the use of critical minerals. Products and components resulting from Japan's R&D efforts to reduce the use of rare earths include abrasives and certain types of magnets.¹⁰⁷ R&D on material reduction and substitutes has also been among the most active areas of Japan's cooperation with the United States. Additionally, submarine deposits of critical minerals in Japan's territorial waters have become a recent focus of Japan's R&D endeavors. Between 2013 and 2017, six deposits were discovered off the southern island of Okinawa. Critical mineral deposits, including those containing cobalt and nickel, are under resource survey and various technical evaluations to ascertain their commercial feasibility.¹⁰⁸

A combination of Japanese strategies to seek non-Chinese upstream capacity, reuse materials, and develop substitutes has resulted in the reduction of Japanese reliance on Chinese rare-earth supplies from 85 percent in 2009 to 58 percent in 2018.¹⁰⁹ Japan's official target by 2025 is to reduce its rare-earth import reliance on a single supplier country below 50 percent, as well as to increase its self-sufficiency in meeting cobalt demand to 50 percent.¹¹⁰

In March 2020, Japan released its latest perspective on how to secure its supply chains for critical minerals and materials as part of the *New International Resource Strategy*. The strategy underscored the growing importance of critical minerals for EVs and renewable power generation equipment in the context of the carbon emissions mitigation effort. In formulating the strategy, policymakers took into account rising resource competition with the United States, Europe, China, and various emerging economies.¹¹¹ Under this strategy, the Japanese government called for better aligning mineral-specific criticality profiles and policy tools, reviewing the stockpile system, promoting international collaboration on research, and focusing on innovation related to mineral recycling, among other goals.¹¹²

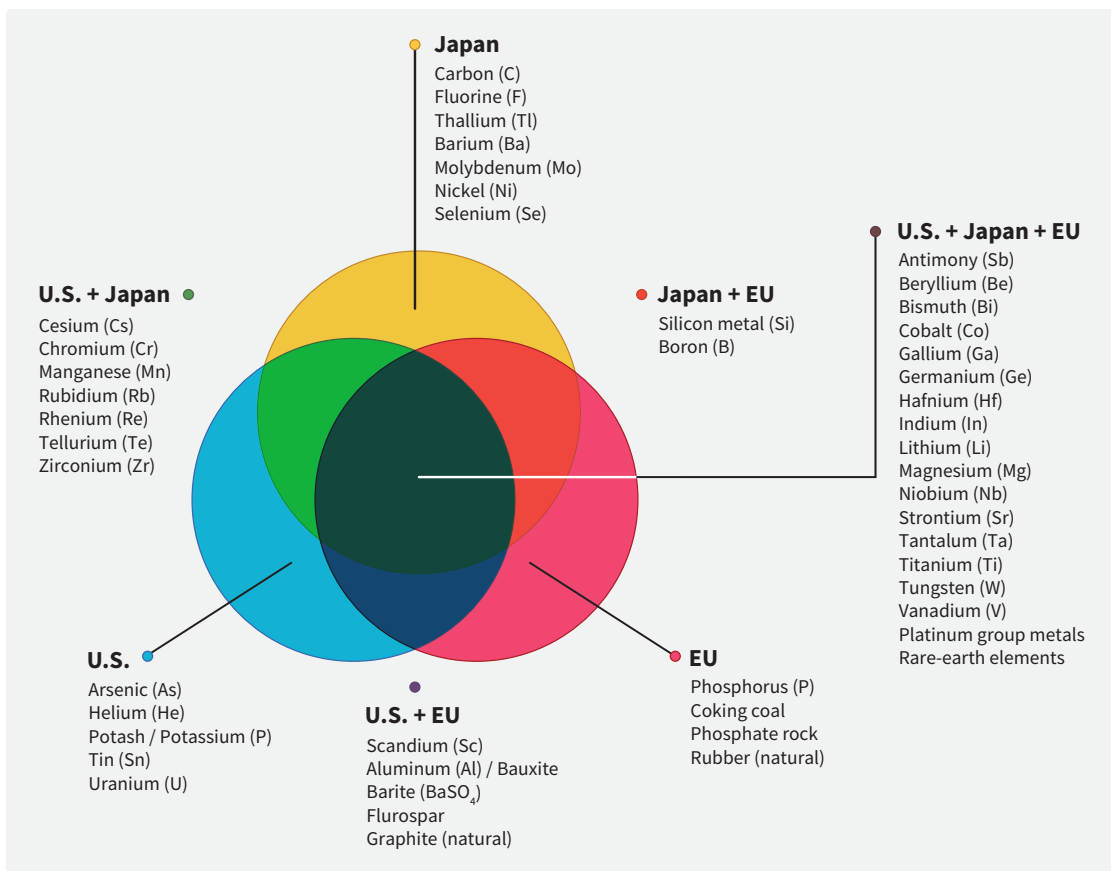
Per the *New International Resource Strategy*, Japan's national parliament passed legislation in June 2020 to amend and expand the scope of JOGMEC's financial functions in aiding Japanese businesses' involvement in upstream projects abroad. Prior to the amendment, JOGMEC's equity activities were limited to exploration, acquisition of existing development and production assets, and investment in refining activities tied to mining. The amendment expanded JOGMEC's scope to include the ability to continue financing a project that progressed from the exploration phase to the development and production phase.¹¹³

Moreover, the Japanese stockpile will expand beyond the original seven minerals and increase the reserve level from 60 days of domestic consumption equivalent to as much as 180 days for some of them.¹¹⁴ This would signify major modernization of Japan’s rare metal stockpiling policy; what goes into the strategic reserve (seven minerals) at what reserve level (60-day domestic consumption equivalent) had remained the same since the stockpile system was established in the mid-1980s.¹¹⁵

While the centrality of industrial competitiveness has served as the core driver of Japan’s approach to strengthening the security of its critical minerals supply chains, its recent priority-setting has been attuned to major global developments, such as the Covid-19 pandemic. In particular, the disruption in supply chains for key electronic and automobile components from Asia during the pandemic heightened Japan’s sense of vulnerability. Seeking to enhance the resilience of Japan’s supply chains, the Japanese government passed several budgets in JFY2020 (April 2020–March 2021), totaling \$5.45 billion (when US\$1 = JPY100), to aid Japanese manufacturers of goods “whose production is highly concentrated in select countries overseas and the disruptions in whose supply chains could deal significant damage to the economy,” such as critical minerals. This aid aims to reshore manufacturing capacity or to relocate it to elsewhere with a lower risk of supply disruptions.¹¹⁶

Minerals Identified as “Critical”

United States, Japan, and the European Union



Source: Created by Ian Barlow based on Department of the Interior, “Final List of Critical Minerals 2018,” Federal Register 83, No. 97 (May 18, 2018): 23295-6, <https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018>; European Commission, Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability (Brussels: European Commission, September 3, 2020); Ministry of Economy, Trade and Industry, Issues for Consideration in Formulating A New International Resource Strategy [author’s translation] (Tokyo: Government of Japan, October 4, 2019).

Conclusion

Key economies with innovation and manufacturing bases that are import-dependent for critical minerals face emerging geoeconomic competition over the supply chains of critical minerals. Clean energy technologies play an important role in mitigating the worst effects of the global climate crisis, and as such, demand is expected to grow for clean energy technologies and for their component critical minerals. These forces, combined with the geopolitical uncertainty stemming from China's ascent and the fragility in global supply chains as illuminated by the Covid-19 pandemic, enhance the strategic importance of strengthening supply chains for critical minerals and materials. Successfully securing supply chains has implications beyond access to these minerals—it affects one's ability to preserve or enhance competitiveness in advanced technology manufacturing, such as EVs.

Greater recognition of the issue on the heels of the 2010 Chinese rare-earth export embargo and the WTO victory in 2014 has not appeared to materially improve current import-dependence for critical minerals by key economies such as the United States and the European Union. However, there are indications that progress is being made. For example, the U.S. strategy is beginning to show promise, with the launch of several domestic separation/processing and component manufacturing projects. The EU effort is gaining momentum in the area of reuse and recycle, while intra-EU upstream development may leverage additional resources from the post-Covid economic recovery plan. Meanwhile, Japan's focused approach on partnering with resource-rich countries for mineral supplies and on advancing the development of reduce, reuse, and recycle technologies has effectively reduced its dependence on Chinese rare earths, although the country remains import-dependent for critical mineral supplies.

Different economies are motivated by different concerns that reflect their resource endowment profiles and industrial structures. The United States appears most concerned with securing uninterrupted access to critical minerals-based components for defense applications, as well as reducing substantial import dependence on a single supplier that could be exploited geopolitically. Meanwhile, the European Union and Japan appear primarily concerned with securing uninterrupted access to affordably-priced critical minerals and processed materials to protect their industrial competitiveness and domestic manufacturers. While likely inevitable, this lack of a common definition of “security” as it relates to critical minerals supply chains may be one barrier to effective multilateral partnerships on this matter.

The experiences of key economies suggest that the availability of domestic mineral supplies is hardly the sole indispensable factor in one’s ability to have secure supply chains. For instance, the lack of domestic capacity to separate and process rare-earth concentrates has limited the United States from fully capitalizing on its rare-earth mineral supplies at Mountain Pass. Moreover, Chinese experience with the DRC shows that one need not hold major domestic cobalt deposits to become dominant in subsequent midstream and downstream phases along the value chain.

The potential contribution of domestic upstream capacity presents an interesting question in the context of the United States and Europe. In both economies, the environmental and climate-mitigation movement has favored renewable power sources and clean energy technologies, sometimes at the exclusion of lower-carbon fossil fuels, such as natural gas. The use of hydrocarbon resources has come under scrutiny in phases ranging from resource extraction, to domestic combustion, to export for use in a power or industrial sector abroad. Balancing concerns on import dependence with the public acceptance of domestic mineral production is a public policy issue that merits robust discussion.

Another important issue is the tension between national economic security concerns and commercial concerns. The former relates to issues such as energy import dependence and industrial competitiveness from a national perspective, while the latter relates to corporate interests in preserving market share and maximizing profits. Would a manufacturer procure domestically sourced minerals if they were much more expensive than foreign supplies, even in the name of national interest to develop more secure critical minerals supply chains?

The security of supply chains for the minerals and materials needed in clean energy technologies has become a strategic issue, not only because it could affect the pace of clean energy technology deployment but also because clean energy technology has become the latest frontier for geoeconomic rivalries. Competition over critical mineral supplies and the technical capacities to turn them into clean energy goods is increasing. Major economies are reexamining the security of their critical minerals supply chains and refining their strategies in order to enhance their security. While the U.S. approach is multipronged, reflective of its mineral wealth as well as its strong innovation base, EU and Japanese approaches favor innovation to drive the reduction, reuse, and recycling of materials. What exactly drives each economy’s strategy to enhance the security of critical minerals may differ, but their efforts warrant sustained political commitment, especially in the area of technology innovation. It was innovation and ingenuity—in the form of combined application of hydraulic fracturing and horizontal drilling for shale oil and gas extraction—that played a central role in turning the public concern over “peak oil” from one about finite supply to one about declining demand. Innovation has helped

to diminish oil's currency as a geopolitical asset and altered the geopolitics between oil-producing economies as well as their relationships with oil import-dependent economies. Will innovation play a similar role in altering the geopolitics of critical minerals supply chains? A race is on for innovation. It is a race that could make every economy a winner if the outcome significantly improves the security of supply chains for minerals and materials and facilitates the deployment of clean energy technologies that are essential in addressing the existential threat of climate change.

About the Author

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