ENERGY & ENVIRONMENT
aspen institute

A CRITICAL MINERALS POLICY FOR THE UNITED STATES

The Role of Congress in Scaling Domestic Supply and De-Risking Supply Chains

The Aspen Institute, Energy & Environment Program
Spring, 2023

Meghan L. O'Sullivan and Jason Bordoff
Co-Chairs

Drafted by Robert Johnston with Cina Vazir



The Aspen Institute's Energy & Environment Program convened a task force of experts over the last year and a half to focus on an immediate policy priority: securing a responsible and resilient critical mineral supply chain for the United States. This report is motivated by the roundtable discussions between task force members. It includes objectives, a strategic approach, findings, and recommendations for U.S. policy on critical minerals. The report is directed specifically toward the United States Congress. A full list of signatories can be found at the end of the document.

Table of Contents

This report was made possible with generous support from the ClearPath Foundation and The William and Flora Hewlett Foundation.

This report seeks to capture the essence of participant conversations, but individual participants may not agree with every aspect of the report. Rather, in affixing their name as a signatory, a participant is signaling support for the overarching concept of the series and the broad outcomes discussed herein.

Executive Summary

The United States currently faces a rapidly shifting global environment that increasingly places strategic importance on responsible and resilient access to critical minerals. These minerals—which are essential inputs to a wide range of applications ranging from clean energy technologies to advanced defense systems—will continue to increase in importance over the coming decades. Global competition over these resources due to the rapidly accelerating energy transition, fragmentation of international supply chains, and rising geopolitical tensions with adversaries is of key importance to the climate, economic, and national security interests of the United States in the 21st century.

There is an urgent need for policymakers to define a coordinated critical minerals strategy for the United States. A U.S. critical minerals strategy must set out to achieve two objectives. First, it must seek to responsibly increase domestic and global production and processing of critical minerals at the scale and timeline needed to limit global temperature increases. Second, it must aim to secure responsible and resilient critical mineral supply chains that minimize vulnerability to external risks.

These minerals–which are essential inputs to a wide range of applications ranging from clean energy technologies to advanced defense systems–will continue to increase in importance over the coming decades.

As Congress formulates a comprehensive U.S. critical minerals strategy, it should bear in mind key insights that emerged from a task force of experts convened by the Aspen Institute throughout 2022 and 2023. In particular, Congress should take note that:

1. There is a clear role for targeted policy intervention to address current and potential causes of failure in critical mineral markets.
2. Environmental and social issues are an essential component of the critical minerals puzzle. A failure to balance efforts to streamline supply with these considerations will not only result in harm and injustice to local communities, but will also jeopardize supply growth as projects are subject to legal challenges and mining companies lose their social license to operate.
3. The United States cannot solve the critical minerals challenge on its own. Regardless of the reforms taken, the United States will be unable to fully reach self-sufficiency for critical mineral mining and processing in the time frame available.
4. Policymakers should view with nuance the extent to which China's dominance of critical mineral processing currently represents a source of geopolitical leverage. While China is a major refiner of minerals like copper and nickel, its processing capacity provides it with more limited geopolitical leverage in those supply chains than is often perceived. China's dominance of rare earth elements, by contrast, provides it with a more pronounced degree of leverage. The influence that China derives must be assessed mineral by mineral, based on factors such as China's status as a net exporter, American diversity of imports, and the availability of substitutes.

Executive Summary

These insights are among those that have led the Task Force of the Aspen Institute to make a series of 11 recommendations to the U.S. Congress. Three clusters of recommendations are particularly of note:

First, Congress must take steps to help close what is anticipated to be a yawning gap between both domestic supply and demand. Most importantly, Congress must make it easier to extract and process critical minerals domestically by legislating a place-based approach to critical mineral permitting and by setting timelines on project adjudication. At the same time, Congress needs to encourage measures to reduce the demand for critical minerals, such as investing more in technology for substitutes and recycling.

Second, Congress needs to take a leadership role in clarifying and enforcing the rights of indigenous communities affected by mining. It should clarify and endorse the concept of Free, Prior, and Informed Consent and see that it is adhered to. The Task Force recommends clarifying that Free, Prior, and Informed Consent—in the sense of consent being a requirement for progress—applies to Tribal Nations directly impacted by critical mineral development; best efforts to achieve consent should also be sought from Tribal Nations which can only claim to be affected indirectly by such development. In both cases, consultations are essential. In addition, Congress should facilitate the ability of Tribal Nations to obtain equity in the form of an ownership stake in critical mineral projects.

The Task Force's recommendations—around permitting reform, Free Prior and Informed Consent, and Tribal Nation project equity—will help boost U.S. critical mineral supply in a manner that is economically, environmentally, and socially responsible and innovative. Even still, the United States will be unable to bring new projects online as quickly as is needed to meet future needs or completely eliminate dependence on China for refining and processing supply chains.

The Task Force therefore offers a third set of actions around sourcing critical minerals responsibly from overseas. Rather than embracing Buy America provisions, the Task Force recommends working with allies, partners, and others around the world to agree upon a common set of clearly defined environmental, social, and governance standards for the production and processing of critical minerals. Resource-rich countries are seeking investment in higher-value segments of the supply chain rather than upstream, extractive segments alone. The United States and other likeminded countries, including the EU, UK, Canada, Japan, and South Korea, among others, can increase and coordinate concessional finance to strategic producers across various stages of mineral value chains.

In addition, Congress should facilitate bilateral and multilateral frameworks that increase critical mineral supply chain coordination, as well as the negotiation and passage of bilateral and multilateral trade agreements among countries that meet mutually agreed upon standards. Such efforts should establish a framework to enhance cooperation with a broad range of countries around the world—including in South America, Africa, South Asia, and elsewhere—at the speed and scale necessary to secure U.S. economic and national security interests and buffer reliance on Chinese supply chains.

The dynamism of the global landscape and of critical mineral markets will require U.S. policymakers to continuously re-evaluate the challenges the country faces and the policy prescriptions that it requires. The content of this report, including the objectives, strategic approach, findings, and recommendations, lay out a principled, bipartisan roadmap for Congress to continue building on recent momentum and place the United States in a strong position to pursue the energy transition, build economic opportunity, and strengthen national security.

Recommendations for U.S. Congress

Develop the domestic foundation for more responsible and resilient supply chains

1 Permitting

Congress should streamline permitting by using a place-based approach and setting strict timelines on adjudication.

2 Free, Prior, and Informed Consent

Congress should clarify and endorse the concept of Free, Prior, and Informed Consent, making clear that it should be received from Tribal Nations directly impacted by critical minerals development.

3 Project Equity

Congress should endorse and further facilitate the ability of Tribal Nations to obtain equity in critical mineral projects.

4 Strategic Stockpile

Congress should continue to increase funding for the National Defense Stockpile, enabling it to effectively fulfill its mandate for defense and security.

5 Innovation

Congress should expand funding for R&D and undertake regulatory reform to promote substitution of alternatives, demand reduction, and recycling of critical minerals.

6 Workforce

Congress should implement a grant program for accredited mining programs in the United States and should earmark a certain proportion of funds for recruitment initiatives.

Maximize connections with strategic exporting and importing countries

7 Collaboration

Congress should resist reliance on Buy America provisions when crafting legislation related to critical minerals and seek to develop alternative international agreements to meet domestic needs.

8 Standards

Congress should work with federal agencies and international allies to establish clear standards for foreign mining projects that qualify for support.

9 Finance

Congress should increase funding for the Development Finance Corporation and provide it with an expanded authority, and priority, to invest in critical mineral projects abroad that meet—or can, with U.S. support, meet—approved standards.

10 Trade

Congress should facilitate bilateral and multilateral frameworks that increase coordination of critical mineral supply chains and support the negotiation and passage of bilateral and multilateral trade agreements among countries that meet approved standards.

11 Information

Congress should help establish and fund a structure to improve demand projections and increase price transparency.

Letters from the Co-Chairs

Professor Meghan L. O'Sullivan

Incoming Director, Belfer Center for Science and International Affairs

Jeane Kirkpatrick Professor of the Practice of International Affairs, Harvard University Kennedy School

Professor Jason Bordoff

Founding Director, Center on Global Energy Policy

Professor of Professional Practice, Columbia University School of International and Public Affairs

The global transition to clean energy is at a crossroads. Cost declines across a range of low-emissions technologies have driven a surge of clean energy growth in recent years. But the scale of deployment necessary to bring the global energy system to net zero will require even faster growth, placing new burdens upon supply chains.

The availability of critical minerals such as lithium, cobalt, copper, nickel, and others will be a key determining factor for whether it is possible to scale up clean energy at a pace commensurate with the climate crisis. Demand for these materials, which are needed to manufacture a range of clean energy technologies, is set to escalate dramatically as the energy transition gains momentum. Global supply chains are not yet ready to accommodate this surge of demand.

Policymakers have begun to wake up to this impending bottleneck. In the past year, the United States Government has announced strategic initiatives to shore up the country's supply of critical minerals, including announcing convening a Minerals Security Partnership and using the Defense Production Act to accelerate domestic mining and processing. Key provisions in the Energy Act of 2020, the Bipartisan Infrastructure Law (BIL), the CHIPS and Science Act, and the Inflation Reduction Act were also aimed at boosting domestic mining, refining, and processing capabilities. But as demand continues to grow, the United States still lacks a comprehensive critical minerals strategy.

Without a plan, the United States faces serious risks to its economy and national security, not to mention an accelerated clean energy transition. Chronic material shortages may inflame tensions with allies and adversaries abroad, as governments vie for dominance over supply chains. And high prices for such materials risk choking off the growth of American clean energy. A coherent strategy is needed to address these risks, and to do so in a way that advances equity, environmental conservation, and indigenous sovereignty.

This report seeks to fill that gap. In three separate sessions over the course of a year, policymakers, Indigenous leaders, investors, subject matter experts, civil society leaders, and industry leaders weighed in on the key considerations and policy actions they believed should be included in such a strategy. What follows are both the findings of the Task Force and the recommendations these discussions yielded.

We direct this report toward Congress intentionally because it has an important and yet unrealized role in advancing a critical mineral strategy for the United States. The recommendations in this report are focused on the most immediate area for action; they do not constitute every action that Congress, or even the U.S. government, should take in the coming years. Like other components of a national strategy to help the country meet the opportunities and challenges of the energy transition, these issues will demand continuous assessment and action in the years to come as many of the uncertainties described in this report clarify.

Nevertheless, we believe these recommendations are important components of a United States critical minerals policy. Happily, they are not simply our own ideas, but reflect the insights and wisdom of a large, diverse, and bipartisan groups of experts. They would, if adopted, contribute significantly to the growth of a robust, secure, resilient, and just supply chain, itself a vital ingredient of a successful energy transition.

We are grateful for the work of many people who were instrumental in bringing this report to fruition. We appreciate the time and expertise of all the members of the task force, who engaged constructively and were the source of the many ideas contained in this report. We are also immensely indebted to two people—R.J. Johnston and Cina Vazir—who wielded the pen, not only capturing conversations and accurately translating them into crisp language, but also bringing their own deep expertise to the issues at hand. Without R.J. and Cina, there would be no report. Lilly Lee and Dan Propp also provided invaluable research assistance. Finally, we owe our gratitude to Tim Mason, Francesca Reznik, Tanzia Redi and Greg Gershuny and the whole team at the Aspen Institute for conceptualizing this Task Force and providing it support throughout its existence.

Introduction

Critical minerals require urgent attention from policymakers. These minerals range from the lithium used in lithium-ion batteries to the rare earth elements used in advanced defense systems. They are required throughout the U.S. economy and are an essential foundation for American economic prosperity and national security. But critical mineral supply chains currently face exceptional challenges due to increasing demand and fragile supply. In 2022, the U.S. Government designated 50 minerals as "critical" based on their importance to U.S. economic and national security interests, and their vulnerability to supply chain disruption.[1]

Critical minerals will play an increasingly pivotal role in the global economy over the coming decades. As the world transitions to a new energy mix, it will require clean energy technologies that are extremely mineral-intensive. Demand for minerals is projected to rise at unprecedented rates and could generate supply shortfalls that will slow, or potentially even derail, global efforts to reach net-zero targets.[2] Despite this impending supply gap, efforts to scale supply must take into account environmental and social considerations, particularly given the mining industry's troubled historical performance on these issues.

The supply-demand dynamics of critical minerals are further complicated by the vulnerability of critical mineral supply chains. Supply chains are highly geographically concentrated, exposing American climate, economic, and national security interests to potentially traumatic disruptions. Vulnerabilities not only apply to disruptions in mine production, but also to the processing of critical minerals. Most global processing capacity is heavily concentrated in China, which has in the past shown strategic intent to wield its market power as a geopolitical and economic tool.

The Aspen Institute's Energy & Environment Program convened a task force of experts in 2022 to help policymakers address these challenges. This task force represented the wide range of domains and expertise needed to shape the success of U.S. critical minerals policy. Participants included the following:

- Former U.S. Congress members
- Investors
- National security and geopolitics experts
- International and multilateral organizations
- Environmental non-governmental organizations
- Academics and scientists
- Innovators and technologists
- The manufacturing industry
- The mining industry
- Indigenous and tribal leaders

Over the course of three days of roundtable sessions dispersed over the calendar year, these individuals focused on defining the critical minerals challenge, designing a strategic approach, and providing actionable recommendations to the U.S. Congress. Participants are in strong alignment that reaching our goals regarding critical minerals will require both domestic and foreign policy responses. Without action on both fronts, U.S. policy will fail to fully overcome the challenges and grasp the opportunities at hand.

Objectives

Based on the important role of critical minerals for climate, economic, and national security interests, and on the challenges facing these supply chains, Congress should focus on achieving two key objectives:

1. Responsibly increase domestic and global production and processing of critical minerals at the scale and timeline needed to limit global temperature increases (to 1.5°C above pre-industrial levels).
2. Secure responsible and resilient critical mineral supply chains that minimize vulnerability to external risks.

Achieving these two objectives will reduce the risks that the insufficient and fragile supply of critical minerals pose to U.S. climate, economic, and national security interests. But risk reduction is only one part of the picture. A bold, coordinated, and swift strategy to achieve these objectives can also develop new sources of American power, both at home and abroad.

Strategic Approach

The signatories of this report are in unanimous consensus that the U.S. Congress must pursue a bold, coordinated, and swift strategic approach toward critical minerals.

Over the last few decades, U.S. policy on critical minerals has generally suffered from insufficient urgency, reach, and harmonization. Meanwhile, competitors such as China have acted aggressively, leaving the United States in what is now a challenging and vulnerable position. Recent legislation such as the Inflation Reduction Act and the Infrastructure Investment and Jobs Act, while not perfect nor comprehensive, are now beginning to make a meaningful impact. But these pieces of legislation are only the first steps in a longer journey. More action is required.

U.S. strategy must be bold if it is to overcome the scale of the challenge, intense competition from China, and vital threats to American climate, economic, and national security interests. It must also be coordinated given the cross-cutting nature of critical minerals, which touch various arenas such as technology, environmental justice, indigenous reconciliation, energy, trade, and geopolitics. And U.S. strategy must be swift for America to gain an advantage in a quickly changing global supply and demand landscape, including in the manufacturing of the clean energy technologies that will dominate the next decades.

In addition to these principles, U.S. strategy must be grounded in the realization that critical minerals are both a domestic and foreign policy challenge.

Domestic initiative will certainly be essential, ranging from permitting reform to strong social and environmental standards. These initiatives can help the United States contribute to limiting global critical mineral shortfalls and reducing exposure to supply chain risks. However, critical minerals are also an international challenge. The United States will not achieve the scale of critical mineral supply needed to reach global 1.5°C goals on its own. Current projections show that more than 300 new mines will need to be built globally by 2035 to meet estimated mineral demand from electric vehicles alone.[3]

Demand growth provides the United States with an imperative to work simultaneously to increase domestic and international production. Work in these two arenas needs to occur together. The United States will not likely develop the ability to independently meet its own consumption of all critical minerals anytime soon. Experience in energy security shows that although commodity independence can be an alluring goal, it imposes hidden costs and inefficiencies, is often unrealistic, and forfeits geopolitical advantages. Domestic and foreign policy responses are not in tension but should be harmonized. And the U.S. should strive toward broader supply chain resilience, not independence.

Findings

1 Demand for critical minerals is forecast to surge over the next two decades as the world rapidly manufactures and deploys clean energy technologies.

Many clean energy technologies require substantial quantities of minerals. An electric vehicle, for example, requires six times more minerals than a conventional vehicle. Electric vehicles, alongside battery storage and electricity networks, are projected to be a major source of demand growth for various critical minerals, including cobalt, copper, lithium, and nickel. The development and deployment of other technologies, such as wind and solar, will significantly boost demand for minerals like rare earth elements and tellurium.

The forecast increases in demand from clean energy technologies, layered onto more stable existing demand trends, imply steep growth in total demand for many critical minerals. Consulting firm McKinsey estimates that lithium production, for example, will need to increase by more than 700 percent from 2020-2030 for the world to achieve its 1.5°C climate goals.[4] Cobalt, neodymium, and nickel are estimated to require around 100 percent increases in supply over the same timeline.[5] Rapid demand growth also applies to high-volume markets. S&P Global projects that copper demand will almost double from 2021 to 2035, with annual demand expected to rise by an extraordinary 24 million metric tons.[6]

In the cases listed above, demand growth exceeds the rate at which supply grew from 2010-2020 by a factor ranging from about one-half to six.[7] The percent of demand growth is largest for smaller markets such as lithium and tellurium and relatively smaller, but still very significant in terms of the total tons of material, for larger markets such as copper. Production of many minerals will need to grow much faster than it has in recent history. While high prices will lead to investment in new supply, the average time for a mine to come online is more than 16 years, according to the International Energy Agency (IEA), meaning that it will take time for markets to respond to price incentives.[8] Additionally, multiple sources of risk and uncertainty are leading mining companies to retain a cautious approach, directing cashflows to share buybacks and dividends rather than capital expenditure.[9]

Various projections show that supply deficits may be on the horizon. Consulting firm Ernst & Young, for example, projects copper will face a shortage of 4.7 million tons by 2030 based on the existing pipeline of projects.[10] Meanwhile, Benchmark Minerals Intelligence expects that by 2030 there will be a 12.5 percent lithium deficit.[11] Studies from a variety of other sources—including the IEA, McKinsey, and S&P—similarly show that the current level of committed global mine production for minerals such as cobalt, copper, lithium, and nickel is insufficient to achieve the goals of the Paris Agreement.[12]

2 Looming critical mineral shortfalls, caused by a projected gap between rapid demand and slower supply, present a substantial challenge to U.S. economic and climate interests.

Temporary supply imbalances have already demonstrated an ability to increase price volatility, disrupt markets, and challenge the business models of actors throughout the clean energy supply chain. A 10 percent increase in the price of nickel translates to a 1.2 percent increase in the cost of manufacturing a NMC 811 battery cell.[13] A similar increase in lithium and cobalt prices translates to a 0.8 and 0.4 increase, respectively, in the cost of manufacturing a battery cell. The impact of high critical mineral prices was seen in 2022, when the average global price of lithium-ion batteries increased 7 percent from the previous year.[14] This increase represented the first time battery prices increased in more than a decade and reversed a long-time trend of substantially falling prices. Rising battery prices are meaningful given that battery cells represent 30-40 percent of electric vehicle production costs.[15]

Long-lasting supply shortfalls could have even more significant implications. Despite their notable impact on battery prices, the high mineral prices of 2022 resulted in relatively mild economic damage since most battery manufacturers had existing supply contracts with fixed prices.[16] For various minerals, but specifically for lithium, new long-term contracts will have prices linked to market prices, meaning volatility will be more impactful. While many critical mineral prices eased in 2023, the looming long-term mineral supply shortfalls, in contrast, could be larger and more sustained, threatening to cause the prices of clean energy technologies to rise more dramatically and remain higher for longer.[17] For example, the International Monetary Fund (IMF) finds that lithium, cobalt, nickel, and copper prices could reach historical peaks for a prolonged period under net-zero scenarios.[18] Supply shortfalls could thus limit the total quantity of clean energy technology that will be built.

The negative effects of critical mineral shortfalls will not only be felt in clean energy markets. Supply-demand imbalances can also reverberate throughout the entire American economy given the ubiquity of minerals across all sectors of economic activity. Copper, for example, is used across a variety of industries including construction, electronics, transportation, and manufacturing of machinery.[19] High-grade nickel, as another example, is not only used in batteries, but is also a key ingredient of stainless steel. Tight copper and nickel markets could lead to higher prices for numerous products and constrain output in both the clean energy sector and other seemingly unrelated sectors. The sectors in which output will be most affected will depend on the elasticity of suppliers but will span beyond just that of clean energy.

Supply-demand projections are inherently uncertain. While there is consensus that critical mineral shortfalls will harm U.S. interests, there are varying opinions on the likelihood and potential severity of supply shortfalls. A central consideration is whether markets will sufficiently adjust to meet demand. The Aspen Institute's task force highlighted five key factors that could cause markets, both domestically and internationally, to function inefficiently and lead to suboptimal outcomes for the United States and its allies. These factors are outlined in Findings #3-7 and are clear areas of consideration for future policy.

3 Efforts to scale critical mineral production will generate, and already have generated, legitimate and serious environmental and social concerns.

The mining and processing of critical minerals generate considerable environmental risks due to toxic waste, water usage, and impacts on biodiversity. Toxic waste is one of the largest environmental concerns. When mismanaged, this waste can harm local populations and biological habitats. The 2015 Gold King Mine disaster in Colorado, in which three million gallons of toxic waste were released into the Animas River, provides a recent example of the environmental risks posed by mining waste.[20] The 2019 Brumadinho disaster in Brazil is another example. In that case, the collapse of a tailings dam—where toxic waste is stored—not only caused environmental damage, but also killed 270 people.[21] The mining industry's high rate of water usage is another growing concern. Numerous mining projects have been blocked in recent years due to their high water consumption in what are already water-stressed regions. These projects range from lithium mines in Chile to copper mines in Arizona. Operation of mines and processing facilities can also have damaging impacts on biodiversity, especially in cases where there are complex risks to local ecosystems.[22]

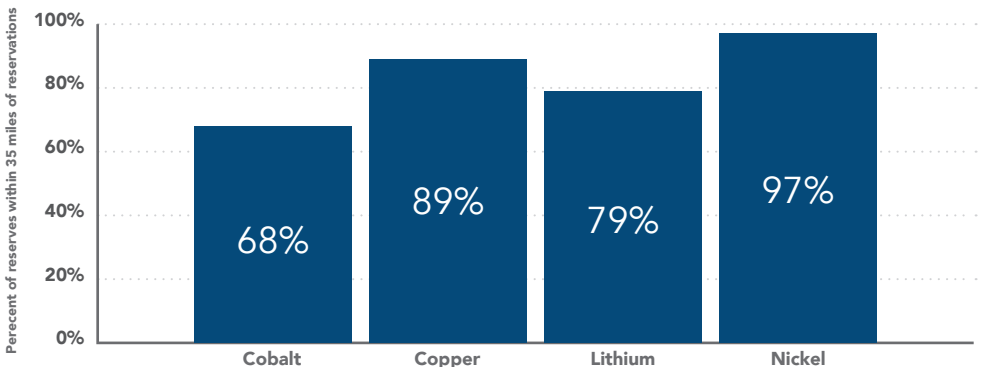
The environmental risks of mining create a tension between efforts to increase critical mineral production to meet global climate goals and valid concerns about protecting local environments. They also create a barrier to scaling critical mineral production. Communities and regulators, from Peru to Malaysia, have recently taken actions to shutdown mines and processing facilities for environmental reasons.[23] If efforts to quickly increase mineral production fail to account for environmental concerns, they could lead to more environmental disasters. These disasters, in turn, would further harm the reputation of the mining industry at a crucial moment, resulting in less political support, lower levels of approval for new projects, more community protests, higher perceptions of risk, and reduced access to capital.

On the social front, the mining industry has a long history of failing to respect community interests, including not consulting locals, breaking agreements, destroying sacred sites, and forcing displacements. This has created mistrust within many communities, particularly indigenous communities that have been disproportionately affected. Uranium mines, for example, have left a devastating impact on the Navajo Nation.[24] Moreover, mining projects have frequently failed to provide sufficient economic opportunities for local citizens. In the United States, many minerals are located near Native American Reservations, underscoring the particularly pressing need to engage in more effective dialogue with Tribal Nations. Without a social license to operate, mines will struggle to receive permits, raise capital, and bring minerals to market, and the United States will not realize its full potential for domestic production.

FIG 1:

Percent of U.S. Critical Mineral Reserves Within 35 Miles of Native American Reservations, 2021

(Source: MSCI)



4 Political risk in various producing countries creates barriers for diversified investment and challenges for responsibly scaling production.

Governments in countries with strategic critical mineral reserves, such as the Democratic Republic of Congo and Zimbabwe struggle with a history of corruption, mismanagement, and economic instability that disincentivize diversified global investment. While these countries have an important role to play in global efforts to increase critical mineral production, their high level of political risk is a barrier to the rapid deployment of capital that is needed to quickly build new mines. As a result, countries with substantial governance risks may fail to achieve their full production potential. Many Western companies are often unsure how and whether to invest in countries with high political risk, whereas Chinese companies are more willing to incur such risk given the strong political backing of the Chinese state. As discussed later, this dynamic makes it more difficult to build diversified supply chains.

Downstream manufacturers also face difficulties in sourcing minerals that may be tied to unethical labor practices. In the Democratic Republic of Congo, for example, an estimated 10-20 percent of cobalt comes from artisanal mines, many of which are connected to child labor, precarious working conditions, and environmental malpractice.[25] The international community remains undecided on how to address the tension between scaling supply of critical minerals and reducing human rights abuses. While there may be potential levers to affect positive change on both the demand and supply side—such as traceability initiatives and formalization of artisanal mining—these levers have thus far not been commonly agreed upon nor exercised at scale.[26]

5 Long project lead times create a situation of inelastic supply in the face of uncertain, volatile demand. In the United States, permitting is a particularly significant barrier to scaling critical mineral production.

According to the IEA, mining projects took an estimated global average of more than 16 years to move from discovery to production from 2010-2019.[27] It took the mines included in the dataset about 12 years move through exploration and feasibility studies, and four to five years to complete construction. Various technical, financial, and regulatory steps contribute to the time it takes for a mine to reach production. Lead times also vary substantially by country and mineral. The IEA reported that the average lead time for lithium mines in Australia was only four years, while the lead time for lithium mines in South America was seven years. Copper mines, meanwhile, had a global average lead time of 17 years. Overall, the average lead time of more than 16 years is alarming when juxtaposed with projected critical mineral supply deficits in 2030 (seven years from now) and even larger projected deficits in 2040 (17 years from now).

The long global lead times in the mining industry are caused by a host of variables including technical difficulties, access to capital, and permitting processes. These factors constrain the ability of markets to respond to price signals. Slowly moving supply, amidst rapid, volatile, and uncertain demand, creates a much larger

possibility of future mineral shortfalls. Reducing lead times is an important area of concern for policy, given the positive impact that shorter lead times could have on calibrating supply and demand, and on facilitating critical mineral production on the timeline needed to meet global climate goals. Although the major barriers to reducing lead times vary by country and mineral, permitting is one of the most significant roadblocks to scaling up production in the United States.

In an in-depth 2015 study on mine permitting in the United States, SNL Metals and Mining concluded that "of all the developed nations, unexpected and often unnecessary delays in obtaining mining permits afflict the U.S. most severely."[28] According to the study, it takes an average of seven to ten years for a mine in the United States to receive all the permits required to begin operations.[29] Permitting comparisons across countries are somewhat problematic given differences in the environmental and social challenges of each country and the way of measuring timelines. Nevertheless, the permitting process in the United States—along with many other OECD countries—and post-permitting legal disputes are a notable contributor to project risk and longer lead times.

Although the major barriers to reducing lead times vary by country and mineral, permitting is one of the most significant roadblocks to scaling up production in the United States.

Some argue that the U.S. permitting process is more efficient than commonly assumed, pointing to a 2016 study by the Government Accountability Office (GAO) which found that it took the Bureau of Land Management and the Forest Service an average of two years to approve hardrock mining plans from 2010 to 2014.[30] However, approval from the two agencies is just one part of a larger puzzle, which can include mining permits and authorizations needed from more than 30 different federal, state, and local programs.[31] The 2016 GAO study also does not seem to fully consider delays from litigation, which can lengthen mineral production timelines by a number of years. The various permitting hurdles beyond approvals from two federal agencies help illustrate the complexity of the U.S. system and the roadblocks mining projects face to begin production.

There are three ways that unpredictable and inefficient permitting can prove a headwind for U.S. efforts to scale production of critical minerals. First, delays can drastically cut a mine's expected value before it even begins production and lead a project to become financially unviable.[32] Second, permitting uncertainty can lead to lower levels of total investment in U.S. mining projects due to the higher level of perceived risk. And third, permitting delays can lengthen the time it takes for projects that do eventually receive permits to begin production. These three constraints have meaningful implications for the U.S.'s prospects of rapidly scaling critical mineral production to meet increases in demand and climate objectives. American policymakers face the challenge of making permitting more efficient, predictable, and transparent while minimizing important social and environmental tradeoffs. A failure to do so could result in investments moving toward foreign countries that have less permitting risk, thus undermining U.S. efforts to use domestic production as a means of bolstering supply chain resilience.

6 Substantial uncertainty over future critical mineral demand increases the potential for future supply shortfalls.

Changes in technology and policy can drastically affect mineral demand. The IEA projects that the growth in demand from clean energy technologies for minerals such as cobalt and graphite could range from six to 30 times based on the direction of battery chemistry evolution.[33] The wide range of these projections is significant given that clean energy technologies are estimated to be a major source of demand growth for cobalt and graphite. For example, clean energy technologies could make up 69 percent of total cobalt demand by 2040 under the IEA's Sustainable Development Scenario.[34] Cobalt producers, as well as those of many other critical minerals, are struggling to plan for huge levels of demand variance that hinge on unpredictable, and often rapid, technological changes. The IEA estimates that a slow shift to batteries with high nickel content could lead cobalt demand to increase by a factor of slightly more than 30 between 2020 and 2040, compared to projections estimating that cobalt demand will increase by a factor of 21 under the IEA's base case Sustainable Development Scenario.

Policy uncertainty also plays a crucial role. According to the IEA, the main source of demand variance for critical minerals is uncertainty over the climate incentives and implementation policies of governments.[35] Total lithium demand in 2040, for example, differs by more than a factor of three between the IEA's Stated Policies Scenario—which describes current government policies— and its Sustainable Development Scenario—which models a "well below 2.0°C" pathway.[36] While producers are largely basing their demand forecasts on current government policies, new climate pledges and policies could quickly change demand for critical minerals. Changes in both demand and supply can also be rapidly induced by geopolitical forces. The mining industry will likely struggle to react to these changes and to provide elastic supply given the long lead time of the industry. This heightens the risk of possible future shortfalls.

7 A lack of reliable data and sufficient transparency make it difficult for markets to align supply and demand, and increase the risk of volatility, thereby limiting investment in supply growth.

Many critical mineral markets lack reliable data and transparency, particularly in comparison to other commodities such as oil and gas. This opacity complicates the ability of consumers and producers to assess supply-demand balances, plan for potential risks, and interpret price signals. These dynamics were recently evident in 2022 when the London Metals Exchange suspended nickel trading after short selling caused prices to increase more than 250 percent over two days. They were also present when lithium carbonate spot prices in China increased twelvefold from 2020 to 2022, before declining by more than half in the first few months of 2023.[37] Supply shortfalls are likely when reliable supply and demand data is unavailable, future changes in demand are rapid and unpredictable, and supply is inelastic in the near term.

Despite current projections, sustained critical mineral shortfalls may not materialize for every critical mineral given uncertainty around the pace of the transition and technological innovation. Global experience has shown that markets have a powerful ability to respond to price incentives. Commodities such as lithium have also displayed more elastic supply than commonly thought.[38] But environmental, social, and governance challenges, long lead times (particularly due to permitting in the United States), demand uncertainty, and a lack of market transparency heighten the risk that critical mineral markets will not function efficiently moving forward. The implications could be severe given the nature of minerals as an increasingly important foundation for American climate, economic, and national security interests.

8 The upstream supply of many critical minerals is extremely geographically concentrated and vulnerable to supply chain disruptions.

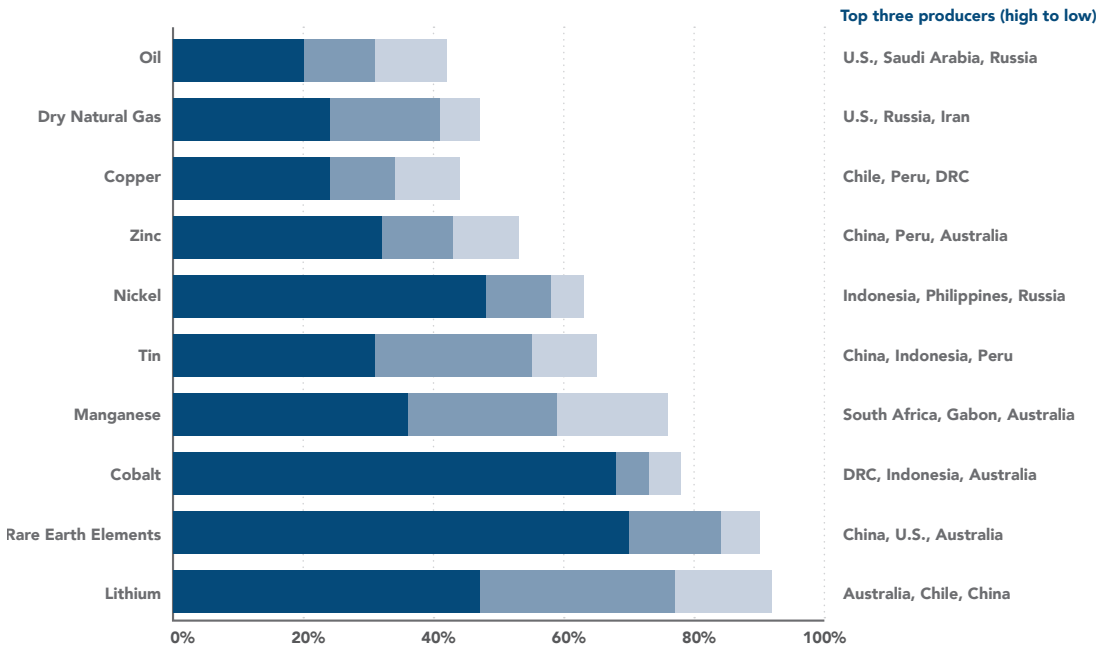
The United States currently imports most of its critical minerals. As of 2022, the United States imported more than half of its consumption of more than 51 different minerals.[39] For 15 of these minerals, the United States relied on imports for 100 percent of its consumption.[40]

High import reliance is problematic given the concentration of critical mineral supply chains. As shown in the figure below, global production of critical minerals is even more concentrated than that of oil and gas. In many cases, the top three critical mineral producers control more than 50 percent of global production. Some supply chains are dominated by a single supplier. The Democratic Republic of Congo, for example, produced 68 percent of global cobalt in 2022.

FIG 2:

Market Share of Top Three Producers (Oil and Dry Natural Gas in 2021, Minerals in 2022)

(Sources: USGS and EIA)



The concentrated production of critical minerals places supply chains at severe risk of disruption from unintentional supply shocks, which could result from events such as political instability or natural disasters, and intentional supply shocks, which could result from production cuts or export restrictions. These risks are increasingly likely as the world moves away from globalization and into an era in which trade wars, nationalizations, and geopolitics promise to feature more prominently. Early signs of disruption are already taking place. In Latin America, Argentina, Bolivia, and Chile have reportedly considered forming a lithium cartel.[41] Although the effects and likelihood of a cartel are uncertain, a lithium cartel could threaten to limit lithium production, both from lower levels of private investment and efforts to control output. Peru, the countries' neighbor, has shown it could also generate major supply disruptions as its copper production remains threatened by political instability.[42] More generally, rising resource nationalism in Latin America, amid a shift to more populist politics, is generating concerns about future critical mineral supply. Similar sentiments are also being expressed in other important producing regions, such as Africa.[43] In Asia, Myanmar recently imposed a ban on all tin exports, while Indonesia has banned exports of nickel concentrate.[44]

China's acquisitions of overseas mining assets add another variable to existing challenges in critical mineral markets. As of 2020, for example, 15 of the 19 largest cobalt producing mines in the Democratic Republic of Congo were fully or partially financed by Chinese companies.[45] The DRC may be an extreme example, as China does not hold such dominant control of mining in most other countries. Nevertheless, Chinese investments in overseas mining assets, like its "going out" strategy with oil and gas, have increased over the last decades. They will continue to grow as China's demand for minerals mounts and the energy transition accelerates. To support these endeavors, the Chinese government has often provided Chinese companies with large credit lines, allowing them to claim ownership of strategic mining assets throughout Africa, Asia, and South America.

While Chinese investments are positive for boosting global supply, they could also distort trade flows in ways that are difficult to track. Since many of the Chinese mining companies operating abroad are state-backed, they could potentially opt to supply resources to China in the case of a global shortage, even if higher prices are offered elsewhere. This is different than how a normal market with independent companies and traders would function. These dynamics are particularly important given the growing trend of vertical integration in critical mineral markets. Various downstream manufacturers are increasingly interested in locking up supply through offtake agreements or through direct ownership stakes in upstream production. This behavior is not only seen in Chinese firms but is also a model being pursued by American companies such as General Motors and Tesla. As companies pursue vertical integration and fixed offtake, ownership of overseas assets will become increasingly important in determining a country's ability to obtain the supply—and stable prices—of minerals that are needed for the domestic production of clean energy technologies. China's role in overseas investments also has diplomatic implications for the United States, as it has provided China with a means of strengthening its relationship with and increasing its leverage over various countries in the Global South.[46]

Mineral production is further concentrated at a corporate level, with companies like Glencore producing nearly one-fifth of global cobalt, and four companies responsible for nearly 60 percent of global lithium production.[47]

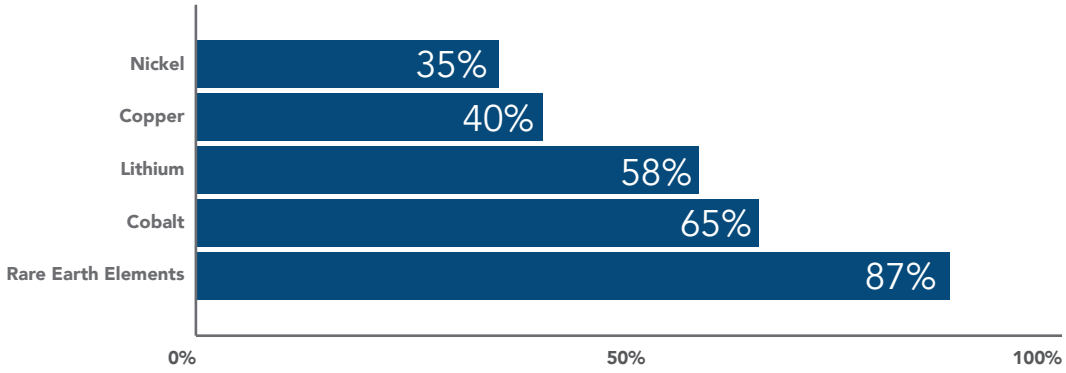
9 Global processing capacity for critical minerals is also geographically concentrated, creating risks to U.S. and global supply.

Processing of critical minerals, which converts raw material into usable components in manufactured technologies, is a central bottleneck to developing more resilient supply chains. More than half of the processing of minerals used in lithium-ion batteries, such as cobalt, lithium, and nickel, is concentrated in three or fewer countries. For certain minerals, such as rare earth elements, China holds an effective monopoly on global processing.

FIG 3:

China's Market Share in Total Processing of Selected Minerals, 2019

(Source: IEA)



China's dominant role in critical mineral processing is the result of decades of targeted industrial policy which has significantly subsidized domestic industry, invested heavily in R&D, and focused on workforce development. These policies coincided with decades of globalization and the gradual offshoring of the U.S. mining and processing industry, in addition to downstream manufacturing industries. As for talent, U.S. enrollments in mining engineering degrees began to dramatically decline beginning in the 1980s due to the offshoring of jobs and decreased funding for academic programs.[48] The United States then closed the U.S. Bureau of Mines—an important agency for research and development, and for information collection and dissemination—in 1996.[49] During this same period, China invested heavily in building its technical capacity and human capital. In 2020, the graduating class of the China University of Mining and Technology was larger than the total number of all mining engineering graduates in the United States.[50]

China's advantages in processing have been further reinforced by its cost competitiveness historically derived from lower environmental, safety, and labor standards. As global trade flows moved to lowest cost points of production, China gained market power due its favorable policy and regulatory environment that provided key inputs, high subsidies, and low costs.

10 China's dominance of rare earth elements extends across the full value chain, creating risks and vulnerabilities distinct from those of many other critical mineral supply chains.

Rare earth elements present a distinct challenge to the United States. China produces approximately 70 percent of global mined production of rare earth elements. Even more importantly, China currently controls an estimated 89 percent of separation, 90 percent of metallization, and 92 percent of magnet production in the rare earth element supply chain; it also accounts for over 70 percent of U.S. imports of rare earth oxides, chlorides, metals, and permanent magnets.[51] This dominance takes on additional significance since the United States relies on imports for all of its refined rare earth elements.[52] China derives leverage from rare earth elements due to its status as a dominant net exporter and an overwhelming source of U.S. imports.

China is aware of its leverage and the government has signaled strategic intent to wield rare earth elements as an economic and geopolitical tool, as it did when it restricted exports of rare earth elements to Japan in 2010 following a diplomatic dispute.[53] Since 2009, China has led the world in the number of export restrictions on minerals, increasing its export restrictions by a factor of nine.[54] China also passed an export-control law in 2020 that established a broad mandate to restrict exports if in China's national security and public policy interests.[55] Some experts, such as William Reinsch of CSIS and Gary Hufbauer of the Peterson Institute, have speculated that recent actions could signal China's consideration of restricting exports to the United States.[56] Other reports suggest that China has drafted plans to use its rare earth elements as a trade weapon against the United States and is considering banning the sale of rare earth refining technology to the United States.[57] Reports from Chinese national media, point to Xi Jinping's visit, along with his lead trade negotiator, to a rare earths facility during the height of the 2019 trade war as suggestive of China's willingness to use rare earth elements as a source of leverage in trade disputes.[58]

Economic interdependence is not inherently bad nor is China guaranteed to wield rare earths as a geopolitical weapon. But the case of rare earth elements provides three important takeaways. First, China's share of processing provides more leverage for some minerals than it does for others, largely depending on China's level of exports and imports. Second, China has at least signaled that it is *considering* use of its processing dominance as a form of geopolitical leverage. Third, the benefits of less reliance on China may be particularly worthwhile for certain minerals. An interagency group led by the Department of Defense in 2021 found that although the United States consumes only $613 million in rare earth elements, that consumption unlocks an estimated $496 *billion* in U.S. economic activity, demonstrating outsized economic vulnerabilities.[59]

11 China's dominance of midstream supply chains for battery metals affords it a real advantage, but the extent to which that dominance creates energy security risks and geopolitical leverage is often exaggerated.

Contrary to common perception, China's control of critical mineral processing does not automatically generate unilateral geopolitical leverage in critical mineral supply chains. For example, despite holding a large share of global processing for copper and nickel, China is currently a net importer of refined copper and nickel.[60] China's dominance of cobalt and lithium processing also does not seem to constitute a major geopolitical threat to those supply chains. China represents a major share of global demand for refined cobalt and lithium and exports very small quantities of these materials to the United States; rather, Chinese cobalt and lithium are used domestically in value added sectors such as battery cell manufacturing and eventually appear in the United States embedded in end products.[61]

China's control of global processing of these minerals *could develop into an area of more pronounced leverage*, especially as the United States seeks to localize manufacturing of key technologies in the short term. China's existing dominance and competitive advantages in processing may make it economically challenging for certain midstream operations—such as lithium or nickel processing—to gain market share and scale in the United States. Even if the United States increases its capacity to mine critical minerals and manufacture clean energy technologies, American supply chains will remain vulnerable if there are not significant increases in mineral processing capacity. In fact, increasing mining and manufacturing without increasing processing will heighten American reliance on Chinese processing and strengthen China's ability to use processing as a means of geopolitical and economic leverage.

Critical minerals are ultimately different in nature than other commodities such as oil and gas. While a shock in energy has immediate impacts on everyday citizens, minerals are inputs to manufactured products, offering more time for adjustment and less tangible impact on most citizens. If there were a disruption in mineral exports, intentionally motivated by geopolitics or unintentionally by a natural disaster or other event, there would be supply chain bottlenecks, delivery delays, and higher costs for new clean energy products, such as solar panels and EVs, but the ability to keep the lights and heat on or drive existing EVs would not be affected. Many minerals may also prove more substitutable than a commodity like oil historically has, even if such substitutes can be inferior in technical characteristics, as is the case for sodium as a substitute for lithium and aluminum as a substitute for copper. Over time, manufacturing and processing can be done anywhere, unlike oil and gas production which depend on geological fortune.

Nevertheless, critical mineral supply shocks can still significantly impact the profitability of value-adding activities such as the manufacturing of clean energy technologies and related industries, like the auto industry. And, as observed above, critical mineral supply chains are more concentrated than those for oil and gas, so may suffer from even more pronounced supply chain risks. The U.S. 100-day Supply Chain Review in 2021 found that there were 37 different mineral markets where more than half of global production comes from a single non-American source.[62]

While mineral disruptions may not have the same effects as those of energy, they will certainly restrict global efforts to meet climate goals. They can also hamper the economic security, and in some cases national security, of many nations, including the United States. As has historically been the case with other commodities, there is definite value in ensuring that both global and American supply chains are less vulnerable and more resilient.

12 The United States will not be able to attain self-sufficiency in critical mineral production, let alone supply all global demand, anytime in the near future.

The United States is heavily reliant on imports to meet its domestic demand of most critical minerals. In 2022, U.S. mined production of battery metals such as cobalt, manganese, and nickel satisfied only 10 percent, 8 percent, and 0 percent, respectively, of domestic consumption.[63] While recycling helped bridge the gap for cobalt and nickel, the United States still relied on imports for 76 percent of its cobalt consumption and 56 percent of nickel consumption. The United States currently imports 100 percent of the manganese that it consumes domestically. Although efforts to build domestic mines are accelerating, many of these projects will only make a small contribution to fulfilling total U.S. demand. For example, Jervois's new cobalt mine in Idaho has been touted as a breakthrough for the United States but is projected to meet only 10 percent of annual U.S. demand.[64] As discussed earlier, the United States will not be able to build new mines quickly, given permitting timelines, local objections, and other challenges to project development. And with minerals such as manganese, the United States faces the additional challenge of not having produced for more than a half century and lacking reserves, with existing resources thought to have low grades and high extraction costs.[65] The United States currently relies on imports for more than half of its consumption of 51 different minerals.[66] Attempting to scale mined production to meet existing, not to mention rapid growth in, U.S. demand for all critical minerals will be costly and timely.

Even if the United States were to produce all the minerals it consumed, that would come at a cost, as the gains of trade would be lost and domestic resources more costly to produce. Moreover, as is true for oil and other commodities, if the United States would remain integrated into a global market, the price of domestic commodities would still be vulnerable to threats from global supply shortfalls. There are many benefits to being part of an integrated global market, as interconnected and well-functioning energy markets increase energy security by allowing supply and demand to respond to price signals so the entire system can better handle unexpected shocks. At the same time, interconnectedness means global critical mineral shortfalls could impact U.S. mineral prices, which would harm American downstream manufacturers. Global critical mineral shortfalls, as discussed throughout this report, would also harm U.S. interests by impeding the pace of the energy transition. Recent analysis shows that it will take unprecedented action for all global democracies to jointly produce enough critical minerals to meet their combined demand based on stated 2030 climate goals.[67] It is obvious that the United States will not be able to supply enough critical minerals to meet the global demand of all democracies, let alone the entire global market. Given the magnitude of projected growth in critical mineral demand and realities of integrated commodity markets, it is neither feasible nor desirable to have as a policy objective "independence" or "self-sufficiency" in critical minerals.

13 Current U.S. efforts to diversify its sources of supply and encourage global production are too geographically narrow.

The United States has recently attempted to diversify upstream production through legislation such as the Inflation Reduction Act and new structures such as the Minerals Security Partnership. Although these initiatives have generated some positive movement, they have been overwhelmingly focused on an exclusive group of countries. Tax credits under Inflation Reduction Act are offered to countries with which the United States has a free trade agreement, and members of the Minerals Security Partnership are primarily advanced economies, most of which are net importers of critical minerals. These initiatives exclude an important "middle group" of suppliers.

Middle group countries—those that are neither U.S. free trade partners nor U.S. adversaries—do and will continue to play a strategic role in critical mineral markets. Over 60 percent of global cobalt, manganese, and nickel production, for example, comes from middle group suppliers. In many cases, these suppliers are not included in U.S. initiatives, leaving them with little option but to turn to China for investment. As outlined earlier, this has been the case in countries like the Democratic Republic of Congo, which produced 68 percent of global cobalt in 2022 but has a cobalt sector largely dominated by Chinese investment. The same has occurred in Indonesia, which produced 48 percent of global nickel in 2022.[68] That same year, Indonesia's nickel-rich islands of Halmahera and Sulawesi received $3.4 billion in investment, of which 94 percent came from China and less than one percent from the United States.[69] Argentina's lithium sector is beginning to present a similar story.[70] Three different countries and commodities, but all share the similarity of being strategic producers that are not engaged as free trade partners in the Inflation Reduction Act nor as core members of the Minerals Security Partnership. The United States has shown a pragmatic approach to IRA implementation by making countries that have recently conducted mineral-specific "trade agreements" with the United States eligible for IRA compliance, although political hurdles may constrain some of these efforts to expand eligibility.

FIG 4: Global Critical Mineral Production and Reserves by Type of U.S. Relationship, 2021 (Source: USGS)

Global critical mineral production by type of US-relationship (2021, %)

Production (2021, %)	Lithium	Nickel	Cobalt	Manganese	Copper	Graphite
Total USMCA	0	5	3	1	12	1
Total FTA	81	6	5	17	41	0
Total FTA-suggested	1	14	3	0	2	0
Total Non-FTA	9	48	75	74	19	17
Total Concern	14	14	8	7	12	86
Total (rounded)	105	87	93	98	87	104

Global critical mineral reserves by type of US-relationship (2021, %)

Reserves (2021, %)	Lithium	Nickel	Cobalt	Manganese	Copper	Graphite
Total USMCA	3	2	4	0	13	1
Total FTA	68	22	19	18	42	0
Total FTA-suggested	0	5	3	0	4	0
Total Non-FTA	11	39	56	78	11	77
Total Concern	7	11	11	4	10	23
Total (rounded)	90	79	93	99	79	102

1) These numbers are based on USGS statistics. Percentage errors are due to rounding by USGS of production totals or the omission of 'rest of world' estimates.
2) Countries of concern include China, Russia, Iran, North Korea, and Cuba. FTA countries include Australia, Bahrain, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Israel, Jordan, Korea, Morocco, Nicaragua, Oman, Panama, Peru, and Singapore. FTA-suggested countries include EU countries and the Philippines.

Recommendations

1 Congress should streamline permitting by utilizing a place-based approach and setting strict timelines on adjudication.

The slow pace of permitting prevents the United States from positioning itself as a key hub for responsible mining that it has both the physical resources and the high environmental and social standards to be. Addressing this challenge requires balancing two truths. First, a long and unpredictable permitting process can threaten the financial viability of existing projects and lead to lower levels of future investment, which will slow production and the ability to address climate challenges. Second, the dangers of mining present a compelling need to safeguard an impeccable level of environmental and social standards. In fact, a permitting process that fails to respect these standards could result in damage that substantially turns public support against the mining industry and undermines the initial climate, economic, and national security goals of streamlined permitting.

American environmental and social standards have greatly improved over the last decades. This provides the United States—and its key, like-minded trading partners—with an advantage as it evaluates options for permitting reform. Not only are strong standards in place prior to project approval, but adherence to these performance standards is strictly monitored when a project begins construction. Civil and criminal penalties are imposed on those who violate existing standards. When thinking through permitting reform, Congress must distinguish the approval process from substantive performance standards. Streamlining the former does not imply making any changes to the latter.

Congress should follow two steps in pursuing permitting reform. These steps are partially based on the ideas laid out more fully in the Aspen Institute's 2021 Building Cleaner Faster Report.[71]

First, Congress should pursue a place-based approach to streamline permitting for mines and processing facilities located in specific areas. Such an approach would entail establishing a presumption of project approval for any operation located on brownfield sites that have already been cleared for redevelopment and greenfield zones that have been previously designated and agreed upon by relevant parties (e.g., Bureau of Land Management (BLM) and Tribal Nations on public land). In these cases, Congress should require the lead permitting agency (such as BLM or the United States Forest Service (USFS)) to approve or reject the application within a 90-day period. These locations have already been pre-assessed, reducing the need for a lengthy permitting process unless there is a particularly unique risk posed by the nature of the new project. New projects approved in this manner will still be subject to the full suite of performance standards and resulting civil and criminal penalties for noncompliance.

Second, Congress should set strict timelines on the adjudication process for critical mineral permits. Protracted litigation can be a major risk and source of delay during permitting. Congress has precedent for establishing firm adjudication timelines on projects of national importance. Examples include the establishment of an aggressive 100-day time limit for

administrative resolution of contract award disputes with the Government Accountability Office related to defense and other vital government services, and similarly limited timelines for any appeal and the grounds for review of the administrative decision. Congress also expressly created a streamlined 30-day process for all transactions reviewed by the Committee on Foreign Investment in the United States to avoid the impact of delayed approval on U.S. businesses.[72]

Although mining is much more complex, a similar time-limited approach could be applied to critical mineral projects given the scale of production that is needed over the next two decades to meet U.S. climate objectives and contribute to the domestic production of key technologies. More specifically, Congress should restrict adjudicative review to clear and obvious errors in the assessment of harmful impacts or interpretation of existing standards. A specific scope and timeline for the review process will prevent the possibility of long delays and improve efficiency. It will also maintain environmental and social considerations by ensuring that all potential harms and relevant standards have been properly assessed.

As Congress tackles permitting reform, it can additionally investigate opportunities to streamline permitting by incorporating more mining projects into coverage under Title 41 of Fixing America's Surface Transportation Act (FAST-41). FAST-41 sets strict permitting timelines and improves permitting transparency. Coverage of FAST-41 was recently granted to a $1.7 billion zinc and manganese mining and processing operation in Tucson, Arizona.[73] It was the first critical mineral project accepted for coverage under FAST-41 and may set an important precedent for coverage of similar projects in the future.

2 Congress should clarify and endorse the concept of Free, Prior, and Informed Consent, making clear that it should be received from Tribal Nations directly impacted by critical minerals development.

As described in the findings above, many of the delays in developing U.S. critical mineral deposits stem from permitting delays. Such delays are often the product of the opposition of local and indigenous groups to the projects, and occur against the backdrop of a painful history of such groups with the mining industry.

In 2007, 143 countries voted for the UN General Assembly to adopt the UN Declaration on the Rights of Indigenous People (UNDRIP). The United States was opposed to the declaration at the time, in part due to opposition to the concept of "Free, Prior, and Informed Consent (FPIC)," which suggested to many that indigenous groups hold a veto over the development of projects affecting their interests. In 2011, however, the United States revised its position and, a decade later in 2021, ratified UNDRIP, yet called the declaration's provisions "aspirational" rather than legally binding.

This sequence of events has left lingering uncertainty about what Free, Prior, and Informed Consent means in the U.S. context. While many stakeholders in the mining industry rhetorically embrace the idea of consultation with parties to be affected by projects, there is less support

2

and consensus around the idea of consent and whether it should constitute a veto. Further, there is no shared sense of what is required versus what is desirable around FPIC, leading to drawn out timelines, often involving extensive court battles. This ambiguity meets neither the interest of mining companies seeking to move ahead, nor indigenous groups seeking protection, nor indigenous groups wishing to benefit from such developments.

For these reasons, Congress should clarify which communities can expect to be afforded Free, Prior, and Informed Consent and what that consent means. One possibility the Task Force found attractive is for Congress to distinguish between tribal communities immediately adjacent to mining projects and those who live further away but may still have environmental or cultural concerns. For the first group, FPIC would be a binding concept in the sense that a project could not proceed over the objection of a direct affected Tribal Nation; for the second group, FPIC would be encouraged, but full consent of these Tribal Nations would not necessarily be required for the project to move forward. In both cases, the process of consultation would be required, augmented by clearer standards and guidelines from Congress on the timelines and scope for the consultation process.

Some may initially find this position as too definitive and discouraging of private investment in much-needed areas to produce much-needed resources. However, it was the sense of the Task Force that more was to be gained by a clearer, sharper definition and application of FPIC than lost. Even without holding a legally recognized veto, indigenous groups have been able at times to manifest their opposition to particular projects and effectively prevent project approval for decades.

A clearer understanding of what it means to withhold consent, as well as who possesses the ability do so, will expedite the process. It would likely reduce rather than increase uncertainty over critical minerals project development timelines by removing the prospect for long regulatory and legal battles over projects in communities that are opposed to development. FPIC would also provide strong incentives for industry to both target investment in communities that support project development and to engage early on with these communities on both sharing of benefits and mitigation of environmental impact. In contrast, a poorly designed or overly broad FPIC process is likely to lead to major project delays while potentially undermining the ability of tribal communities that favor development to move forward.

3 Congress should endorse and further facilitate the ability of Tribal Nations to obtain equity in critical mineral projects.

Congress should ensure that Tribal Nations that do wish to engage in project ownership have access to the required financial and technical assistance. Enabling Tribal Nations to become full project partners could be an important step in increasing their leverage, knowledge, and power, creating a more just system of shared economic opportunity, reducing the possibility of future litigation, and building the trust between the private sector and local communities that will be required to sustain an increase in the domestic production of critical minerals required to meet at least a portion of future American needs.

Currently, companies commonly ensure that local communities benefit from critical minerals development by paying local taxes and supporting local jobs and procurement. While important, Congress can help ensure that Tribal Nations are more meaningfully invested in these projects by providing concessional financing and loan guarantees to Tribal Nations that are interested in obtaining equity in critical mineral projects.

CANADA'S EXAMPLE. Canada offers useful examples of indigenous equity agreements. Multiple indigenous groups in Canada have obtained equity in local projects, particularly in those involving petroleum and renewable energy. The growing popularity of these arrangements—which are structured differently for each project—show that the private sector and indigenous communities are beginning to view co-ownership as a potential win-win scenario. The First Nation's Major Projects Coalition in Canada is a coalition of 27 aboriginal groups that have joined together to invest in high-value projects. Moreover, in Canada, equity has been granted as a recognition of historical claims. Despite these successes, access to affordable capital has often proven a major roadblock for Canadian indigenous groups seeking to acquire equity.

Congress should provide Tribal Nations with concessionary finance and loan guarantees to acquire equity at rates that are attractive and fair to existing equity owners. A *Tribal Energy Loan Guarantee Program* already exists to provide loan guarantees to support tribal investment in energy-related projects, including those in mining. It is well funded, with an increase in authorities to $20bn through the Inflation Reduction Act, and with an additional $75 million provided to carry out the program.[74] Yet unlocking these funds will require Congress to provide clearer guidelines about its use. Ongoing concerns regarding "double dipping"[a] and other bureaucratic hurdles have meant that the program has not yet funded a single energy project on Native American reservations.[75] Alternative arrangements for equity involvement may also be structured with the mining company as creditor, paying for the initial shares, and with the indigenous group's repayments drawn out of dividends.

a Double dipping" refers to the prohibition in the budget reconciliation law against using loan guarantee funds for projects that already received other federal support. Critics argue that the DOE's interpretation of the law is unduly harsh and limits the program in ways that contradict the intent of Congress.

3

Congress should also ensure that Tribal Nations have access to technical assistance to manage the complexity, risks, and high transaction costs of equity negotiations. Congress could either mandate that technical assistance be offered through the Department of the Interior or offer grants for Tribal Nations to hire independent consultants. Given that many critical minerals are near, but not specifically on, Native American Reservations, Congress should offer the benefits listed above to indigenous communities that are deemed to be directly affected by critical mineral projects.

The Task Force was divided about whether Congress should impose a royalty fee for mines operating on federal land.[b] Some argued that royalties are a barrier to investment in critical minerals development at a time when more investment is urgently needed to increase supply. Others argued that a mechanism to impose and redistribute royalties could provide local communities with a risk-free flow of shared economic benefits, which could compensate communities for the risks that they face and better align incentives between mining companies and local citizens, ultimately making increases in production more sustainable.

Congress should further study the merits and risks of a limited royalty fee on all hardrock mines located on federal land used for the purpose of redistribution to local communities affected by mining activity. The exact structure of such royalties—including whether they are levied on revenue, profit, or some other metric—would need to be assessed carefully to ensure a steady flow of funding while not placing an undue burden on mining companies. The same principles should be applied to the rate of the royalty. Ideas can also be taken from local and state royalty structures for mines outside of federal land and from international models. Congress should assess the merits of royalties relative to other approaches to shared benefits discussed above, including equity-based participation for local communities affected by mining.

Regardless of its eventual decision on royalties, Congress should also provide the Federal Bureau of Land Management and the United States Geological Survey with the relevant funding and mandate to collect data on all mines located on federal land. Federal agencies are not currently collecting sufficient data on the activity of hardrock mines that are located on public domain land since these mines do not pay royalties. Improved data collection will require more funding and a specific mandate.

b The absence of a royalty framework for mining on public domain land stands out given that the federal government earns royalties on extraction of other commodities on federal lands including for oil, gas, and coal. Hardrock mines on public domain land are excluded from royalty payment due to the 1872 Mining Law, which has now turned more than 150 years old and has limited relevance to the contemporary context of critical minerals. However, it should be pointed out that several states collect royalties from mining on public land. Furthermore, Congress has updated the 1872 Mining Law over past decades but has so far not opted to introduce royalties.

4 Congress should continue to increase funding for the National Defense Stockpile, enabling it to effectively fulfill its mandate for defense and security.

The National Defense Stockpile (NDS) is an essential tool to help the United States withstand shocks to critical mineral supply chains, reduce overdependencies on foreign countries, and ensure the ability to maintain production in defense, industrial, and essential civilian sectors.[76] An early version of the stockpile was first formed shortly before World War II to help the United States acquire and store raw materials in the face of a looming war effort.[77] The NDS was guided by the idea that stockpiles improve supply chain resilience and decrease vulnerabilities. These principles were powerful during the interwar era and various instances of geopolitical uncertainty.

Today, the NDS remains as crucial as ever. The increasing importance of critical minerals and the fragile state of supply chains presents an imperative to maintain a robust national stockpile. Now is the right time to reassess and reform the NDS, given how the energy transition is posing a new set of challenges, including the possible, if bounded, ability of U.S. adversaries to use dominance in critical mineral supply chains for geopolitical reasons.

The United States government has already acknowledged the need to expand the use of the NDS. The Departments of Energy, Defense, and State have signed a memorandum of agreement that paves the way for stockpiling for a larger purpose, specifically to support the transition to clean energy.[78] This stockpiling can further give a public procurement angle to ESG-compliant mineral production by establishing standards around operations that qualify for public procurement.

For the new NDS to be effective, two efforts must be part of this reform. First, there will need to be a detailed study (outside the scope of this task force) to determine which type of critical materials to stockpile. While the decision may be simple for some minerals, it will be difficult for others. Minerals such as lithium have a variety of specialized final forms, many of which are highly specific and difficult to store and transport. In such cases, the NDS could generally seek to have the largest stockpiles for the form of material that is least logistically complex and can most easily be converted into a wide range of different final forms. Similar logic explains why the Strategic Petroleum Reserve is based around crude oil, rather than refined oil products. For minerals, storing concentrate or semi-refined material will be most effective if domestic processing capacity is increased. Many of these materials are useless on their own and must be processed, underscoring the importance of domestic processing. Holding sizable stockpiles of concentrate or semi-refined material can help support the growth of the mineral processing industry in the United States by guaranteeing processing facilities feedstock in the case of a supply chain emergency—such as dramatic cuts in access to imports of concentrate—that would otherwise leave these facilities vulnerable to financial collapse.

In addition, rebuilding the NDS as a pillar of U.S. critical minerals policy will require sustained fiscal support. Even when just considering its more traditional mandate, the NDS is currently severely underfunded. Annual funding for the NDS decreased from $42 billion in 1952 to less than $1 billion in 2021, in adjusted dollar terms.[79] According to the United States 100-day

supply chain review, "from FY2003 to FY2018, Congress diverted 89.8 percent of the proceeds from NDS program activities" to other programs.[80] Congress has recently decided to reverse course, authorizing $1 billion for the NDS in the 2023 National Defense Authorization Act.[81] It must continue to increase funding for the NDS over the coming years. Congress should ensure that this funding is sufficient for the NDS to provide an effective buffer for defense and security in the case of a national emergency.

Congress should avoid the impulse to alter the fundamental nature of the NDS. The NDS should not be used as an economic stockpile that aims to control market prices. Rather, efforts to rebuild the NDS should continue to focus on the NDS's role as a provider of supply chain resilience. This mandate means that the NDS will not cover all U.S. civilian needs, nor smooth commodity prices. But a rejuvenated and refinanced NDS will first and foremost provide a crucial buffer against supply chain disruptions for defense needs. With sufficient funding, the NDS could also provide initial protection against extreme supply chain disruptions that could cause levels of instability that are significant enough to impose long-term harm on American climate and economic interests. Congress should seek to provide the NDS with the adequate financial resources to potentially provide defense, industrial, and essential civilian sectors with strategic raw materials; allow time for markets to reposition in the case of supply emergencies; and offer protection against foreign adversaries' ability to use critical minerals as geopolitical leverage against the United States.

5 Congress should expand funding for R&D and undertake regulatory reform to promote substitution of alternatives, demand reduction, and recycling of critical minerals.

Substitution of alternatives, demand reduction, and recycling can help build multiple pathways for low-carbon technologies, reduce the need for mining, encourage the more efficient use of critical minerals, and decrease the potential for supply chain disruptions.

In the market for batteries, the development of alternatives looks promising. For example, Lithium Iron Phosphate (LFP) batteries reduce the need for the nickel, cobalt, and manganese used in Nickel Manganese Cobalt (NMC) batteries. Sodium-ion batteries are another alternative and reduce the need for lithium, although demand for battery-related minerals, particularly lithium, will remain strong in the near term. Technologies such as sodium-ion batteries are still nascent and present a variety of tradeoffs on range and vehicle size, but are promising alternatives in the long term, and for grid storage, specifically if supported by policy incentives.[82] The same applies to other technologies, such as iron nitride magnets, which could potentially substitute for rare earth elements that are used in magnets.

There are a number of reasons why policies may be needed to support the development of such alternatives. Adoption and full commercialization of such new technologies can fail or take longer than expected due to various reasons. Many technologies may face cost differentials that hinder adoption. In some cases, the private sector may not fully internalize the positive externalities of new technologies. For example, a battery that requires less minerals will offer

5

benefits to society by reducing the need for mining. But this may not always be a primary consideration for auto companies, which may be more focused on variables such as product cost and performance. A good example is LFP batteries, which do not require nickel, manganese, or cobalt. These batteries were developed in the United States but abandoned because they had a lower energy density than other batteries. China further developed the technology to achieve 85 percent of energy density of NMC 811 batteries, while holding a grip on patents until the end of 2022, by which time a significant portion of electric vehicle batteries in China were LFP, compared to around 5 percent in the United States.[83]

Recycling can also play an increasing role in reducing the need for future mining as a larger number of mineral-intensive products reach the end of their life cycle. For every recycled battery, or for every new battery that relies to some extent to recycled components, the need for critical minerals is reduced. Increasing the contribution of recycling in the supply chain also reduces the negative environmental impacts associated with critical mineral mining and supports climate objectives. Recycling can also improve supply chain resiliency for advanced economies—such as the United States—which are large consumers of minerals embedded in end products. The IEA projects that by 2040 recycled quantities of copper, cobalt, nickel, and lithium from spent batteries could meet 10 percent of global demand for those four minerals.[84] In fact, recycling currently accounts for a significant portion of United States cobalt and nickel consumption.[85] United States recycling rates of other minerals, such as lithium and rare earth elements, however, are extremely low. It is essential to lay the groundwork for a national battery recycling program now, so that it is available at the necessary scale as the stock of end-of-life electric vehicles and depleted batteries grows over the next decade.

Congress can address barriers to developing alternative technologies and to recycling by increasing funding for research and development related to demand reduction, substitution, and recycling and/or to mandate specific requirements, such as battery recycling, as well as funding start-ups and de-risking emerging technologies through programs such as the DOE Loan Program Office. Yet, when it comes to recycling, simply creating incentives and funding is not enough. Congress and regulatory agencies such as the Environmental Protection Agency should, through targeted regulations, also encourage development of recycling infrastructure; this can be done by ensuring spent batteries are framed and categorized as a valuable recyclable product and resource in the regulatory framework, rather than categorized as a waste or hazardous waste. Further, Congress should ensure that the regulatory and permitting entitlement framework is set up in a way that accelerates the development of recycling infrastructure.

These are important avenues for policy and Congress should evaluate the effectiveness of scaling recycling vis a vis substitution and demand incentives. Continuing to increase funding for research and development of technologies that reduce critical mineral dependencies is crucial. Development of these technologies often rely on government early- and mid-stage support. In some cases, more funding for research and development or more federal requirements on issues such as recycling may prove far more effective and practical than demand incentives. In other cases, demand incentives may be a productive compliment to other existing initiatives.

6 Congress should implement a grant program for accredited mining programs in the United States and should earmark a certain proportion of funds for recruitment initiatives.

The U.S. workforce faces challenges that could significantly constrain efforts to increase critical mineral mining, processing, substitution, and recycling. More than half of the current United States mining workforce—equating to about 221,000 workers—are expected to retire by 2029.[86] Meanwhile, the United States only conferred 327 mining and mineral engineering degrees in 2020, with the number of mining programs in the United States in large decline since the 1980s.[87]

Over the longer term, supply-demand dynamics will play a role in helping recalibrate labor markets. However, the rapid scale of projected mining growth, intense competition for talent, and students' lack of knowledge about mining indicate a need for Congressional support.

Congress should design a grant system for accredited United States mining programs, ensuring that a certain proportion of new funds are earmarked for recruitment initiatives. Mining currently struggles with a variety of recruitment-related issues, including a negative perception of mining and students' lack of exposure to the industry. In fact, research indicates that students' lack of knowledge about mining may be one of the main drivers of low enrollment in mining degrees.[88]

Congress can build on existing legislation, such as the Mining Schools Act of 2022 that requires the Secretary of Energy to provide technology grants to strengthen domestic mining educations through a newly established Mining Professional Development Advisory Board as well as via the mine safety, health training, and education funding managed by the Mine Safety and Health Administration of the Department of Labor.[89]

Where possible, Congress can also seek to offer grants to multidisciplinary initiatives. These initiatives can seize on the fact that developments in robotics, automation, big data, and cloud computing are changing the landscape of mining. For the United States to build a competitive mining industry, it must focus not only on training mining and chemical engineers, but also on attracting technologists, data scientists, and mathematicians. Supporting interdisciplinary initiatives will allow the United States to leverage the strengths of its existing workforce and position itself to become a leader in the future of critical minerals.

New initiatives to train qualified mining talent will not reap rewards overnight but will be essential for building a competitive American mining sector over the next decades. Strengthening the United States workforce will help develop the necessary talent to power domestic supply chains and support the Biden Administration's Just Transition agenda.

7 Congress should resist reliance on Buy America provisions when crafting legislation related to critical minerals and seek to develop alternative international agreements to meet domestic needs.

Congress has recently increased its use of Buy American provisions as a means of building support for legislation, supply chain resilience, and the U.S. manufacturing base. While these objectives are understandable and important, Congress should look for other ways to achieve them apart from requiring that manufacturers and others buy American inputs only. Buy America provisions can distort investment and lead to supply shortfalls in critical mineral supply chains. These provisions also risk alienating key U.S. allies and triggering similar responses from other countries, leading to a race to the bottom where countries compete to offer the highest subsidies.

This cautionary note is particularly important given that, as explained earlier in this report, under no feasible circumstance will the United States meet all its needs for critical minerals exclusively through domestic production. The United States will need to draw on the resources and developments of other countries to meet its future demand. For this reason, the United States should focus on developing an alternative approach to Buy America that forms relationships with reliable countries to help them develop their resources and provide those resources to global markets.

The below recommendations build on one other to create standards, frameworks of support, and relationships that would collectively construct this system. Ideally, the efforts described below would be pursued in a multilateral context. However, in the interest of speed, or due to other reasons, bilateral agreements might be developed simultaneously, with an eye to creating umbrella frameworks in the future.

In seeking to build these arrangements, the United States can build on existing dialogues and agreements, such as the Minerals Security Partnership, ongoing 30D negotiations with the EU and Japan, the Americas Partnership for Economic Prosperity, and the Indo-Pacific Economic Framework for Prosperity. It can do so by leveraging financing tools and encouraging member countries to offer similar mechanisms, thereby pooling resources and maximizing impact. As they take form, agreements should seek to include an expansive group of strategic exporting and importing countries. They should also have an open architecture, allowing countries to join over time. Multilateral agreements should seek wide membership rather than exclusivity.

8 Congress should work with federal agencies and international allies to establish clear standards for foreign mining projects that qualify for support.

The United States and its partners should engage in a "race to the top" to create supply chains and markets with new standards around climate, human rights, transparency, biodiversity, and indigenous rights. As discussed in subsequent recommendations, these standards can be the basis for greater financial support and trade benefits. In this way, the United States can develop reliable trading partners for critical minerals, while having greater confidence that the environmental and social aspects of these projects are managed responsibly.

Congress can play an important role by working with federal agencies and international partners to define the required environmental and social standards for mining projects that qualify for support and benefits. Environmental, social, and governance (ESG) standards should reflect existing American values and legislation while leaving space for input from partner countries. They should embody the existing Minerals Security Partnership Principles for Responsible Minerals Supply Chains, which is explicit about not endorsing a single ESG accreditation framework but requiring internationally recognized ESG standards.

In working with others to develop such standards, Congress has a range of useful precedent from which to draw. First, Congress can lean on existing work by the Department of Labor Mine Safety and Health Administration, which sets labor standards for mine operations in Title 30 of the Code of Federal Regulations, and that of the Environment Protection Agency, which establishes environmental standards for mineral mining and processing (last updated in 1979).[90]

Congress can also rely on international frameworks such as the Extractives Industry Transparency Initiative (EITI), the Global Industry Standards on Tailings Management (GISTM), and the Initiative for Responsible Mining Assurance (IRMA) for important reference points. These frameworks reflect a variety of reforms and innovations the mining industry is using to reposition from an "extractive" sector to an "enabling" sector that supports the low carbon transition with more sustainable industrial practices and reimagined, stronger partnerships with local communities.

In terms of sustainable mining, several areas of innovation and industry best practices stand out. These include the adoption of net zero Scope I emissions for critical minerals mining operations, through the incorporation of electrification, hydrogen, biofuels, and CCUS. Industry standards are also emerging around biodiversity protection through growing industry commitment to net positive land impact. This policy means that mining companies commit to setting aside a greater amount of land for long-term conservation than the amount of surface that is disrupted by the mining development and operations. Also embedded in biodiversity protection and land protection are stronger reclamation standards for new projects and a more fulsome effort on reclaiming historic, abandoned mine sites.

Among the emerging global standards for sustainable mining, perhaps none will be more vital than the adaptation of the strictest industry standards around managing tailings waste from mine operations. Tailings waste poses risks of both potentially disastrous large volume breaches and floods, as well as slow leaching of toxic materials. The emerging standards should require,

8

wherever possible, the usage of clean dry stack tailings to replace legacy approaches of tailings ponds and slurries. The principles of the Toward Sustainable Mining (TSM) protocol provide sound language for consideration. Efforts to more responsibly manage tailings will be enhanced by emerging brownfield business models around the secondary processing of minerals that might otherwise end up in tailings deposits, but could in many cases be extracted for economic value.

Congress and partner countries should offer support to countries that wish to meet these standards (for their own benefit or in order to qualify for the types of assistance that follows). The ultimate goal of such efforts is to be inclusive, rather than exclusive, and some countries will need assistance in meeting the agreed upon standards. While many developing economies react negatively to Western conditions around governance standards, strategic exporters are extremely interested in determining how to retain more economic value. This is true in countries ranging from Chile to the Democratic Republic of Congo. The United States should recognize this opportunity and provide technical assistance to exporters to standardize, design, and implement regulatory and legal frameworks to capture more value, either directly or through partnerships with technical assistance providers such as the World Bank and the Intergovernmental Forum on Mining, Minerals, Metals, and Sustainable Development. As discussed below, these initiatives will be most impactful if paired with hard financing for project development or market access for products.

9

Congress should increase funding for the Development Finance Corporation and provide it with an expanded authority, and priority, to invest in critical mineral projects abroad that meet—or can, with U.S. support, meet—the above standards.

The United States and its allies must develop a coordinated package of policy tools to partner more effectively with strategic exporters of critical minerals. Many strategic exporters are developing economies with limited access to mineral expertise, intellectual property, and finance. This presents a gap for the United States and its allies to step into as important partners. However, a lack of sufficient action in the last two decades has forced many countries to rely overwhelmingly on Chinese investment. More active engagement by the United States and its allies will help boost global production and diversify supply chains.

Congress should provide the Development Finance Corporation (DFC) with an expanded authority to invest in critical mineral supply chain projects, including midstream diversification in mineral-rich countries. The DFC does not currently have substantial participation in mining projects and will need increased funding to invest more heavily in critical minerals. Since 2003, U.S. development finance has only supported a handful of mining projects, including most relevantly US$ 25 million in debt financing in 2020 for expanding the production of Brazilian cobalt and nickel mining and US$ 30 million in equity investments again for Brazilian cobalt and nickel production for green energy transition use cases.

9

In order for the DFC to meet this new mandate, Congress will need to provide it additional funding; the DFC's current budget for all activities is FY 2023 is $7.7 billion, which is insufficient given the scale of the critical minerals supply gap and the multiple calls on the DFC for other areas of economic involvement beyond mining.[91] The need for more finance is particularly true given the high capital requirements of critical mineral operations. Even with a blended finance model, meaningful investments in critical minerals will impose significant financial demands on the DFC. The DFC will also need increased funding to hire and compensate new staff with relevant mining expertise. Congress should increase the DFC's funding to overcome these challenges.

In addition to increasing the DFC's funding, Congress should provide it with an explicit mandate to prioritize investment in critical minerals, including mining, processing, and recycling operations. Investments should primarily focus on countries that are U.S. partners and have signed up to and verifiably met the standards mentioned above. In cases where there is sufficient confidence, the DFC can offer its range of financial products, including debt financing, equity investments, and political risk insurance. Given that, resource-rich countries are seeking investment in higher-value segments of the supply chain rather than upstream, extractive segments alone, the United States and other likeminded countries, including the EU, UK, Canada, Japan, and South Korea, among others, can increase and coordinate concessional finance to those countries. As discussed below, the United States, in particular, can increase access to certain IRA incentives to enhance supply-chain coordination.

Ideally, these DFC products can be offered in tandem with parallel financial support from other partner countries. Pooled financing mechanisms will provide a robust package of support to qualified projects. This will strengthen the incentives of net exporters to partner with the United States, will help diversify sources of investment, and will allow for increased, and more responsible, critical mineral production.

Where possible, the DFC and the parallel development organizations of partner countries can also invest in infrastructure adjacent to critical mineral operations. For example, investments in roads and electricity can provide important public goods to civilians while also de-risking nearby critical mineral operations. Selected projects could also qualify for follow-on agreements with EXIM, MCC, and USAID, further bolstering partnerships between the United States and strategic exporting countries. As alluded to earlier, the goal of such projects should not be to exchange minerals for infrastructure. Rather, the United States must approach projects through a lens of partnership, offering assistance that will allow countries to successfully manage their critical minerals, while also helping meet international climate and supply chain objectives.

10 Congress should facilitate bilateral and multilateral frameworks that increase coordination of critical mineral supply chains and support the negotiation and passage of bilateral and multilateral trade agreements among countries that meet the standards recommended above.

Given the inability of the United States to meet its own domestic needs for critical minerals, it is in America's interest that countries with which the United States has predictable political relations develop their critical minerals for global markets and for purchase by American companies and the U.S. government.

The United States can pursue these arrangements through new partnerships and existing bilateral and multilateral frameworks like US-EU Trade and Technology Council and Indo-Pacific Economic Framework.

Bilateral trade arrangements between the United States and countries that sign up and adhere to the standards listed earlier can be the first step in spurring even greater investment and production. These agreements can reduce tariffs and expand market access in other ways. Even better than bilateral approaches are multilateral ones that promote investment and supply-chain coordination among the developed and developing countries while protecting against unfair competition from countries which derive advantages from poor labor, social, and environmental practices. Ideally, these would take the form of multilateral trade agreements, although other frameworks are also possible.

These initiatives will require strong regulations around traceability given the complex nature of markets and the traders within them. Congress should study innovative contemporary traceability initiatives, alongside United States experiences tracing conflict minerals, oil, and natural gas.

11 Congress should help establish and fund a structure to improve demand projections and increase price transparency.

When the IEA was formed in 1974, it was created to address a variety of challenges that were facing oil markets. One of the IEA's key functions was to ensure improved visibility of global prices and supplies. At the time, oil markets were suffering from a lack of transparency, leading to an increased probability of price volatility and supply shortfalls. Over the years, the IEA has demonstrated its ability to serve other important functions, such as coordinating international stockpiles to promote energy security.

Today, many of the challenges that plagued oil in the 1970s and incentivized the creation of the IEA are now affecting critical minerals in a similar, if not more pronounced, fashion. First, the sheer number of critical minerals makes markets difficult to fully track. However, an even larger problem is the opacity and small size of many of these markets. The recent volatility in lithium prices, meanwhile, shows that volatility comes not only from insufficient price transparency,

11

but also from insufficient data on total market supply and demand. As mentioned earlier, demand uncertainty is one of the main barriers confronting critical mineral producers. Insufficient data on current and future global supply further complicates the picture.

The IEA could be the best place to take on this challenge, but it may fall outside the purview of Congress to coordinate changes within the IEA or facilitate the construction of a new international organization. In the meantime, Congress can still ensure progress by creating and funding a structure like the Energy Information Administration (EIA) but dedicated specifically to critical minerals. Such as structure could be housed within the United States Geological Survey (USGS) or could be created independently. The former is likely preferable given USGS's existing access to data, institutional experience, and expertise.

This new domestic structure should focus on similar tasks as the EIA, such as conducting short- and long-term domestic and international mineral projections, building various scenarios, assessing potential risks, and conducting detailed analyses. This agency could be complimentary, rather than duplicative, of current USGS initiatives. For example, it could focus on providing additional transparency in international markets. Like the EIA, it could also specialize in assuring that public sector consumers have access to timely, reliable, and customized information to guide policy decisions. Congress could grant this new structure with a mandate to collaborate closely with similar information agencies in other countries, working together to form joint analyses. This new structure should have a specific task of sharing its domestic and international forecasts with the public to promote more clarity around future demand.

Signatories

Jason Bordoff, Founding Director of the Center on Global Energy Policy, Professor of Professional Practice in International and Public Affairs, Columbia University SIPA

Meghan O'Sullivan, Jeane Kirkpatrick Professor of the Practice of International Affairs and Incoming Director of the Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University

Adina Adler
Deputy Executive Director
Silverado Policy Accelerator

John Bailey
Partner
Yorktown Partners LLC

Rahim Bapoo
Managing Director
BMO Capital Markets

Morgan Bazilian
Professor
Colorado School of Mines

Andy Blackburn
CEO
Niron Magnetics

Juan Carlos Jobet Eluchans
Distinguished Visiting Fellow
Columbia University Center on
Global Energy Policy

Ana Cabral-Gardner
Managing Partner and Co-founder
A10 Investimentos

Amrita Dasgupta
Energy Analyst
International Energy Agency

Stephen D'Esposito
President and Chief Executive Officer
RESOLVE

Rohitesh Dhawan
President and Chief Executive Officer
International Council on Mining
and Metals

Jeff Donahue
Natural Resources Industry Executive
and Investor

Roderick Eggert
Professor; Viola Vestal Coulter Foundation
Chair In Mineral Economics; Deputy
Director Of Critical Materials Institute
Colorado School of Mines

Jonathan Elkind
Senior Research Scholar
Center on Global Energy Policy

Jeffrey F. Kupfer
Adjunct Professor
Carnegie Mellon University

Alex Fitzsimmons
Head of Government Affairs
Sila Nanotechnologies Inc

Greg Gershuny
Executive Director,
Energy & Environment Program
The Aspen Institute

Heidi Heitkamp
Former United States Senator

Maureen Hinman
Chairman and Cofounder
Silverado Policy Accelerator

Robert Johnston
Senior Research Scholar
Columbia University Center on
Global Energy Policy

Melanie Kenderdine
Principal
Energy Futures Initiative

Tae-Yoon Kim
Energy Analyst
International Energy Agency

Niamh King
Director
Aspen Strategy Group and
the Aspen Security Forum

Daniele La Porta
Global Head of Sustainability and ESG,
Gerald

Tamara Lundgren
Chairman,
President and Chief Executive Officer
Schnitzer Steel Industries, Inc.

Brian Menell
Chairman & CEO
TechMet Ltd.

Timothy Mister
Head of Credit and Royalties
Appian Capital Advisory

Tom Moerenhout
Adjunct Associate Professor of
International and Public Affairs;
Adjunct Associate Research Scholar of
International and Public Affairs
Columbia University

Guilherme Oliveira
Scientific Director
Vale Institute of Technology

Rich Powell
Chief Executive Officer
ClearPath

David Sandalow
Inaugural Fellow
Columbia University Center on
Global Energy Policy

Sridhar Seetharaman
Vice Dean for Research and Innovation
Fulton Schools of Engineering
Arizona State University

Yang Shao-Horn
JR East Professor of Engineering
Massachusetts Institute of Technology

Dan Steingart
Stanley-Thompson Professor of
Chemical Metallurgy in the Department
of Earth and Environmental Engineering
and Professor of Chemical Engineering
Columbia University

Greg Walden
Former Member of Congress and
Former Chairman,
Energy and Commerce Committee

Alan West
Samuel Ruben-Peter G. Viele Professor of
Electrochemistry and Professor of
Earth and Environmental Engineering
Columbia University

Abby Wulf
Vice President and Director,
Center for Critical Minerals Strategy
Securing America's Future Energy

Signing Statements

Amrita Dasgupta, Tae-Yoon Kim, International Energy Agency

"In March 2022, the IEA was given a Ministerial mandate by its member governments to deepen its work on critical minerals. In April 2023, the G7 Ministers committed to a Five-Point Plan for Critical Minerals Security that the IEA will support, including by producing medium- and long-term outlooks for critical minerals demand and supply, to help informed decision making. In response to these requests, the IEA plans to strengthen further its market monitoring and outlook work for critical minerals and provide policy recommendations to enhance market transparency."

Andy Blackburn, Niron Magnetics

We strongly concur with Recommendation 5. Accelerating production of critical minerals is a necessary but insufficient condition for a successful energy transition. Without significant innovation in the engineering of new cost-effective and sustainable materials and more cost-effective and sustainable mining and processing of existing critical minerals, the transition will be slowed and negative environmental and social impacts will be elevated.

A key role for government is fostering innovation in new material science and engineering. Accelerated investment in development of innovative substitutes can disrupt existing material supply chains that are overly dependent on unsustainable resources, environmentally damaging processes and unfriendly nations. This is particularly true for rare earths used to make permanent magnets where China dominates in both market share and production costs and, according the US Department of Commerce, no amount of mining investment will close the competitive gap. However, sustainable and affordable new materials are now coming to market can change the game - without any mining.

Government policymakers should use three approaches to minimize potential harms from accelerated mining of minerals for legacy technologies: 1) Mining and processing should have increasingly strict environmental targets to encourage clean process innovation, 2) Government funding programs to encourage development and production of critical minerals should apply equally to substitutes (including tariffs or subsidies that can disadvantage new materials if only applied to legacy materials), 3) The government should aggressively invest in development and scaling of substitute materials and methods that reduce or eliminate toxic mining and processing or drive down costs.

Rahim Bapoo, BMO Capital Markets

This report is the culmination of a robust investigation that I am proud to have been involved in.

Global economies are taking meaningful steps to enhance critical mineral supply chains. However, extraordinary action is required to achieve the critical minerals targets associated with 1.5°C climate goals. Several such actions are listed in this report. It is crucial that these actions be taken using an equitable approach that engages local communities and indigenous groups.

Private industry will need to act decisively to build the robust system of mines, refineries, processing plants and recycling facilities required to support the global energy transition. For national security reasons, this system should have both redundancy and diversification. In order to promote the development of this sector, governments should focus on capital markets. Clear policy that directly addresses key investor concerns related to the unique risks and market-failures associated with the critical minerals and mining complex has the potential to marshal the resources required for the extraordinary results that are envisioned. In the absence of such focus, gaps are likely to widen.

Endnotes

[1] USGS. "U.S. Geological Survey Releases 2022 List of Critical Minerals." February 22, 2022.

[2] Moerenhout, Glynn, and Lee. Forthcoming.

[3] Benchmark Minerals. "More than 300 new mines required to meet battery demand by 2035." September 6, 2022.

[4] Azevedo, Marcelo, etc. "The raw-materials challenge: how the metals and mining sector will be at the core of enabling the energy transition." *McKinsey & Company.* January 10, 2022.

[5] Ibid.

[6] S&P Global. "The Future of Copper." July, 2022.

[7] Azevedo, Marcelo, etc. "The raw-materials challenge: how the metals and mining sector will be at the core of enabling the energy transition." *McKinsey & Company.* January 10, 2022.

[8] International Energy Agency. "The Role of Critical Minerals in Clean Energy Transitions." May, 2021.

[9] Kip Keen. "Growing mining industry dividends, buybacks going 'too far'." S&P Global. June 13, 2022. Gupta, Himangi, Siddharth Periwal, Oliver Ramsbottom, and James Whitecross. "How to navigate mining's cash-flow conundrum." *McKinsey & Company.* February 22, 2022.

[10] Ernst and Young. "Critical minerals supply and demand challenges mining companies face." April 25, 2022.

[11] Moores, Simon. "Albemarle's turbo-charged demand data showcases lithium's growing supply problem." *Benchmark Minerals.* 26 January 2023.

[12] International Energy Agency. "The Role of Critical Minerals in Clean Energy Transitions." May, 2021. S&P Global. "The Future of Copper." July, 2022. Callaway, Greg, etc. "Could supply-chain issues derail the energy transition?" *McKinsey & Company.* December 5, 2022.

[13] Bhanduri, Nikhil, etc. "Batteries: the greenflation challenge." Goldman Sachs. March 8, 2022.

[14] BloombergNEF. "Lithium-ion Battery Pack Price Rises for the First Time to an Average of $151/kwH." December 6, 2022.

[15] International Energy Agency. "Global Supply Chains of EV Batteries." July, 2022.

[16] Ibid.

[17] Mandavia, Megha. "Battery Metal Prices Fall Back to Earth." *Wall Street Journal.* February 28, 2023.

[18] Boer, Lukas, Andrea Peskatori, Martin Stuermer, and Nico Valckx. "Soaring Metal Prices May Delay the Energy Transition." *International Monetary Fund.* November 10, 2021.

[19] Garside, M. "Use of copper and copper alloys in the United States in 2022, by purpose." *Statista.* February 16, 2023.

[20] United States Environmental Protection Agency. "Emergency Response to August 2015 Release from Gold King Mine."

[21] BBC. "Vale dam disaster: $7b compensation for disaster victims." February 4, 2021.

[22] Ibid.

[23] Burton, Melanie. "Lynas' Malaysia rare earth plant faces part closure as regulator keeps curbs." *Reuters.* February 13, 2023. Guardian. November 22, 2021.

[24] Morales, Laurel. "For The Navajo Nation, Uranium Mining's Deadly Legacy Lingers." NPR. April 10, 2016.

[25] The Economist. "How the World Depends on Small Cobalt Miners." July 5, 2022.

[26] Responsible Minerals Initiative.Trafigura. "Accelerating transition: the case for formalising artisanal and small-scale mined cobalt in the DRC."

[27] "Average observed lead times from discovery to production for selected minerals, 2010-2019." International Energy Agency. May 3, 2021.

[28] "Permitting, economic value, and mining in the United States." National Mining Association. Jun 19, 2015.

[29] Ibid.

[30] "Hard Rock Mining." United States Government Accountability Office. Jan, 2016.

[31] "Permitting, economic value, and mining in the United States." *National Mining Association*. Jun 19, 2015.

[32] Ibid.

[33] The role of critical minerals in clean energy transitions." International Energy Agency. May, 2021.

[34] Ibid.

[35] Ibid.

[36] Ibid.

[37] "Why crashing lithium prices will not make electric cars cheaper." *The Economist*. Apr 20, 2023. Burton, Mark et al. "LME halts nickel trading after unprecedented 250% spike." *Bloomberg News*. Mar 8, 2022.

[38] Boer, Lukas, Andrea Pescatori and Martin Stuermer. "Energy Transition Metals." *International Monetary Fund.* Oct 12, 2021.

[39] "Minerals Commodity Summaries 2023." *USGS*. Jan 31, 2023.

[40] Ibid.

[41] Nugent, Ciara. "What Would Happen if South America Formed an OPEC for Lithium." *Time.* Apr 18, 2023.

[42] Attwood, James. "Peru's Violent Protests Imperil 30% of Its Copper Output." *Bloomberg News.* Jan 27, 2023.

[43] Roberts, Martin. "Resource nationalism in West Africa." *S&P Global.* May 8, 2023.

[44] Home, Andy. "Tin spooked by threat of supply disruption in Myanmar." *Reuters.* Apr 17, 2023.

Hendrix, Cullen. "Indonesia wants to sell nickel to the US, but first it should scrap its export ban." *Peterson Institute for International Economics.* Apr 26, 2023.

[45] Lipton, Eric, Dionne Searcey and Michael Forsythe. "Race to the Future: What to Know About the Frantic Quest for Cobalt." *New York Times.* Dec 7, 2021.

[46] Benefo, Angela and Michael Addaney. "Promises and Pitfalls: China's Financing of the Atewa Bauxite Mining Project in Ghana." *Georgetown Journal of International Affairs*. Jul 11, 2021.

[47] Bazilian and Hendrix. (2022), "Markets for Critical Minerals Are Too Prone to Failure".

[48] "Federal Support for U.S. Mining Schools." Society for Mining, Metallurgy and Exploration.

[49] "Update on the continuing functions of the former US Bureau of Mines." United States Centers for Disease Control.

[50] Denina, Clara, Helen Reid, and Ernest Scheyder. "Analysis: Miners face talent crunch as electric vehicles charge up metals demand." *Reuters.* Dec 10, 2023.

[51] Ibid.

[52] "Rare Earths." *USGS.*

Endnotes

[53] Bradsher, Keith. "Amid Tension, China Blocks Vital Exports to Japan." *New York Times.* Sep 22, 2010.

[54] Kowalski, Przemyslaw and Clarisse Legendre. "Raw materials critical for the green transition: Production, international trade and export restrictions." *OECD Trade Policy Papers.* Apr 11, 2023.

[55] Bush, Nathan, Sammy Fang, John Zhang and Ray Xu. "China's New Export Control Law." *DLA Piper.* Oct 18, 2020.

[56] Lelyveld, Michael. "China Raises Threat Level Over Rare Earths." *Radio Free Asia.* Jan 29, 2021.

[57] Tabeta, Shunsuke. "China weighs export ban for rare-earth magnet tech." *Nikkei Asia.* Apr 6, 2023.

"China Has Rare Earths Plan Ready to Go If Trade War Deepens." *Bloomberg News.* May 30, 2019.

[58] Areddy, James T. "Xi Jinping Flexes China's Trade Muscle With Visit to Rare-Earths Hub." *Wall Street Journal.* May 21, 2019.

[59] "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth." *The White House.* Jun, 2021.

[60] Nguyen, Mai and Siyi Liu. "RPT-Chinese copper demand revs up, but banking rout could cap prices." *Reuters.* Mar 19, 2019.

[61] Garside, M. "Refined nickel consumption volume in China 2010-2021." *Statista.* Jun 21, 2022.

"China import and export of lithium carbonate and lithium hydroxide in first two month of 2023." SMM. Mar 22, 2023.

"Lithium." *USGS.*

"Cobalt Market Report 2021." Cobalt Institute. May, 2022.

"Cobalt." *USGS.*

"Manganese." *USGS.*

[62] "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth." *The White House.* Jun, 2021.

[63] "Rare Earths." *USGS.*

"Lithium." *USGS.*

"Cobalt." *USGS.*

"Manganese." *USGS.*

[64] Siegler, Kirk. "In Idaho, America's first, and only, cobalt mine in decades is opening." OPB. Oct 8, 2022.

[65] "Manganese." *USGS.*

[66] "U.S. sets mineral import reliance record." *Minerals Make Life.* Feb 8, 2023.

[67] Allan, Bentley, Noah Gordon and Cathy Wang. "Friendshoring critical minerals : What could the U.S. and its partners produce?" *Carnegie Endowment for International Peace.* May 3, 2023.

[68] "Nickel." *USGS.*

[69] Ho, Yudith and Eko Listiyorini. "Chinese Companies Are Flocking to Indonesia for Its Nickel." *Bloomberg News.* Dec 15, 2022.

[70] Lee, Annie. "China Lithium giant expands in Argentina with $962 million deal." *Bloomberg News.* Jul 11, 2022.

[71] "Building cleaner, faster." Aspen Institute. Jun 2021.

[72] Ibid.

[73] "Permitting Council announces first-ever critical minerals mining project to gain FAST-41 coverage." *Permitting Council Press Office.* May 8, 2023.

[74] "Tribal Energy Loan Guarantee Program." *DOE Loan Programs Office.*

[75] Will, K. Sophie. "Energy loan program for tribal lands remains untapped." *Roll Call.* Apr 4, 2023.

[76] "About Strategic Materials." *Defense Logistics Agency.*

[77] Chapell, Clifton G. et al. "Defense national stockpile center: America's stockpile: An organizational history." *Defense Logistics Agency.*

[78] "U.S. Departments of Energy, State, and Defense to launch effort to enhance national defense stockpile with critical minerals for clean energy technologies." *DOE Office of International Affairs.* Feb 25, 2022.

[79] Harris, Bryant. "Congress and Pentagon seek to shore up strategic mineral stockpile dominated by China." *Defense News.* May 23, 2023.

[80] "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth." *The White House.* Jun, 2021.

[81] "Summary of the fiscal year 2023 National Defense Authorization Act." *Unites States Senate Committee on Armed Services.*

[82] Snydacker, David. "Can sodium-ion batteries work for mainstream RVs?" *LinkedIn.* May, 2023.

[83] "Global Supply Chains of EV Batteries." International Energy Agency.

[84] "The role of critical minerals in clean energy transitions." *International Energy Agency.* May, 2021.

[84] "Nickel." *USGS.*

[85] "Cobalt." *USGS.*

[86] Hale, Thomas. "The United States needs more than mining engineers to solve its critical minerals challenges." *Center for Strategic and International Studies.* May 8, 2023.

[87] Ibid.

[88] Banta, Jodi, Isable Barton and Lynnette Hutson. "Where have all the mining engineering students gone?" *Mining engineering.* Feb, 2021.

[89] Barrasso, John. "S.3915 – Mining Schools Act of 2022." United States Senate. Mar 24, 2023.

"US Department of Labor announces $10.5 funding availability to support mine safety, health, training, education." *Mine Safety and Health Administration.* Apr 14, 2023.

[90] "Standards and Regulations." *Mine Safety and Health Administration.*

"Mineral mining and processing effluent guidelines." *Environmental Protection Agency.*

[91] "U.S. International Development Finance Corporation (DFC)." *USA Spending.*