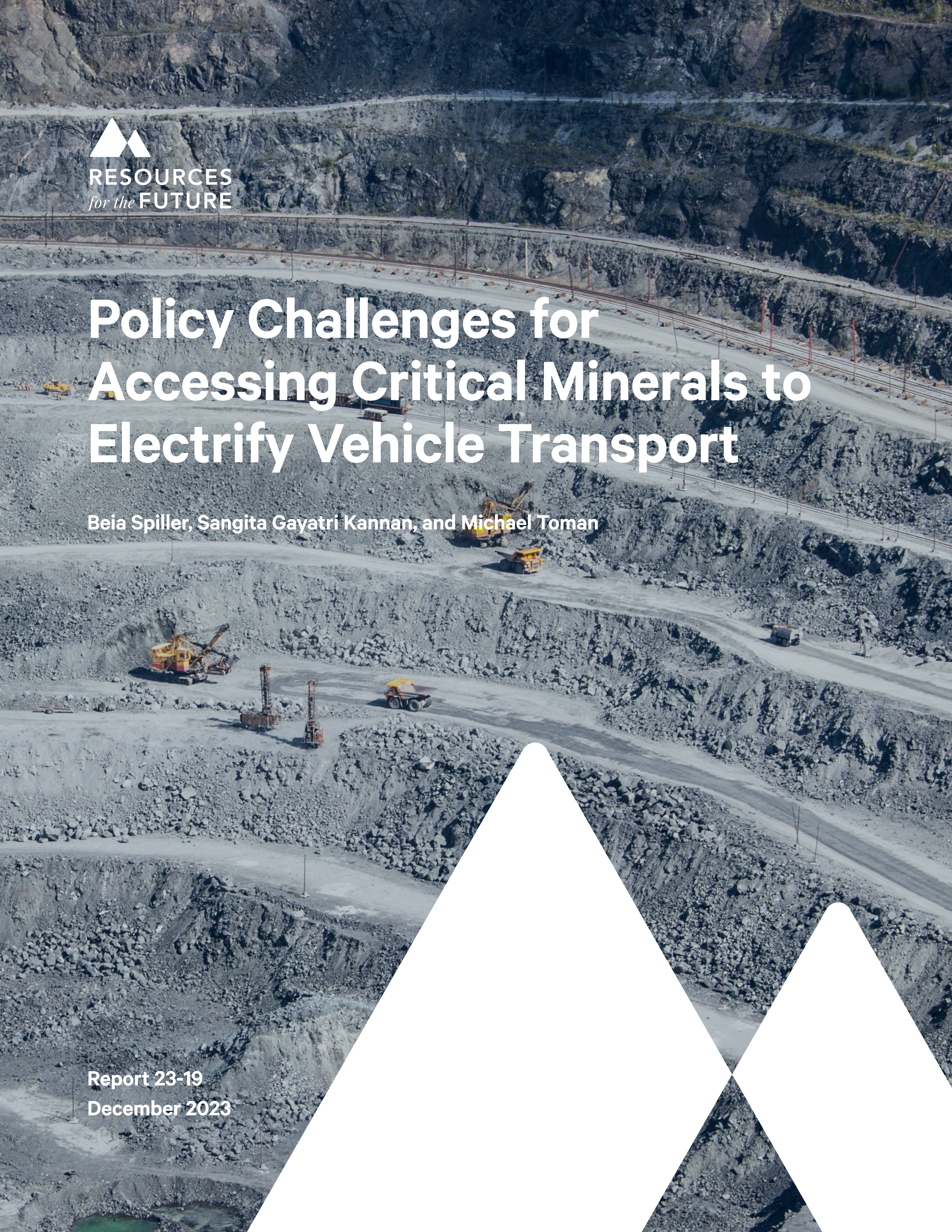


RESOURCES
for the FUTURE

Policy Challenges for Accessing Critical Minerals to Electrify Vehicle Transport

Beia Spiller, Sangita Gayatri Kannan, and Michael Toman

Report 23-19
December 2023

About the Authors

Beia Spiller is a fellow and the director for Resources for the Future's (RFF) Transportation Program. Prior to joining RFF, she was Lead Senior Economist at Environmental Defense Fund (EDF), where she worked for almost a decade. She is also a Board member for the Association of Environmental and Resource Economists. Spiller is an energy economist, with experience working on electricity and transportation issues. During her time at EDF, she participated in many electric utility proceedings in New York and California, with a goal of ushering in a cleaner, more efficient and equitable energy system. She also has many years of experience working in the transportation sector. Her more recent efforts have focused around electric vehicles and environmental justice, exploring some of the most pressing issues around electric car, truck and bus adoption. Her publications range across the energy space, with a large focus on identifying environmental, community and health impacts of renewable energy resources and energy policies.

Sangita Gayatri Kannan is a PhD student in the Mineral and Energy Economics (MEE) program at Colorado School of Mines (CSM) and was a 2023 RFF summer intern. She researches the various aspects of the critical minerals supply chain and has a keen interest in the role of critical minerals in the energy transition toward renewable energy. She holds a masters in MEE from CSM and a bachelors in chemical engineering from Anna University, India.

Michael Toman returned to RFF as a senior fellow in 2021 after stints at the World Bank Development Research Group, RAND Corporation, and the Inter-American Development Bank. Mike served as a Senior Staff Economist at the White House Council of Economic Advisers from 1994–1996. His current research interests include reduction of agricultural greenhouse gas emissions, critical minerals for decarbonization, markets for emission reduction credits, and climate change policies in developing countries. Mike has a BA from Indiana University, a MSc in applied mathematics from Brown University, and MA and PhD degrees in economics from the University of Rochester.

About RFF

Resources for the Future (RFF) is an independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. RFF is committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy.

The views expressed here are those of the individual authors and may differ from those of other RFF experts, its officers, or its directors.

Sharing Our Work

Contents

1. Introduction

Transition by the United States to a decarbonized economy by the middle of the century must include transportation, which today accounts for a little less than 30 percent of US greenhouse gas (GHG) emissions and over one-third of total CO_2 emissions (EPA 2023; EIA 2023). Among the options for decarbonizing ground transportation, current policy emphasizes increased electric vehicle use along with decarbonizing the power grid and further advances in electric vehicle (EV) technology, especially for EV batteries.

Current EV battery designs use significant quantities of so-called critical minerals, specifically lithium, cobalt, manganese, nickel, and graphite. Radically increasing global production and purchases of EVs with these battery designs will lead to order-of-magnitude increases in demand for these minerals (IEA 2022). However, as discussed in Section 2, critical minerals tend to be found mainly in a handful of countries outside the United States. Moreover, the capacity for processing extracted minerals into forms suitable for use in manufacturing EV batteries is highly concentrated in one country, China.

Thus, there are substantial concerns about perceived risks to future affordability and reliability of the supplies of these minerals because of the geographic concentration of the supply chains and the economic and political power that dominant mineral suppliers could wield. Another concern is about mineral price volatility, including large price shocks of uncertain duration, which would complicate planning and management for both battery and vehicle manufacturers. Moreover, critical mineral supplies can be increased and diversified only after lengthy periods for exploration and development of new mineral reserves, as well as construction of new processing facilities. In short, the response of critical mineral supplies to higher prices generally is highly inelastic, at least until enough time has elapsed for mineral extraction and processing capacity to expand. As noted in Section 3.4, in the United States that interval often is many years.

This paper explores these challenges in greater detail and highlights implications for US policy toward critical minerals. Section 2 reviews key geographic characteristics of critical minerals and uncertainties regarding expanding their supplies within the United States. Section 3 examines critical mineral policies in the United States and their limitations. The final section identifies some priorities for developing critical mineral policy and filling knowledge gaps.

2. The Geographic Distribution of Critical Mineral Production and Reserves

Understanding the geographic distribution of critical mineral production and reserves is important for two key reasons. First, it provides a backdrop for understanding the consequences of market concentration. Concentration across the supply chain increases economic risks from possible disruptions leading to volatile prices. There is also concern among many stakeholders about the potential threat to national security from geopolitically-motivated deep cuts in supply by dominant suppliers.[1]

Second, it demonstrates the amount of critical minerals extracted and exported from fragile and conflict-affected regions and from sources with inadequate environmental safeguards. As shown in Sections 2.1 and 2.2 , significant quantities of production and reserves for some of the critical minerals that are the focus of this paper are in regions of the world that are economically unstable, prone to conflict, and have a history of corruption and human-rights violations, as well as a lack of environmental standards. This has been a concern, for example, with the significant share of cobalt coming from the Democratic Republic of Congo (DRC; see, e.g., Nkumba-Umpula et al. 2021 for a discussion of environmental and social challenges of cobalt production in the DRC).

2.1. Global Supply Patterns for the Critical Minerals Used in EV Batteries

Figures 1 and 2 show the shares of extraction and processing of critical minerals by country in 2021. Figure 1 shows that extraction is highly concentrated for cobalt, natural graphite, and lithium, with one or two suppliers providing over 70 percent of global supplies.[2] Manganese and nickel extraction are somewhat less concentrated. These figures are just a snapshot in time and do not account for how extraction could become more diversified as aggregate supply expands.

1 Examples of issues from direct state involvement in the sector include an Indonesian export ban on nickel ore that has been in place since 2014 (Reuters 2014) and Chile's announced intent to nationalize its lithium industry (Reuters 2023).

2 Synthetic graphite is an alternative to natural graphite.

Figure 1a. Geographic Distribution of Critical Mineral Extraction for EV Batteries, 2021

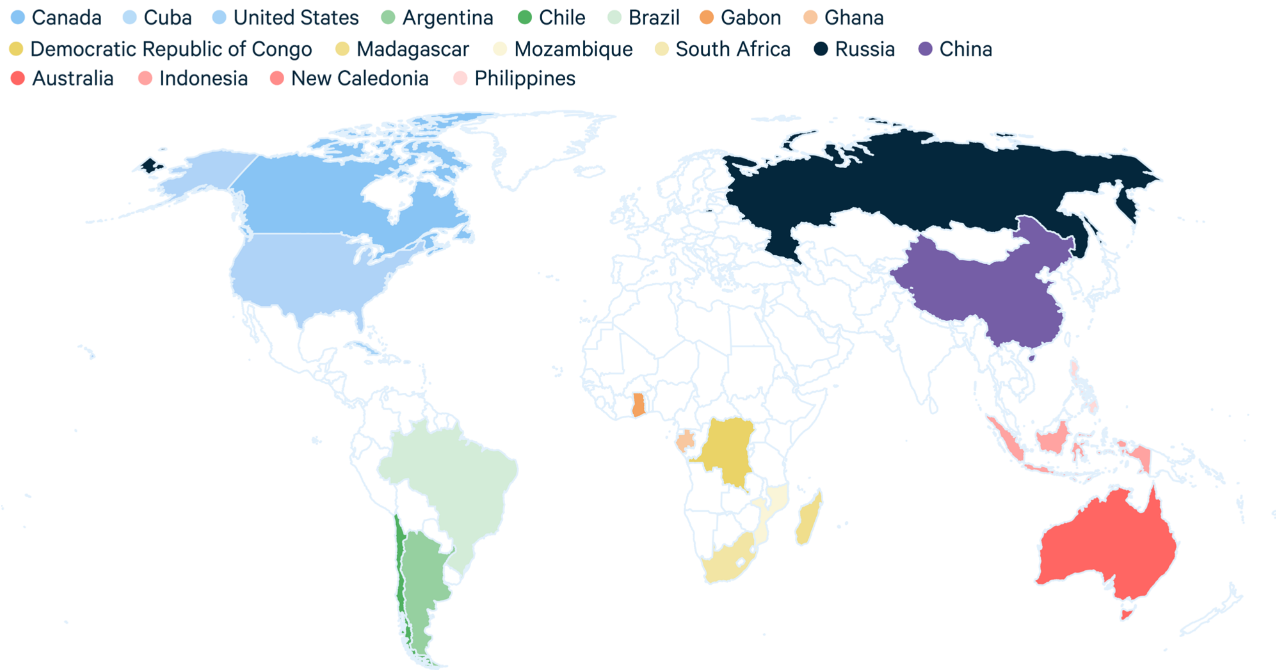
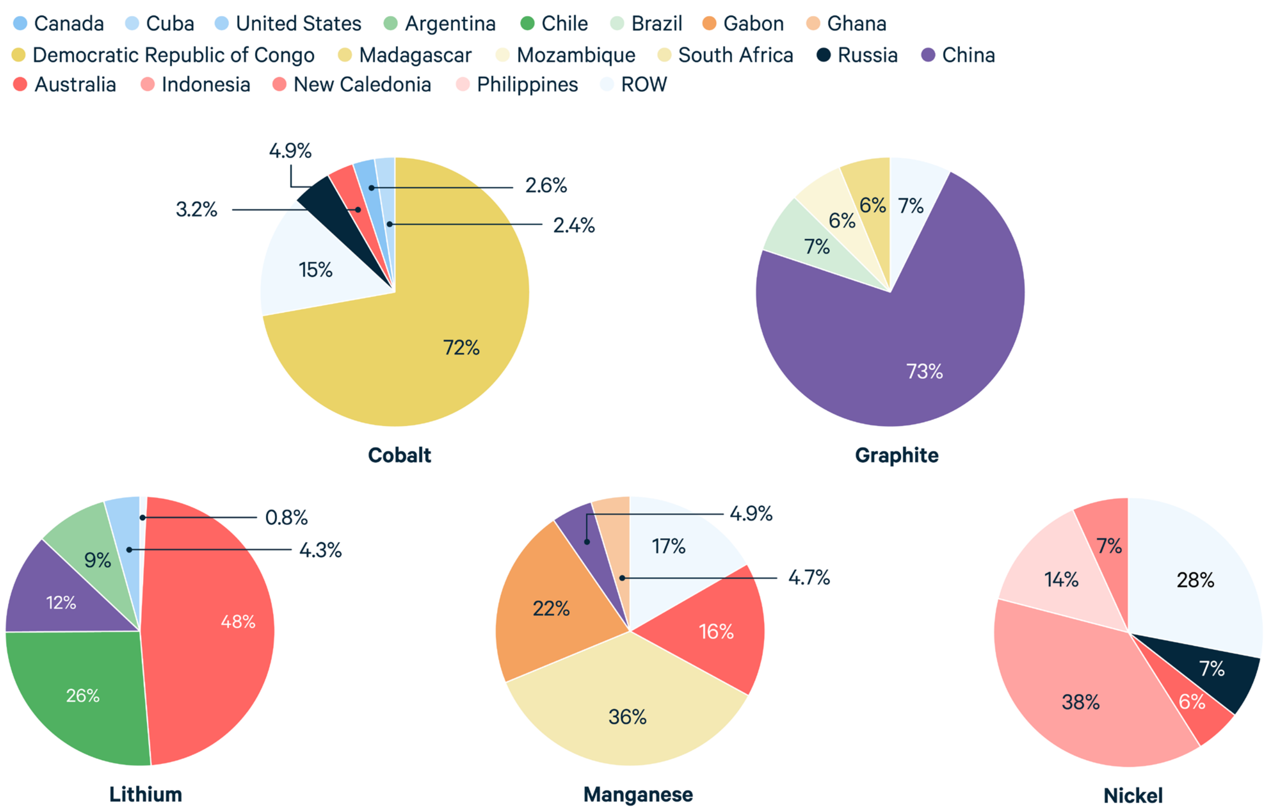


Figure 1b. Shares of Critical Mineral Extraction by Country, 2021



Sources: Estimates based on USGS (2023); NMIC (n.d.); Idoine et al. (2023); Reichl and Schatz (2023).

Figure 2a. Geographic Distribution of Critical Mineral Processing for EV Batteries, 2021

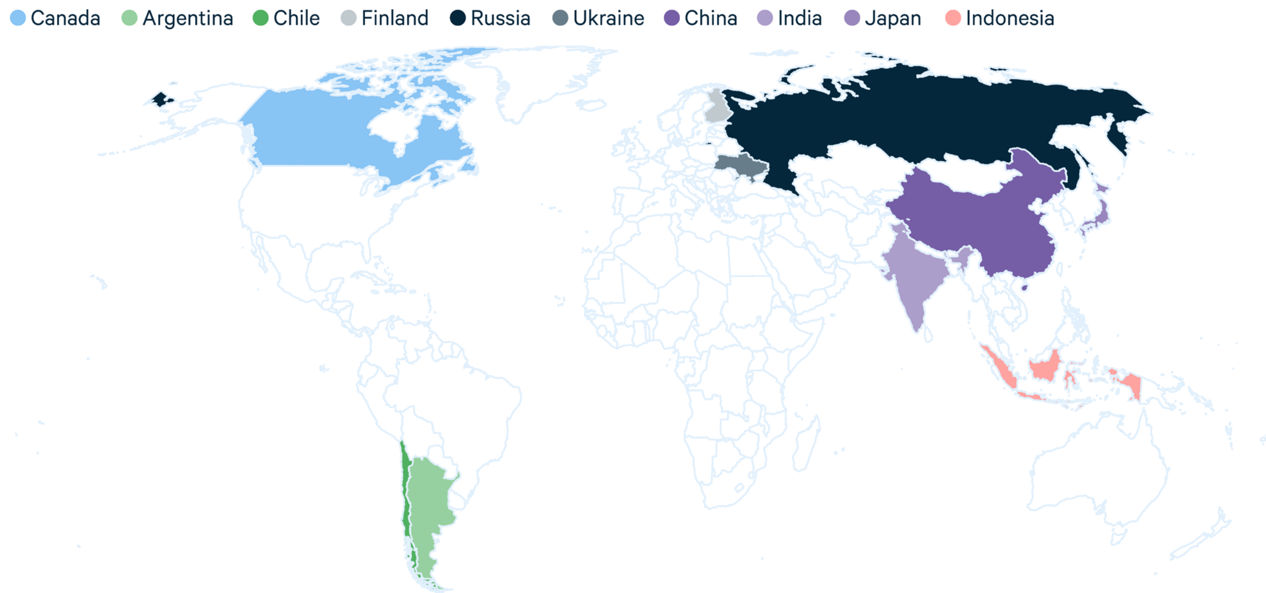
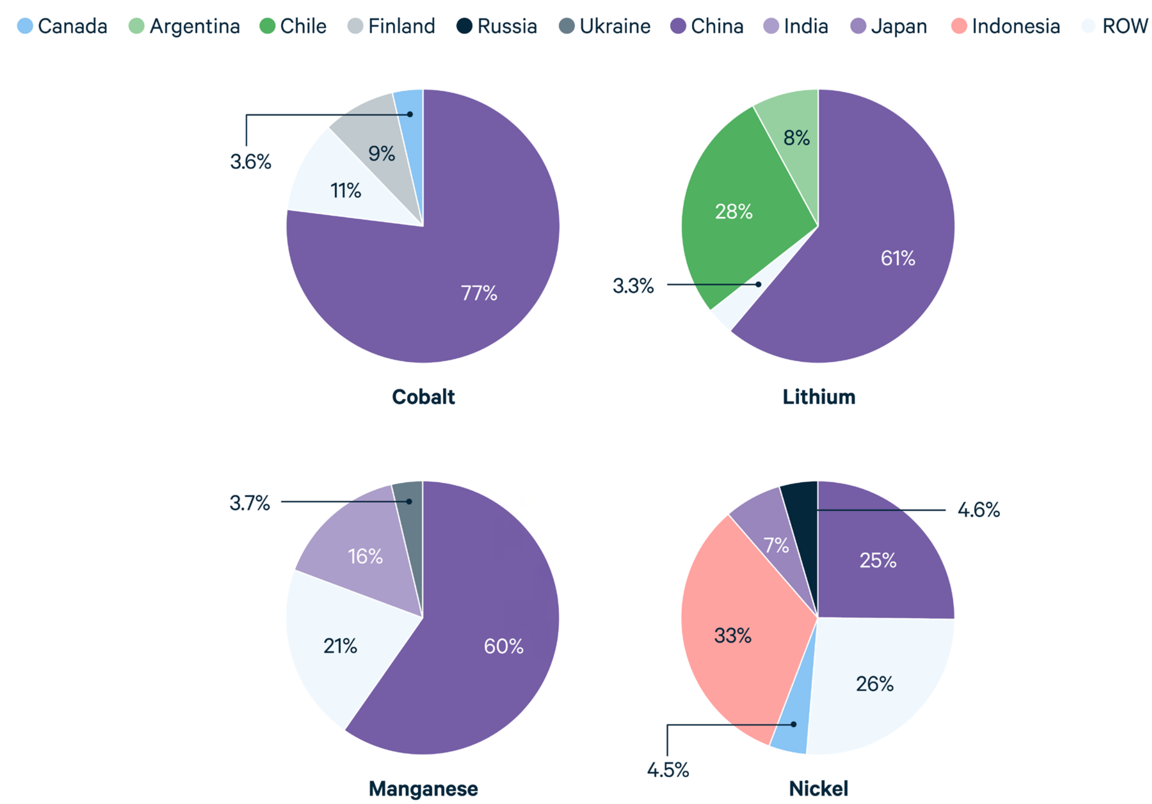


Figure 2b. Shares of Critical Mineral Processing by Country, 2021



Sources: Estimates based on USGS (2023); NMIC (n.d.); Idoine et al. (2023); Reichl and Schatz (2023).

Note: Natural graphite data are not available for the processing stage.

It is important to note that except for natural graphite, China does not have high shares for extraction of these critical minerals. However, China has made significant capital investments in critical mineral extraction companies in other countries, both existing facilities and those that are expected to begin production soon. Lipton and Searcey (2022) report that, as of 2020, Chinese-backed companies owned or had a financial stake in 15 of 19 cobalt-producing mines in the DRC. Table 1 lists some examples of Chinese-owned lithium and cobalt facilities.

Table 1. Examples of Chinese-owned Lithium and Cobalt-mining Facilities outside China

Critical mineral	Facility/company	Location	Percent ownership by Chinese firm
Lithium	Talison Lithium	Australia	Tianqi Lithium Energy Australia (a joint venture between IGO, Australia, and Tianqi Lithium, China), 51%
	Sociedad Química y Minera	Chile	Tianqi Lithium, 22.16%
	Mount Marion	Australia	Ganfeng Lithium, 50%
	Pilbara mine	Australia	Ganfeng Lithium, 6.16%
	Sonora Lithium Project	Mexico	Minera Sonora Borax S.A. de C.V. (a wholly owned subsidiary of Ganfeng Lithium), 100%
	Mariana Lithium Project	Argentina	Ganfeng Lithium, 100%
	Cauchari-Olaroz	Argentina	Ganfeng Lithium, 46.67%
Cobalt	Tenke Fungurume Mining	Democratic Republic of Congo	CMOC Group, 80%

Sources: SQM (2022); Tianqi Lithium (2023); Ganfeng Lithium (n.d.); Tang and Chen (2023).

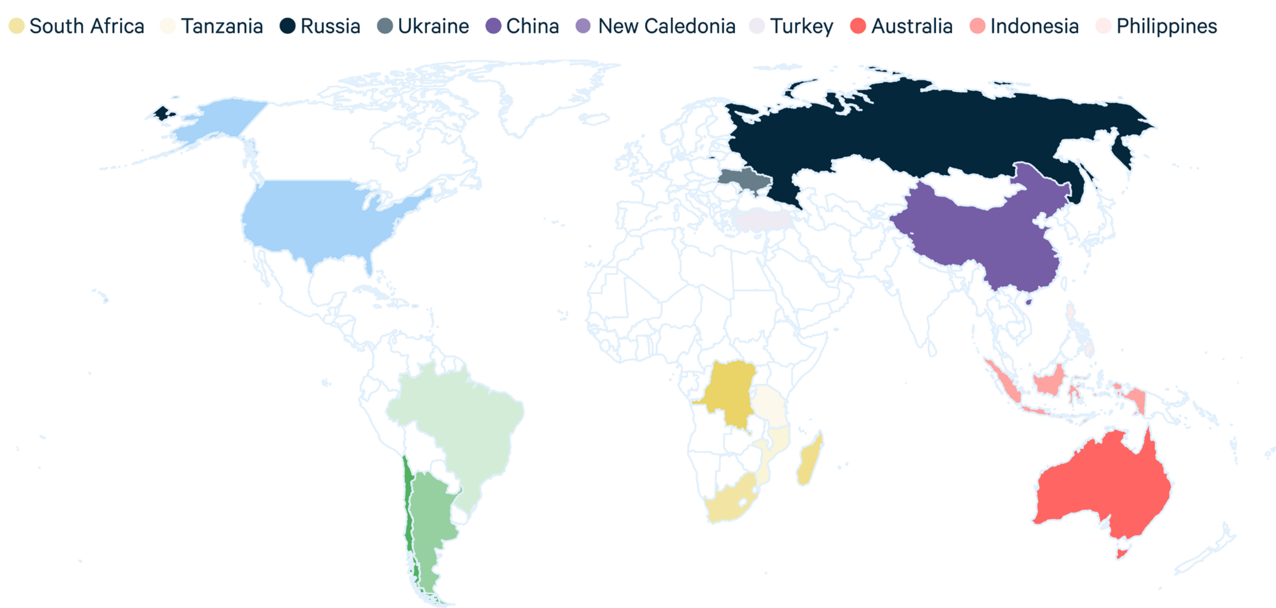
Figure 2 shows that critical mineral processing also is highly concentrated, with China providing about 60–75 percent of all processed cobalt, lithium, and manganese. China and Indonesia together provide almost 60 percent of the processing capacity for nickel.[3] Following Indonesia's export ban on nickel ore, Chinese companies invested $14.2 billion over the last decade for the construction of industrial parks that include nickel smelters in two Indonesian islands with some of the largest known nickel reserves in the world (Ho and Listiyorini 2022).

In the appendix, we provide numerical indicators of the levels of concentration in both stages (extraction and processing). Overall, these statistics demonstrate that the United States contributes little to global extraction of these critical minerals and is highly reliant on imports of processed minerals.

2.2. Distribution of Critical Mineral Reserves

Statistics on mineral reserves can provide an indication of the supply potential from already identified sources once extraction and processing capacities have expanded.[4] Figure 3 shows that reserves of the critical minerals for EV batteries are less concentrated than current production, suggesting the potential for diversifying sources of supply. However, as seen in Table 2, the share of reserves in the top three countries exceeds 55 percent. The share of reserves in fragile and conflict-affected countries varies among the critical minerals.

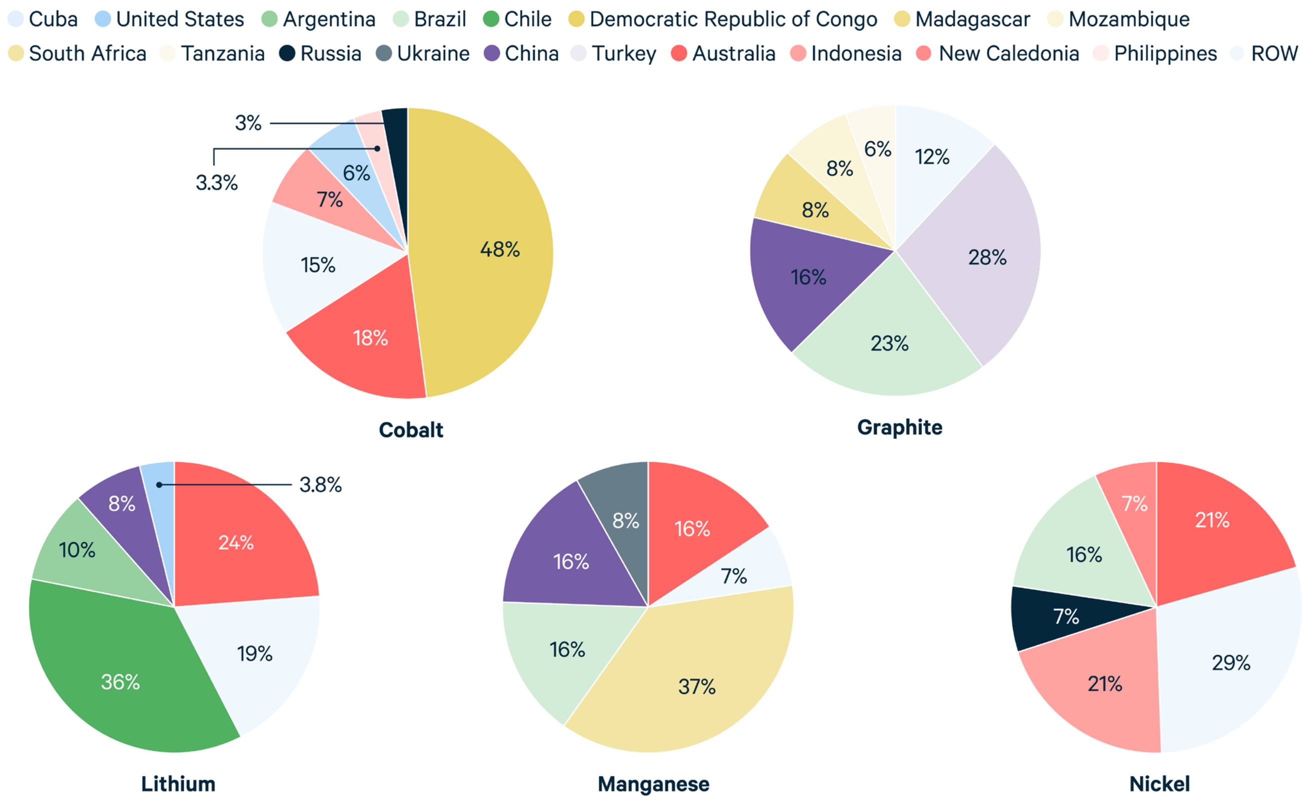
Figure 3a. Geographic Distribution of Critical Mineral Reserves for EV Batteries, 2023



3 This is significant in light of China's substantial involvement as an investor in Indonesia's nickel sector (Tritto 2023).

4 USGS also provides rougher estimates of mineral resources that indicate their long-term physical availability.

Figure 3b. Shares of Reserves of Critical Minerals for EV Batteries by Country, 2023



Source: Estimates based on USGS (2023).

Table 2 also shows that the United States has a small share of reserves for these minerals. Even if extraction from those reserves were to greatly increase, the United States will have to cooperate with other countries to diversify its supplies. This will remain the case even if US reserves can be increased through exploration, unless the increase is outsize.

Moreover, even if sources of extracted minerals were to diversify, investment in mineral-processing capacity in other countries would be necessary to increase diversification of processed mineral outputs for use in EV batteries. However, diversifying processing capacity is complicated and will take time. China's dominance in critical mineral processing is the result of a longer-term industrial policy that allocated capital investment to critical minerals notwithstanding a somewhat modest rate of return. With this investment, China has optimized several processing technologies through learning by doing, and the country has accumulated significant human capital in the industry with lower labor costs relative to developed economies.[5]

5 Less stringent environmental regulations may also be a factor; in the case of rare earth elements, for example, Hurst (2010) found that lax environmental regulation in China's rare earth extraction has helped keep prices down.

Table 2. Shares of Reserves of Critical Minerals for EV Batteries

Critical mineral	Share of reserves in the United States (%)	Share of reserves in top three countries (%)	Share of reserves in fragile and conflict-affected countries[a]
Cobalt	0.8	73	52.7
Graphite (natural)	Negligible	67	21.7
Lithium	3.8	70	1.2
Manganese	0	69	12.0
Nickel	0.4	57	7.3

Sources: Estimates based on reserves data from USGS (2023), and Worldwide Governance Indicators (WGI) from Kaufmann and Kraay (2021).

[a] In this analysis, fragile and conflict-affected countries are those listed in World Bank (2023) and those that have an average score of <–0.5 in World Bank's WGI (Kaufmann and Kraay 2021), including political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. WGI indicators are on a scale of –2.5 to 2.5 and cover 229 countries.

2.3. Challenges of Increasing Mineral Supplies in the United States

Though the United States has a small share of known reserves, exploration could lead to their expansion in the future. There is also concern about the time it takes to identify technically and economically viable new reserves and increase extraction in the United States, where the process sometimes can exceed a decade . Many stakeholders claim that this extended timeline is due to permitting delays, including the time needed for preparation and approval of an Environmental Impact Statement (EIS) or Environmental Assessment (EA) to comply with the National Environmental Policy Act (NEPA).

The process to develop and initiate operation of a producing mine involves several permitting steps. The company first needs to explore land to discover and identify locations that have potential reserves to be extracted. To do this, it must file a plan of operation with the relevant agency, such as the Department of the Interior's Bureau of Land Management (BLM) or the Department of Agriculture's Forest Service (USFS). During the exploration phase, the agency conducts an EA as required to comply with NEPA, which generally takes a relatively short time (about one year) because of the limited land disturbance of exploration activities. However, the company must also undergo permitting at the state and local levels during this phase. Importantly, exploration is an iterative process in which most iterations are unsuccessful, causing the company to have to resubmit a new plan of operation, thus necessitating more approvals at the local and federal levels (and potentially a new EA, depending on the extent of the exploration). Once the company is successful in its exploration phase, it submits a plan of operations for building the mine to a lead permitting agency (BLM or USFS). This process is then usually subject to an EIS, consistent with NEPA requirements.

The company must acquire permits from various agencies, depending on the location and impact of the mine. Mining projects on US federal lands must obtain a total of 30 or more permits from federal, state, and local bodies (SNL Metals & Mining 2016). For example, the company will need permits from the US Environmental Protection Agency related to water and air pollution, and if the mine is within endangered species habitat or will affect US waters, it will also need permits from the US Fish and Wildlife Service or the US Army Corps of Engineers, respectively.

3. US Critical Mineral Policies and Their Limitations

The discussion in Section 2 showed that (a) the United States realistically cannot avoid depending on some other countries for future critical mineral supplies; (b) future extraction of critical minerals for EV batteries can be more diversified than current extraction; (c) diversification of critical mineral processing, which is now highly concentrated, is needed, and that poses several challenges; and (d) possibilities for expanding domestic production quickly are limited, given the small share of US reserves. In this section, we discuss different policies that the United States has implemented or is exploring to increase and diversify critical mineral supplies.

3.1. Federal Support for New Critical Mineral Technologies

The US government has increased R&D support for novel critical mineral supply technologies, consistent with the widely accepted view that knowledge gained from R&D is a public good. For example, the Infrastructure Investment and Jobs Act, passed in November 2021, appropriates $7.9 billion for battery manufacturing, recycling, and critical mineral supplies.[6] This includes the $3 billion Battery Materials Processing Grant Program for the support, construction, and improvement of battery material

6 This includes the $3 billion Battery Materials Processing Grant Program for the support, construction, and improvement of battery material processing demonstration projects and facilities. It also includes a $3 billion grant program for the support, construction, and improvement of battery component manufacturing and recycling demonstration projects and facilities.

processing demonstration projects and facilities. It also includes a $3 billion grant program for the support, construction, and improvement of battery component manufacturing and recycling demonstration projects and facilities.[7]

A presidential determination was issued in March 2022 permitting the use of DPA Title III authorities to strengthen the US industrial base for large-capacity batteries, making DPA funding available for critical minerals needed in EV batteries. However, it remains unclear whether support similar to DPA Title III awards will be sufficient to bring online and help sustain significant domestic production of critical minerals, especially if market conditions become challenging because of measures enacted by incumbent players. For example, Jervois Mining's cobalt project in Idaho had been expected to begin production earlier in 2023. However, the company announced suspension of operations, citing low cobalt market prices and US inflationary pressures (Stevenson 2023). Despite suspension of operations, in June 2023, Jervois Mining USA received a $15 million DPA Title III award to enable the company to undertake mineral resource drilling to expand the currently known cobalt resource base.

3.2. Cooperation and Leadership in International Partnerships

Given the small share of reserves in the United States, international cooperation needs to be a fundamental part of policy strategy for increasing and diversifying critical mineral supplies. An example of such cooperation is the Partnership for Global Infrastructure and Investment (PGII) initiative, launched at the G7 summit in June 2022. The initiative aims to mobilize $600 billion by 2027 for infrastructure investments in developing countries.[8] The PGII has four priority areas, one of which is climate and energy security. This includes developing clean energy supply chains, which involves "responsible mining of metals and critical minerals" and "investing in new global refining, processing, and battery manufacturing sites " (White House 2022).

7 The DOE's LPO has made several investments or commitments that include a $102 million loan for the expansion of a graphite-based anode material manufacturing facility in Louisiana; a conditional loan commitment of $2 billion for the construction and expansion of a battery materials campus in McCarran, Nevada; and a conditional loan commitment of $9.2 billion for the construction of three manufacturing plants in Tennessee and Kentucky to produce batteries for Ford Motor Company's future EVs. An example of DOD funding is the effort to support cobalt production from Jervois Mining USA's project in Idaho.

8 Through the PGII, the United States has facilitated a strategic partnership between TechMet, supported by a US International Development Finance Corporation equity investment, and Lifezone Metals, which has announced an agreement with the Tanzanian government to open a multimetal processing facility for nickel and other critical minerals mined in Tanzania.

The Minerals Security Partnership (MSP), launched in June 2022, is another international program that seeks to diversify global critical mineral supplies.[9] It works with host governments and industry to provide targeted technical, political, and financial support to mining, processing, and recycling projects that maintain high environmental, social, and governance (ESG) standards (DOS 2023). The projects do not have to be located within the MSP countries to receive this support. The MSP partner governments and their institutions may choose to provide support for projects proposed by private companies. The MSP advocates for high ESG standards recognized internationally in a general sense, but the enforcement of ESG standards is left to the discretion of the individual participating countries. "Internationally recognized ESG standards" is loosely defined and could raise subjective disagreements among the MSP participating countries, going forward.

3.3. The Inflation Reduction Act

The Inflation Reduction Act (IRA) uses tax breaks and trade restrictions to influence the direction of critical mineral expansion. These include tax breaks for domestic critical minerals under the clean production provisions of the act (IRA Section 13501) and indirect inducements by conditioning the size of EV tax breaks on whether the critical minerals come from the United States or countries with which it has a free trade agreement (FTA; IRA Section 13401). Under the Clean Vehicle Tax Credit (30D) in Section 13401, a $3,750 credit is available for EVs that meet certain manufacturer's suggested retail price (MSRP) limits if the applicable percentage of the value of the critical minerals contained in the battery was extracted or processed in the United States or a country with which it has an FTA or was recycled in North America. An extra $3,750 credit is provided if the applicable percentage of the value of the battery components was manufactured or assembled in North America. The applicable percentage starts at 40 percent in 2023 and increases gradually to 80 percent in 2027 and beyond. To be eligible for the tax break, starting in 2024, qualifying vehicles' batteries also cannot contain any components manufactured or assembled by a foreign entity of concern (China, Russia, Iran, or North Korea), and starting in 2025, cannot contain any critical minerals extracted, processed, or recycled by any of these entities.

As shown in Table 3, only a fraction of total extraction and processing comes from the United States and FTA countries. Given how long it takes to develop new mines (discussed in Section 2.3), it will likely be difficult for automakers to find sufficient critical minerals so that their vehicles will be eligible for the tax credits.

Moreover, the IRA implicitly creates incentives for auto manufacturers to develop larger batteries through its Advanced Manufacturing Production Tax Credit, which provides battery manufacturers a tax credit of $35 per kilowatt-hour (kWh) of battery cell capacity and significantly more credits based on kWh capacity of the battery modules. The production of larger batteries will in turn increase demand for critical minerals.

9 More countries have since been added. As of September 2023, MSP partners include Australia, Canada, Finland, France, Germany, India, Italy, Japan, Norway, the Republic of Korea, Sweden, the United Kingdom, the United States, and the European Union (represented by the European Commission).

Table 3. Shares of Global Production and Reserves from Countries Eligible for IRA Tax Credits

Critical mineral	Share of global production from US + FTA (%)		Share of reserves in US + FTA countries (%)
	Extraction stage	Processing stage	
Cobalt	7.6	8.7	21.6
Graphite (natural)	2.2	NA	1.5
Lithium	78.4	28.8	66.9
Manganese	17.4	7.0	16.0
Nickel	11.1	18.5	23.1

The provisions of the IRA also may conflict with the MSP. Because the IRA provides tax credits only for manufacturers that obtain their minerals domestically or from FTA countries, it excludes many countries that are currently part of the MSP. Yet because the MSP focuses on improving ESG practices in other countries, the MSP countries may provide more environmentally and socially sustainable minerals than some FTA countries. Furthermore, acquiring critical minerals from FTA countries may be costlier than acquiring them from MSP countries. More broadly, manufacturers need more clarity on the definition of FTAs under the IRA. The definition of FTAs continues to evolve, yet manufacturers make decisions in advance about which EV battery chemistries to use and from which countries to source these critical minerals (particularly given the prevalence of long-term supply agreements).

The IRA EV tax credit restrictions based on the provenance of critical minerals will require major changes in market structure over a fairly short period of time for new EVs to be eligible for the tax credits. In the meantime, these restrictions will likely increase EV prices, especially in the short run, given fixed costs associated with changing battery technologies. This is a challenge because price competitiveness is important in the emerging EV market. Buyers may not be willing to pay a large premium for critical minerals not coming from China (though the magnitude of this willingness to pay remains to be seen), and ultimately, if manufacturers can create cheaper EVs with minerals processed in China, the IRA provisions may lose their bite.

3.4. Permitting Reform

Given the extensive policy conversations around the delayed timeline for developing a mine into production, it is necessary to identify what parts of the permitting process create unnecessary delays to identify policy solutions to accelerate the process. In 2022, the federal government launched an Interagency Working Group on Mining Reform, led by the DOI. The working group issued a report that presents and examines a variety of evidence on factors influencing the effectiveness of mining governance structures, including substantial public input from the industry, environmental organizations, and other actors (IWG 2023).

An important information source is a US Government Accountability Office review (GAO 2016) that examined approvals of plans of operation for hardrock mining projects (both proposed new mines and mine expansions) between 2010 and 2014. The GAO found that for 68 mine plans, the BLM and USFS took, on average, 2 years to approve a plan (more than half were approved in under 18 months; the maximum was over 11 years). The GAO analysis did not cover plans of operation for exploration, which precede plans of operation for production. Most of the reviewed projects did not have all approvals completed by 2015, due in part to the need to obtain other permits at the federal and state levels. The GAO's report found 13 key challenges that increased the time required to achieve operational status, of which the top three were (a) poor-quality information provided in the mining companies' plans; (b) a lack of agency resources, in terms of budgets and expert staffing, for conducting these approvals; and (c) expansions in mine plans after initial submission, necessitating additional review. This finding indicates that both agency circumstances and industry decisions influence the duration of approval processes.

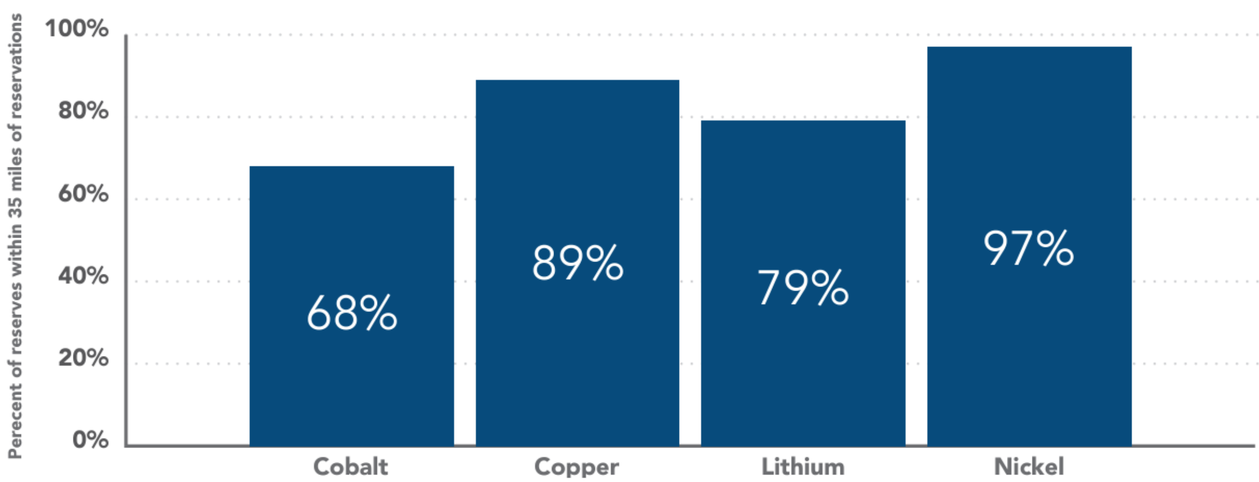
The IWG carried out its own analysis of permitting times by BLM and USFS for new mine operations (but not mine expansions), using EPA NEPA records over longer time periods (since 2000 or 2013). It found a somewhat longer average approval time than in the GAO analysis, about 4.5 years (median approval times are lower since averages are raised by a few projects with long approval times). This is about the same as average approval times across all agencies for projects involving an EIS.

A major challenge in assessing the duration of mining applications is that when an agency calculates the number of years to finalize permitting, it may (a) include or exclude the permitting related to exploration, (b) include permitting for exploration as part of or separate from the overall permitting process, and (c) include or exclude the permitting required by other agencies or at the state and local levels. Having a common definition of what is involved in the permitting process and providing the most comprehensive information possible (including exploration and mine permitting and all agencies and different levels of government) will allow for a better understanding of barriers to mine development and solutions to overcome them.

Opposition by other stakeholders is also frequently mentioned as a challenge and source of delay associated with bringing mines into production. In the United States, participants in the review process have the opportunity to comment on or oppose the process at any time: during the exploration phase, during the EA and EIS, and through litigation after a decision has been made.[10] Some critics state that environmental NGOs, community groups, and others opposed to a project can challenge NEPA decisions by engaging in prolonged and sequential litigation activities in an effort to outspend the mining company and kill the project. To our knowledge, however, there is no systematic review of the record of mining permitting litigation by an independent party to affirm or negate that this is a regular occurrence.

IWG (2023, p. 61-62) also notes that federal approaches for mine permitting provide opportunities for public comment only at certain points in the NEPA review. Yet, experience has demonstrated the importance of early, effective, and transparent engagement with affected communities (IWG 2023, p. 64). Accordingly, both agencies and mining companies will need to carefully consider how they approach public engagement. Recent research has found that most mineral resources in the United States are within 35 miles of Native American reservations (see Figure 4), so early engagement with Native American communities will be particularly important for any domestic mining project.

Figure 4. Percentages of US Critical Mineral Reserves within 35 Miles of Native American Reservations, 2021



Source: Aspen Institute (2023).

10 Since litigation over NEPA can start only after the EIS has been conducted and a decision is made, delays from litigation are different than delays due to the time required to process a permitting application, the focus in the previous paragraphs.

The IWG recommendations include the following:

- providing clearer direction and encouraging early agency engagement with prospective developers
- increasing coordination among the DOI, USFS, and other state agencies involved in permitting
- encouraging early and meaningful community and stakeholder engagement while establishing strong requirements for Tribal consultation on proposals
- developing legislative options to establish a hardrock mining leasing system, versus the mining claim approach in the 1872 mining law
- imposing royalties on hardrock mineral production on federal lands

4. Conclusions

Some policy challenges are common to all the critical minerals currently used in EV batteries, while others pertain more to certain minerals. Generally, to increase affordability and reliability of supplies of these minerals, the emphasis needs to be on global diversification of critical mineral supplies, not just on increasing US production. Given the small size of reserve estimates in the United States and the costs of domestic supplies, US production likely will remain limited unless and until there is a major increase in domestic reserves due to exploration efforts or technological innovation.

The Minerals Security Partnership could be a promising model for diversifying critical mineral extraction, depending on how consistent and effective its project evaluation process turns out to be. An ongoing analysis of that issue and other elements of the program as it develops would be useful. There also is a need for a more thorough comparison of the potential impacts of the MSP, with a program focused primarily on expanding free trade agreements.

Diversifying options for critical mineral processing will be more challenging than diversifying mineral extraction. China is a low-cost supplier of processed minerals, given its overall economic structure, the scale of its processing sector, the recovery of past capital investment costs, and its technological capabilities in the sector derived from lengthy experience. The governments of the United States and other industrialized countries will have to make difficult decisions about whether to provide ongoing financial support, and how much, so that new processing facilities facing competition from China can be financially viable.

Would the benefits of doing so justify the costs? It is difficult to say, because much remains uncertain regarding the scale of the mineral security challenge. How likely is it that an extended critical mineral supply restriction might occur? What would be the economic and other consequences of such a supply restriction? To what extent might countries that buy critical minerals act collectively to deter dominant-supplier market power?[11]

IWG (2023) observes that there are methods for effectively and responsibly addressing stakeholder opposition to mining projects. These would involve early engagement with affected communities (including Native communities) to identify risks from proposed mining operations, mitigate those risks, and propose revenue-sharing agreements. This approach reduces delays and improves fairness.

To better assess the magnitude of the permitting challenges for mining and highlight approaches to mitigating them, it would be useful to have additional data on factors that may influence permitting times in the United States at different levels of government and across different agencies. Data also are needed on the impacts of local governments' regulations and permitting processes.

Finally, knowledge gaps exist regarding critical minerals. These include data on production and reserves (claims) on federal lands and on royalties for minerals extracted from nonfederal lands. More information on patterns of foreign direct investment and ownership in the critical mineral sector also would be useful to better understand its scale and the resulting influence on critical mineral supplies.

11 This is one important dimension of discussions in the EU around the possibility of a critical mineral "buyers club." See, e.g., Hendrix (2023) for a discussion of these clubs and some of the challenges they face.

Appendix: Concentration Indicators for Critical Mineral Supply Chains

The global supply chains of critical minerals used in EV batteries are concentrated in both the extraction and processing stages, with higher concentration in the processing stage, as indicated by the global Herfindahl-Hirschman Index (HHI) numbers in Table A.1. Among the five minerals analyzed, cobalt has the highest HHI in both stages. The table shows that the United States is an insignificant global producer for almost all these critical minerals and is highly reliant on imports for most of them. The imports are also less diverse because of concentrated global supply chains. The supply chains for these critical minerals are therefore vulnerable to supply chain disruptions, voluntary or not. Table A.1 shows that China dominates the global processing sector for these minerals, with global production shares exceeding 25 percent.

Table A.1. Shares of Global Production and Reserves from Countries Eligible for IRA Tax Credits

Critical mineral	Extraction stage					Processing stage (primary production)				
	US share of global production (%)	US import reliance (%)	China's share of global production (%)	Top 3 producers' share of global production (%)	Global HHI for extraction	US share of global primary production (%)	US import reliance (%)	China's share of global primary production	Top 3 producers' share of global production (%)	Global HHI for processing
Cobalt	0.4	NA[a]	1.3	80	5,286	0	100	77	89	6,027
Graphite (natural)[b]	0	100	73	86	5,437	—	—	—	—	—
Lithium	4.3	E	12	86	3,220	1	38	61	97	4,572
Manganese	0	100	5	74	2,094	Negligible	100	60	79	3,863
Nickel	0.7	E	4.0	60	2,073	0[c]	100	25	65	1,855

Sources: Estimates based on USGS (2023); NMIC (n.d.); Idoine et al. (2023); Reichl and Schatz (2023).

Note: Import reliance is calculated as (imports – exports) / apparent consumption. HHI is measured at the country level. A market with HHI >2,500 is highly concentrated; one with HHI of 1,500–2,500 is moderately concentrated. E = export oriented (the United States exports all domestically mined nickel and lithium to other countries for processing).

[a] Not applicable because the United States does not refine cobalt ores and concentrates, and hence they are not imported.

[b] Data for natural graphite is available only at the extraction stage.

[c] The United States produces some nickel as refinery byproduct, which is not included in primary production.

References

Aspen Institute, Energy & Environment Program. 2023. *A Critical Minerals Policy for the United States: The Role of Congress in Scaling Domestic Supply and De-Risking Supply Chains*. **https://www.aspeninstitute.org/wp-content/uploads/2023/06/Critical-Minerals-Report.pdf**.

DOS (US Department of State). 2023. "Minerals Security Partnership." **https://www.state.gov/minerals-security-partnership/#:~:text=The%20Minerals%20Security%20Partnership%20(MSP,projects%20along%20the%20value%20chain**.

EIA (US Energy Information Administration). 2023. "Energy and the Environment Explained: Where Greenhouse Gases Come From." Last updated August 22, 2023. **https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php**.

EPA (US Environmental Protection Agency). 2023. "Transportation Sector Emissions." Last updated October 5, 2023. **https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#transportation**.

Ganfeng Lithium. n.d. Pilbara, Australia, Spodumene. Accessed November 16, 2023. **https://www.ganfenglithium.com/aboutz_en/id/2.html**.

GAO (US Government Accountability Office). 2016. *Hardrock Mining: BLM and Forest Service Have Taken Some Actions to Expedite the Mine Plan Review Process but Could Do More*. GAO 16-165. **https://www.gao.gov/assets/gao-16-165.pdf**.

Hendrix, C. 2023. *Why the Proposed Brussels Buyers Club to Procure Critical Minerals Is a Bad Idea*. Report PB 23-6. Peterson Institute for International Economics. **https://www.piie.com/sites/default/files/2023-05/pb23-6.pdf**.

Ho, Y., and E. Listiyorini. 2022. "Chinese Companies Are Flocking to Indonesia for Its Nickel." Bloomberg. **https://www.bloomberg.com/news/articles/2022-12-15/chinese-companies-are-flocking-to-indonesia-for-its-nickel?sref=B2BBHw9t#xj4y7vzkg**.

Hurst, C. 2010. *China's Rare Earth Elements Industry: What Can the West Learn?* Institute for the Analysis of Global Security (IAGS). **http://www.iags.org/rareearth0310hurst.pdf**.

Idoine , N. E., E. R. Raycraft, F. Price, S. F. Hobbs, E. A. Deady, P. Everett, R. A. Shaw, E. J. Evans, and A. J. Mills. 2023. *World Mineral Production 2017–21*. Nottingham, UK: British Geological Survey. **https://nora.nerc.ac.uk/id/eprint/534316/**.

IEA (International Energy Agency). 2022. *The Role of Critical Minerals in Clean Energy Transitions*. **https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions**.

IWG (Interagency Working Group on Mining Laws, Regulations, and Permitting). 2023. *Recommendations to Improve Mining on Public Lands*. Washington, DC: Department of the Interior. **https://www.doi.gov/sites/doi.gov/files/mriwg-report-final-508.pdf**.

Kaufmann , D., and A. Kraay. 2021. World Governance Indicators, 2021 Update. World Bank. **https://info.worldbank.org/governance/wgi/**.

Lipton, E., and D. Searcey . 2022. "Chinese Company Removed as Operator of Cobalt Mine in Congo." *New York Times*, February 28, 2022. **https://www.nytimes.com/2022/02/28/world/congo-cobalt-mining-china.html#:~:text=The%20ruling%2C%20which%20removes%20Chinese,the%20Chinese%20owner%2C%20China%20Molybdenum**.

National Mining Association. 2016. “Permitting, Economic Value and Mining in the United States.” London: SNL Metals & Mining. **https://nma.org/wp-content/uploads/2016/09/SNL_Permitting_Delay_Report-Online.pdf**.

NMIC (National Minerals Information Center). (Various years) *Mineral Yearbooks*. Vol. 1, Metals and Minerals. Washington, DC: US Geological Survey. Accessed 10/24/2023. **https://www.usgs.gov/centers/national-minerals-information-center/minerals-yearbook-metals-and-minerals**.

Nkumba-Umpula, E., A. Buxton, and B. Schwartz. 2021. *Islands of Responsibility? Corporate Sourcing of Artisanal Cobalt in the Democratic Republic of Congo*. London: IIED. **https://www.iied.org/20436iied**.

Reichl, C., and M. Schatz. 2023. *World Mining Data 2023*. Vol. 38, *Minerals Production*. **https://world-mining-data.info/wmd/downloads/PDF/WMD2023.pdf**.

Reuters. 2014. “Indonesia Bans Mineral Ore Exports, All Eyes on Nickel Impact.” CNBC. **https://www.cnbc.com/2014/01/11/indonesia-bans-mineral-ore-exports-but-may-allow-some-shipments.html**.

———. 2023. “Chile Plans to Nationalize Its Vast Lithium Industry.” CNBC. **https://www.cnbc.com/2023/04/21/chile-plans-to-nationalize-its-vast-lithium-industry.html**.

SNL Metals & Mining. 2016. *Permitting, Economic Value and Mining in the United States*. **https://nma.org/wp-content/uploads/2016/09/SNL_Permitting_Delay_Report-Online.pdf**,

SQM (Sociedad Química y Minera de Chile). 2022. *Annual Report, 2022*. **https://s25.q4cdn.com/757756353/files/doc_financials/2022/ar/sqm-2022-annual-report.pdf**.

Stevenson, I. M. 2023. “Jervois Cobalt Mine in Idaho Halts Work before Production.” *Idaho Statesman*, March 21, 2023. **https://www.idahostatesman.com/news/northwest/idaho/article273790660.html**.

Tang, J., and L. Chen. 2023. “China’s CMOC, Gécamines Reach Resolution on DR Congo Copper-Cobalt Mine.” S&P Global. **https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/041923-chinas-cmoc-gcamines-reach-resolution-on-dr-congo-copper-cobalt-mine**.

Tianqi Lithium. 2023. “About Us.” **https://www.tianqilithium.com.au/site/About-Us/company-overview**.

Tritto, A. 2023. “How Indonesia Used Chinese Industrial Investments to Turn Nickel into the New Gold.” Carnegie Endowment for International Peace. **https://carnegieendowment.org/2023/04/11/how-indonesia-used-chinese-industrial-investments-to-turn-nickel-into-new-gold-pub-89500**.

USGS (US Geological Survey) 2023. Mineral Commodities Summary 2023. **https://doi.org/10.3133/mcs2023.**

White House. 2022. “Fact Sheet: President Biden and G7 Leaders Formally Launch the Partnership for Global Infrastructure and Investment.” June 16, 2022. **https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/26/fact-sheet-president-biden-and-g7-leaders-formally-launch-the-partnership-for-global-infrastructure-and-investment/**.

World Bank. 2023. *FY23 List of Fragile and Conflict-Affected Situations*. **https://thedocs.worldbank.org/en/doc/a91e714e0a53291b569c4a41981aa2c5-0090082023/original/FCSList-FY06toFY23.pdf**.