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CRITICAL MINERALS AND GREAT POWER COMPETITION

An Overview

JIAYI ZHOU AND ANDRÉ MÅNBERGER

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE

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STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE

Signalistgatan 9
SE-169 70 Solna, Sweden
Telephone: +46 8 655 97 00
Email: sipri@sipri.org
Internet: www.sipri.org

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Preface

Great powers have always sought to organize the world in their interests, influencing production systems and value chains well beyond their individual borders. That is a large part of why colonial empires were built. Today, amid renewed global turbulence, division and competition between the great powers and their respective allies are increasingly influencing policy and action beyond the military-industrial sector, reaching into the wider economy. This politicizes supply chains, including those in clean energy, advanced technology and other strategic emerging industries. Securing the mineral inputs that are necessary for all these downstream applications has thus become a subject of growing attention by great powers. Understanding how they define and pursue mineral security is, therefore, essential for better understanding and anticipating key trends in commerce and international security.

This report contributes to that wider understanding. In assessing critical and strategic mineral policies of China, the European Union, Russia and the United States, it covers both national and cross-national dynamics that go well beyond the minerals sector. The authors—SIPRI's Jiayi Zhou and André Månberger of Lund University—thus provide a timely, fact-based input to better unpack the drivers and implications of the increasingly securitized and even weaponized web of economic relations between great powers. Their work also illuminates how security policy is simultaneously expanding into new domains and returning to conceptualizations reminiscent of the cold war. As they highlight, discussion of mineral security must be global in scope, but is too often national in approach. With its broader approach and its close attention to the evidence, the report offers a foundation for dialogue on how to approach issues that are matters of both economic and security policy.

Dan Smith
Director, SIPRI
Stockholm, October 2024

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Executive summary

Minerals are fundamental inputs for industrial economies and are increasingly necessary for states and other polities to progress technologically, to transition to cleaner sources of energy, and to remain economically and even militarily competitive. Connected to these goals, mineral security has become a significant and growing subject of policy attention. However, recent efforts by governments to secure mineral resources are taking place in the shadow of wider geopolitical and geoeconomic tensions. Emerging mineral security strategies are entangled in that wider competition. This report surveys mineral security as it is considered and pursued by four major powers: China, the European Union (EU), the Russian Federation and the United States. In doing so, it also offers insights into how their strategies interact and, indeed, the degree to which the pursuit might exacerbate or mitigate the broader tensions between them.

While there is overlap between the four cases, there are also differences. This is notable in both the conceptualization and formal assessments of the importance of various minerals. The assessments of the EU and the USA centre primarily around 'criticality'—a concept that encapsulates a mineral's supply vulnerability in addition to its strategic or economic importance. China and Russia instead organize their priority lists in terms of 'strategic' value, reflecting in part comparative advantage and leverage in their resource capacities for important mineral supply chains. However, both also include minerals for which scarcity and (import) supply dependence are of significant policy concern.

Different minerals on priority lists also reveal important divergences in economic and political priorities. China's focus on bulk industrial minerals (e.g. iron) reveals continued concern for basic industrialization. The EU and US lists feature the more specialized minerals needed for advanced and emerging technologies. Notably, both China and Russia continue to emphasize fuel minerals, the former as a major global importer and the latter as an exporter.

While mineral security is a concern in its own right, it is the broader policy drivers and political imperatives for which mineral security is oriented and justified that determine how competition for minerals interacts with great power competition. These ends include, to varying degrees, national development and industrial policy, clean energy transition, economic security and competitiveness, and military defence. Although some of these are driven by geopolitical factors, others are much more domestically oriented. These pursuits have potential both for zero-sum competition and for shared positive-sum outcomes across the four cases. However, what is equally interesting are the ways in which these imperatives also work at cross-purposes domestically; for instance, more insular trade measures intended to enhance economic security sometimes work against the pace and scale of green transition.

The effective pursuit of mineral security, of course, is not only a matter of achieving explicit or implicit end goals. More fundamentally, it depends on how the subject of that security is demarcated. Although the focus is largely on individual states and polities—or governments—differing subjects of security inevitably give rise to the possibility that the pursuit of security for one polity may come at the expense of another. In consideration of these interaction effects, these varying state pursuits may work at cross-purposes and also may create or exacerbate insecurities or risks at the global level. Among these are risks for the green transition, the risk of geoeconomic escalation, and the risk of violent conflict and military confrontation. In the latter case, although minerals have significance for military-industrial supply chains increasingly oriented against each other, minerals themselves are not likely to precipitate or trigger interstate conflict. That being said, mineral resources can and have become part of wider political destabilization and territorial conflicts—for example, as Russia has done

in its activities in Africa and war in Ukraine. Resource-rich developing countries are thus inevitably caught in wider dynamics of great power competition both within and outside the minerals sector.

Several general recommendations can be made to channel mineral resource competition into more constructive, globally inclusive social, economic and political outcomes. Mineral resource competition has clearly become subsumed into wider geopolitical tensions, with the EU and the USA on one side and China and Russia on the other. This competition has become oriented towards more parochial—and often conflicting—strategic considerations. However, there may be avenues for positive global spillovers of mineral resource competition. This would require deeper and more inclusive partnerships with other actors, including developing countries, as well as multilateral institutions—particularly those that have much less stake in escalating great power competition and strategic tensions.

Overall, there remain many open questions and unknowns about how diverse mineral security strategies will interact over the coming decades; mineral security is a complex, multifaceted and multi-stakeholder pursuit entangled in both evolving geopolitics and technical dynamics. Taking an overview of the scope and contour of diverse mineral-securing strategies of great powers nevertheless provides some clarity in this regard.

Abbreviations

BRI	Belt and Road Initiative (China)
DOD	Department of Defense (United States)
DRC	Democratic Republic of the Congo
ESG	Environmental, social and governance (standards)
EU	European Union
FTA	Free trade agreement
GDP	Gross domestic product
IEA	International Energy Agency
IIJA	Infrastructure Investment and Jobs Act (United States)
IRA	Inflation Reduction Act (United States)
NDAA	National Defense Authorization Act (United States)
REE	Rare earth element
SEI	Strategic emerging industry (China)
SOE	State-owned enterprise
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WTO	World Trade Organization

1. Introduction

Amid the so-called fourth industrial revolution and unprecedented ecological challenges, the geopolitical landscape remains marred by dynamics reminiscent of the mid-20th century. Simultaneous advancement and entrenchment are also evident in the minerals sector, which provides the fundamental inputs for both technological progress and the green transition. While minerals are receiving growing policy attention, they have become subsumed into wider zero-sum competition, with countries increasingly focused on mitigating chokepoints and vulnerabilities, boosting self-sufficiency, and even resource mercantilism.

Efforts to secure supplies of various minerals have both been driven by and have accelerated wider trends of geopolitical fragmentation and bloc-formation—with Western states and their allies on one side and China and Russia on the other. Moreover, hardening consensus on the need to 'de-risk' from competitors' markets has heralded a reversal of the previous decades of global orthodoxy, in which economic integration was considered the foundation of mutual prosperity and peaceful international relations.[1] It marks a return of state intervention into the markets and supply chains of so-called critical or strategic minerals.

Indeed, mineral supply chains—from upstream geological exploration and extraction to downstream manufacturing—are increasingly shaped not by markets, but by policy frameworks formulated in national capitals. These frameworks are already beginning to concretely shape industry activities, trade flows and even technological innovations. Understanding the future trajectory of the minerals sector therefore requires commensurate analysis of evolving institutional and political landscapes. This includes, for instance, how states and polities define which minerals are critical or strategic; how mineral security as well as threats to it are evaluated and pursued; and how diverse and sometimes contradictory policy aims related to mineral supply chains interact. Furthermore, open questions remain regarding how the pursuit of mineral security might itself exacerbate or mitigate the geopolitical, economic and environmental challenges that are driving this very competition.

As a contribution to such analysis, this report provides an overview of policy perspectives in four centres of power: China, the European Union (EU), the Russian Federation and the United States. These four cases by no means represent a comprehensive picture of global mineral markets or capacity. Each polity is tied to a complex web of interdependencies, not only to each other but also to geographies beyond the scope of this report. However, their unique importance to the wider international order—economic, environmental and geopolitical—to which pursuit of mineral security has been connected is also of interest. While the China–USA strategic competition and tension has had the most glaring influence on recent developments in this space, the EU and Russia also play key roles in shaping the international landscape for minerals.

The following represents a qualitative analysis and review of the political landscape for mineral security among the four powers. It uses the term 'mineral security' to refer to the range of activities officially enacted or adopted by governmental authorities to enhance what they individually consider security as it relates to minerals. Notably, it uses the term agnostically: it describes rather than prescribes, without attempting to assess the appropriateness or efficacy of the minerals-related measures or goals of each of the polities.

[1] Zhou, J., Su, F. and Yuan, J., 'De-risking: The EU's and Japan's approaches to managing economic relations with China', SIPRI, Feb. 2024.

The analysis proceeds in chapter 2 by examining definitional issues, including how 'criticality' is understood in policy terms in China, the EU, Russia and the USA, as well as disaggregating their various lists of critical and strategic minerals. Chapter 3 presents a deeper dive into each of their national policy frameworks for mineral security. Chapter 4 then considers the diverse policy imperatives that drive mineral competition—including industrial policy, environmental concerns, economic security and competitiveness, and military matters. Chapter 5 reflects on several potential international risks and consequences of intersecting pursuits of mineral security, including possible impacts on developing countries, with conclusions following in chapter 6.

2. Mineral security: What is critical and for whom?

Mineral resources can be broadly categorized as inorganic elements or compounds in or on the earth's crust that are extracted for their economic potential. As a subset of strategic materials more broadly, governments have long been concerned with various mineral resources, whether as inputs for economic development, as tools of foreign policy or for national defence. While these minerals are naturally occurring, they are understood as a resource only in relation to human activity and value systems; that value is not inherent, but rather contingent on wider—and mutable—economic, social and political systems and structures.[2] At the same time, the uneven geographic distribution of mineral resources has played a significant role in shaping international relations, including conditions for war and peace, throughout the centuries.

Although geological conditions can be slow to change, the economic landscape for mineral resource competition has undergone important transformation in the past three decades. For example, processes of privatization in the 1990s and early 2000s significantly reduced the role of states and increased the role of transnational corporate control of mineral supply chains.[3] China—which barely registered in Western assessments of mineral security in the early 1990s—now dominates many key mineral markets, particularly in midstream processing.

Markets for specific minerals have also undergone change. Fuel minerals such as oil, gas and coal remain key inputs of contemporary energy systems—and continue to represent, by far, the largest share of global production value.[4] However, their importance is declining in relative terms, as governments and industries increasingly turn their attention to metals essential for clean energy technologies, including lithium, cobalt, nickel, copper and rare earth elements (REEs). This brings to the fore the diversity of minerals. Individual mineral categories are not the focus of this report, but it is important to acknowledge the need to differentiate them. Minerals differ in their geological availability, their chemical and physical properties, and their industrial and in some cases non-industrial functions. Some critical or strategic minerals serve as key, irreplaceable components in a range of technological, energy and military applications. Other minerals have also more financial or speculative value.[5]

The market structures for individual minerals are also diverse.[6] Some are globally traded, that trade being governed by well-established regulatory frameworks, and with high liquidity and more universal pricing schemes. The trade in other minerals, particularly those that are essential for emerging technologies, is quite new and less transparent; they may be traded in relatively small quantities, in transactions between specific suppliers and buyers that are not publicly disclosed.[7] Unregistered flows present a data challenge as well as a policy challenge. Some identified critical or strategic minerals are only byproducts of extracting other metals; their availability is thus dependent on that of the more economically significant base metals or minerals.[8]

[2] Barteková, E. and Kemp, R., 'National strategies for securing a stable supply of rare earths in different world regions', *Resources Policy*, vol. 49 (Sep. 2016).

[3] World Bank, Oil, Gas and Mining Unit, *Overview of State Ownership in the Global Minerals Industry: Long Term Trends and Future*, Extractive Industries for Development Series no. 20 (World Bank: Washington, DC, May 2011).

[4] World Mining Data, 'Minerals—Backbone of the economy', 2023; and Statista, 'Mining—Worldwide', 2024.

[5] Krol-Sinclair, M. J., 'Bring commodities market regulators into the critical minerals discussion', Center for Strategic and International Studies (CSIS), 23 Aug. 2023.

[6] Hendrix, C. and Bazilian, M., 'Markets for critical minerals are too prone to failure', Barron's, 17 Dec. 2022.

[7] Vakulchuk, R. et al., *Critical Materials for Renewable Energy: Improving Data Governance* (International Renewable Energy Agency (IRENA): Abu Dhabi, 2024).

[8] Mudd. G. M., Jowitt, S. M., Werner, T. T., 'The world's by-product and critical metal resources part I: Uncertainties, current reporting practices, implications and grounds for optimism', *Ore Geology Reviews*, vol. 86 (June 2017).

Table 2.1. Policy definitions of strategic and critical mineral

	Official published terminology	Definition
China	战略性矿产 (strategic mineral), with additional reference to 大宗矿产 (bulk mineral), 战略性新兴矿产 (strategic emerging industry mineral), 紧缺矿产 (scarce mineral), 优势矿产(advantageous mineral) and 产能过剩类矿产 (mineral marked by overproduction)	'[Minerals necessary] for protecting national economic security, national defence security, and the development needs of strategic emerging industries'[a]
European Union	'critical raw material', including 'strategic raw materials'	'raw materials which reach or exceed the thresholds for both economic importance and supply risk'[b] 'The strategic importance shall be determined on the basis of the relevance of a raw material for the green and digital transition as well as defence and space applications, in accordance with the following criteria: (a) the amount of strategic technologies using a raw material as an input; (b) the amount of a raw material needed for manufacturing relevant strategic technologies; (c) the expected global demand for relevant strategic technologies.'[c]
Russia	'стратегический минеральныий сырья' (strategic mineral resource), overlapping in some cases with 'дефицитные виды полезных ископаемых' (scarce minerals)	'Strategic types of mineral raw materials are particularly important for the sustainable functioning and strategic development of the national economy, ensuring national defence and security and meeting the needs of high-tech industrial sectors, achieving an international competitive advantage in the global trade in mineral raw materials and products of their deep processing.'[d]
United States	'critical mineral'	'minerals, elements, substances, and materials . . . that the Secretary [of the Interior] determines— (i) are essential to the economic or national security of the United States; (ii) the supply chain of which is vulnerable to disruption (including restrictions associated with foreign political risk, abrupt demand growth, military conflict, violent unrest, anti-competitive or protectionist behaviors, and other risks throughout the supply chain); and (iii) serve an essential function in the manufacturing of a product (including energy technology-, defense-, currency-, agriculture-, consumer electronics-, and health care-related applications), the absence of which would have significant consequences for the economic or national security of the United States.'[e]

[a] Chinese Ministry of Natural Resources, '全国矿产资源规划 (2016 – 2020年)' [National Mineral Resources Plan (2016–20)], Nov. 2016, p. 14 (author translation).

[b] Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials (Critical Raw Materials Act), *Official Journal of the European Union L*, 3 May 2024, para. 7.

[c] Regulation (EU) 2024/1252 (note b), annex 1, section 2.

[d] Russian Government Order no. 1838-r, 'Стратегия развития минерально-сырьевой базы Российской Федерации до 2050 года' [Strategy for the Development of the Mineral Resource Base of the Russian Federation to 2050], 11 July 2024, section II (author translation).

[e] 2021 Consolidated Appropriations Act, US Public Law 116-260, signed into law 27 Dec. 2020, division Z, 2020 Energy Act, title VII.

As they are extracted during mineral refining and processing, data on the geographical origins of the byproducts is sparse.

Differences between minerals highlight the complexity of discussing mineral security in the aggregate. More complicated are the ways in which differences in individual mineral markets play out in specific economies and polities. Each of these, in turn, has different resource capacities, demands and degrees of foreign dependence across the various levels of a given mineral supply chain.

Even within a polity, different political stakeholders may hold different positions on the importance of minerals and the necessity of risk-mitigation measures—based on separate mandates, priorities or constituencies. Industry perspectives may differ from the concerns of governments, often prioritizing economic efficiency and return on investment; consumer perspectives likewise may differ from those of producers or of organized civil society; and all of these perspectives may vie with each other to influence evolving policies. This indicates an analytical as well as a political challenge in making objective determinations of what in fact constitutes a threat and to whom, under evolving conditions. Much of this complexity is lost in the more general policy frameworks published by the four cases studied here (see chapter 3), although more fine-grained analysis and targeted policies for specific mineral supply chains exist or are in development in all four cases. Official overarching frameworks, including lists of critical or strategic minerals, are meanwhile also subject to re-evaluation and updates based on evolving methodologies and technical assessments.

Moving on from this major caveat, each of the four cases—China, the EU, Russia and the USA—has its own policy definitions and prioritizations that mark whether and how a mineral is considered 'critical' or 'strategic' (see table 2.1). Notably, the term 'critical', which appears in official policy discussions in the EU and the USA, has much less official use in China and Russia, where the concept of 'strategic' mineral is used instead. This variation reflects a semantic difference but also points to some clear distinctions between the focus of policies. It also reflects the fact that China and, to a lesser extent, Russia are globally significant producers of many raw ores or refined minerals, while the EU and the USA are more import-dependent.

In the EU and the USA, a given mineral's 'criticality' is defined by its vulnerability to supply disruption in addition to its economic importance. Chinese and Russian 'strategic' mineral lists centre instead around importance for strategic industries, although both China's and Russia's lists also contain minerals for which supply risks are high. But these lists also include minerals with which the two states are relatively well endowed in terms of share of global production or reserves. In this regard, their appearance on the lists may also reflect the minerals' strategic value as levers of foreign (economic) policy. In the EU, however, several minerals that are marked as 'strategic'—that is, having significance for the EU's market or for strategic industries (including nickel and copper)—are also subsumed within the EU's broader critical raw materials list. Notably, the EU also considers non-mineral materials, such as biobased rubber, in its criticality screening—hence the use of the term 'raw material' instead of 'mineral'.

There is a high degree of overlap—both complete and partial—between the lists of critical or strategic minerals of China, the EU, Russia and the USA (see table 2.2). However, without analysis of individual mineral categories, the degree to which any

Table 2.2. Overlap in the critical and strategic mineral lists of China, the European Union, Russia and the United States

	China	European Union	Russia	United States
Full overlap	Aluminium/bauxite, antimony, cobalt, fluorspar, graphite, lithium, nickel, tungsten, rare earth elements[a]			
Partial overlap				
Gold, molybdenum, natural gas, oil, potassium salts, uranium	x	–	x	–
Helium	–	x	x	–
Arsenic, barite, bismuth, magnesium	–	x	–	x
Caesium, indium, rubidium, zinc	–	–	x	x
Copper, phosphate rock[b]	x	x	x	–
Chromium, tin, zirconium	x	–	x	x
Beryllium, gallium, germanium, hafnium, manganese, niobium, platinum group elements[c], scandium, tantalum, titanium, vanadium	–	x	x	x
No overlap	Coal, coalbed methane, iron, shale gas	Phosphorus[b], silicon metal, coking coal, boron/borate, feldspar, strontium	Diamond, lead, quartz, rhenium, silver, groundwater	Tellurium

[a] Rare earth elements (REEs) include 17 elements in total: scandium, yttrium and the lanthanides. The USA lists these individually while the European Union (EU) aggregates them in two groups—light REEs and heavy REEs—both classified as critical.

[b] The EU has separately assessed and categorized phosphorous, which is a refined derivation of phosphate rock.

[c] Platinum group metals include ruthenium (listed by Russia and the USA), rhodium (Russia and USA), palladium (Russia and USA), osmium (Russia), iridium (Russia and USA) and platinum (USA). The EU does not disaggregate these.

Sources: Chinese Ministry of Natural Resources, '全国矿产资源规划 (2016－2020年)' [National Mineral Resources Plan (2016–20)], Nov. 2016, table 3; European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, 'Critical raw materials', 8 May 2024; Russian Government Order no. 2473-r, 'Перечень основных видов стратегического минерального сырья' [List of the main types of strategic minerals], 30 Aug. 2022; and US Department of the Interior, US Geological Survey, '2022 final list of critical minerals', *Federal Register*, 24 Feb. 2022.

overlap heightens the possibility for zero-sum competition between the powers is difficult to assess.

Non-overlap may denote differences in strategic vulnerability, but also reflects differences in policy scope. For example, the EU and US lists deliberately exclude fuel minerals, while the Chinese and Russian lists include oil, natural gas, uranium and, in the Chinese case, other fossil fuels. This does not indicate that energy fuels lack importance to the EU and US economies, rather that they are covered by guidance and directives published in other areas.

Overlaps and divergences can also reflect domestic sectoral conditions and priorities. For example, China, the EU and Russia emphasize phosphates, which serve as industrial fertilizers. China and the EU are significant importers of agricultural commodities with vulnerabilities in this sector, whereas Russia and the USA have fewer import vulnerabilities. As another example, Russia's inclusion of groundwater as a strategic mineral also significantly expands the scope of comparisons. Beyond the lists of specific minerals compiled by governments, of course, also lies the wider strategies put in place to secure them.

3. National policy frameworks

This chapter provides an overview of the official policies of China, the European Union, Russia and the United States. For China, Russia and the USA, the focus is the national government. In the case of the EU, the analysis is not of state or national actors per se, but the EU-level authorities that issue both guidance and binding policy directives for its 27 member states. The overview primarily focuses on the statement and design of policy, rather than its implementation. Implementation, particularly in the minerals sector, often takes place over the longer term: the International Energy Agency (IEA) estimates that in the decade 2010–19 the averaged lead time for new mining projects was 16 years.[9]

Mineral security frameworks do not necessarily invite direct cross-case comparisons as they have been developed from and address particular policy contexts, efforts and objectives. These vary based not only on the ambitions of polities in relation to specific minerals, but also on the capacities and policy tools available to them, whether regulatory or fiscal.[10] Policy in this regard is also greatly affected by institutional factors: political economy, state–market relations and governance all shape polities' influence on domestic and international markets—and they may change over time. Across longer time frames, policy and, indeed, political will are also subject to change.

There are important differences in the starting points, capacities, ambitions and priorities of each power, as explored below. But, while there is diversity, there is also a broader convergence in the understanding and pursuit of mineral security across the four cases. Namely, each expresses concern to mitigate the supply risks for minerals posed by both specific and general trade dependencies. In other words, growing policy attention to minerals has been marked by their growing politicization and even securitization. The focus below is on domestic policies; it does not cover in significant detail the relations of the four powers to key producers elsewhere, which encompass what can be a complex range of trade and investment patterns, public and private stakes, and political ties.[11]

China

China is the world's largest producer, consumer and exporter of many of the critical and strategic minerals identified by other powers. This includes many minerals used for advanced technology and clean energy applications. For instance, it accounted for over two-thirds of the global production of rare earth elements in 2023.[12] It is globally dominant in the midstream refining and processing of minerals, even minerals of which it does not have significant domestic reserves, such as the cobalt, ores and concentrates that it primarily imports from the Democratic Republic of the Congo (DRC).[13]

China's production and processing capacity developed over the past several decades, both through policy support integrated across mineral supply chains and through significant involvement of foreign investors. Since it developed and started to implement its outwards investment strategy more than two decades ago, mining has also grown as a share of China's overseas direct investment (ODI), and by 2020 it accounted for nearly

[9] International Energy Agency (IEA), 'Global average lead times from discovery to production, 2010–2019', 3 May 2021.

[10] Barteková and Kemp (note 2).

[11] On the topic of ownership, see Faubert, V., Guessé, N. and Le Roux, J., 'Capital in the twenty-first century: Who owns the capital of firms producing critical raw materials?', Banque de France Working Paper no. 952, July 2024.

[12] US Geological Survey (USGS), *Mineral Commodities Summary 2024* (USGS: Reston, VA, 2024), p. 145.

[13] World Bank, 'China cobalt ores and concentrates imports by country in 2023', World Integrated Trade Solution (WITS), [n.d.].

7 per cent of ODI stock.[14] China retains therefore significant access to and control of minerals in other resource-rich countries through the activity of its state-owned enterprises (SOEs). China's mineral resource strategy today serves as the primary foil against which EU, US and, to some extent, Russian strategies are oriented. Importantly, however, China's strategy is tied to a large degree to its own supply concerns.

As noted in chapter 2, Chinese policies and policymakers use the term 'strategic' rather than 'critical' to describe priority minerals. A dedicated list of strategic minerals was published in 2016 in the National Mineral Resources Plan for 2016–20, the most recent publicly accessible national-level sectoral planning document for coordinating mineral exploration, development, utilization and protection.[15] The list notes these minerals' importance for the economy, defence and advancement of strategic industries. Unlike in the EU and the USA, the list includes fuel minerals such as oil, natural gas, coal, shale gas, coalbed methane and uranium. Their inclusion highlights China's vulnerabilities in this area, as the world's single largest consumer and importer of energy resources. In addition to energy minerals, China also includes several 'bulk' (大宗矿产) or staple industrial minerals—such as iron—for which it is heavily dependent on world markets, and which do not feature on the EU and US lists.[16]

China's foreign dependence for strategic minerals in 2020 was high: over 70 per cent for aluminium, copper, iron, lithium, nickel, titanium and uranium, and a near total import-reliance for chromium, cobalt and manganese.[17] In several of these categories, China is the world's largest importer. Indeed, it is the overall largest importer of metal minerals and accounts for about half of the globally traded volume.[18] It is itself a growing importer of REE concentrate, including for heavy REEs.[19] China's imports of mineral commodities accounted for 22.5 per cent of the value of the country's total imports in 2020, and their export accounted for 1.4 per cent of the value of total exports.[20] The fact that China's mineral resources are lower than the global per capita average is a persistent policy concern as this has the potential to throttle national development.[21]

However, China's strategic mineral list also contains several minerals for which there are no significant supply risks or dependencies.[22] These include a subcategory of so-called advantageous minerals (优势矿产), including REEs and tungsten. These are regulated separately, including through annual production quotas for mining, smelting and separation, stricter export controls (historically including export quotas),

[14] Moon, J., 'The mineral industry of China', US Geological Survey (USGS), *2020–2021 Minerals Yearbook*, vol. 3, *Area Reports—International—Asia and the Pacific* (USGS: Reston, VA, May 2024), pp. 9.1–2.

[15] Chinese Ministry of Natural Resources, '全国矿产资源规划（2016－2020年）' [National Mineral Resources Plan (2016–20)], Nov. 2016. See also Andersson, P., 'The growing secrecy around China's mineral resource planning: Implications for the EU', Commentary no. 2, Swedish Institute of International Affairs (UI), Swedish National China Centre, May 2024.

[16] E.g. China Geological Survey, 中国地质调查百项成果 [100 achievements of the China Geological Survey] (Geological Press: Beijing, 2016), pp. 144–56.

[17] Wang, Y. (王永中), '资源国关键矿产博弈的新动向及可能影响' [New trends and possible impacts of critical mineral games in resource-rich countries], Chinese Academy of Social Sciences, Institute of World Economics and Politics, 17 Aug. 2022. See also China Geological Survey, '全国政协委员、江苏省自然资源厅长刘聪：加大战略性矿产等重要资源勘查力度' [Liu Cong, member of the National Committee of the Chinese People's Political Consultative Conference (CPPCC) and Director of Natural Resources of Jiangsu Province: Increase exploration efforts for strategic minerals and other important resources], 15 Mar. 2021.

[18] Wang (note 17).

[19] 'China's rare earth imports from Myanmar surge in first half of 2023', Reuters, 20 July 2023; and Chen, W. et al., 'Interdependence in rare earth element supply between China and the United States helps stabilize global supply chains', *One Earth*, vol. 7, no. 2 (Feb. 2024), p. 247.

[20] Moon (note 14), p. 9.3.

[21] Chinese State Council, 'China's policy on mineral resources', Dec. 2003.

[22] Wang, A. (王安建) and Yuan, X. (袁小晶), '大国竞争背景下的中国战略性关键矿产资源安全思考' [Security of China's strategic and critical minerals under background of great power competition], *Bulletin of the Chinese Academy of Sciences*, vol. 37, no. 11 (Nov. 2022).

and restrictions on foreign investment.[23] Additional policy attention is also given to 'strategic emerging industry minerals' (战略性新兴矿产), which are essential for strategic emerging industries (SEIs). Since 2010, SEIs have represented a concerted policy effort to both catch up with—and leapfrog—global advanced manufacturing and technology. Identified SEI sectors range from electric vehicles via biotechnology to digital creative industries.[24] China's 14th five-year plan, for 2021–25, set a target for SEIs to grow from 11.5 per cent of gross domestic product (GDP) in 2019 to over 17 per cent by 2025.[25] SEIs dovetail with other efforts such as Made in China 2025 and other ongoing planning initiatives that are aimed at upgrading the Chinese economy to capture more value-added downstream production; capitalize on domestic and global green and digital transformations; and give China an advantage in emerging technologies. This raises the significance of non-fuel minerals, which overlaps with EU and US critical mineral lists.

Policy attention to mineral security has become much more nationally prominent in recent years. Progressive five-year plans have elevated language regarding mineral resources from 'important' to 'strategic', with the 14th five-year plan focused on more support for 'the planning and control of strategic mineral resources, increasing capabilities to secure reserves and implementation of a new round of strategic activities for mineral prospecting', which will continue to 2035.[26] For the 2021–25 five-year planning period, a development plan for resource-rich regions in China more explicitly names relevant strategic minerals, including oil, natural gas, copper, chromium, tungsten, REEs and crystalline graphite.[27] A high-level review of China's 2021–25 National Security Strategy also mentioned 'mineral security' as a separate category of attention for the first time.[28]

China's particular brand of state-led planning and market interventionism means that the state has multiple avenues to provide significant support across mineral supply chains, from upstream to downstream. In addition, China also keeps mineral stockpiles that serve economic as well as strategic purposes, buffering supply as well as prices for domestic producers.[29] However, for much of the 1990s and 2000s China's mining industry—including strategically protected REEs—was highly fragmented and uncoordinated. Significant unregistered exports of REEs continue.[30]

Concerns about depletion and degradation of mineral resources and ecological damage have marked policy documents as well as expert discourse over the past decade. As early as 2010, for instance, a white paper published by the State Council noted that, by supplying 90 per cent of international demand with China's 23 per cent share of global reserves, overexploitation had depleted China's reserves, led to a decline in mineral

[23] Andersson, P., 'Chinese assessments of "critical" and "strategic" raw materials: Concepts, categories, policies, and implications', *The Extractive Industries and Society*, vol. 7, no. 1 (Jan. 2020).

[24] Wang, X., Sun, K. and Xiao, Z., 'Industrial policy and the rise of China's strategic emerging industries', American Economic Association, 30 Dec. 2022.

[25] Chinese Government, '中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要' [Outline of the 14th five-year plan for the national economic and social development of the People's Republic of China and Vision 2035], 12 Mar. 2021.

[26] Chinese Government (note 25) (author translation).

[27] Chinese National Development and Reform Commission (NDRC), Ministry of Finance and Ministry of Natural Resources, '推进资源型地区高质量发展 "十四五" 实施方案' [Promoting the high-quality development of resource-rich regions during the 14th five-year plan]', 5 Nov. 2021.

[28] Chinese Government, '中共中央政治局会议审议《国家安全战略（2021－2025年）》《军队功勋荣誉表彰条例》和《国家科技咨询委员会2021年咨询报告》 习近平主持' [The meeting of the Political Bureau of the CPC Central Committee deliberated on the 2021–2025 National Security Strategy, the Regulations on Commendation of Military Merits and Honours, and the 2021 Advisory Report of the National Science and Technology Advisory Committee, with Xi Jinping presiding], 18 Nov. 2021.

[29] White House, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth* (White House: Washington, DC, June 2021), p. 180.

[30] Chen et al. (note 19).

grades and significantly damaged the environment.[31] These concerns has driven China to progressively tighten and enforce environmental regulations, close mines and make industry-consolidation efforts.[32] They also mark Chinese arguments in several disputes about China's use of trade-distorting measures, including export restrictions, brought to the World Trade Organization (WTO) by other countries.[33]

Mineral-related measures explicitly tied to geopolitical concerns have also become more prominent, proceeding in line with the general securitization of the economy. In 2023 the Chinese minister of natural resources stated that foreign dependence has an impact on 'economic and even national security', requiring 'preparations to safeguard domestic resource security under special circumstances'.[34] Since 2020 foreign investment has been prohibited in exploration, mining and processing projects related to REEs, radioactive materials and tungsten.[35] The 2020 Export Control Law also provides a more explicit national security-related framework for trade restrictions, including retaliation provisions.[36] Export restrictions on minerals, once framed in terms of environmental concerns, have now been explicitly linked to national security. This includes new export controls on gallium, germanium and graphite-related items introduced in 2023.[37] These are largely considered to be part of escalating trade tensions with the USA, and an indirect response to US restrictions on exports of semiconductor equipment and technology to China.[38] In late 2023 China also banned the export of REE-extraction and -processing technology.[39]

Although this review largely focuses on China's domestic mining priorities and policies, a significant policy effort is centred on overseas supply. China has been pursuing large-scale investment in and contracts for mining in resource-rich developing countries and regions such as Africa, Latin America and parts of South East Asia since the 2000s.[40] From 2013 these efforts were subsumed into wider foreign policy-related frameworks such as the Belt and Road Initiative (BRI) as part of China's growing resource diplomacy efforts. China's overseas investments in metals and mining reached a record US$19.4 billion in 2023, largely through its SOEs.[41] Cross-national comparisons regarding investment value, ownership and control are complicated by the private and transnational corporate interests involved in overseas mining. However, the significant involvement of SOEs—and, by extension, the state—distinguishes China from the EU and USA, where foreign investment is to a larger extent driven and controlled by

[31] Chinese State Council, *Situation and Policies of China's Rare Earth Industry*, White paper (State Council Information Office: Beijing, June 2010).

[32] Chinese Government, *The 13th Five-year Plan for Economic and Social Development of the People's Republic of China (2016–2020)* (Central Compilation & Translation Press: Beijing, 2016), chapter 43, section 4.

[33] World Trade Organization (WTO), 'China—Measures related to the exportation of rare earths, tungsten and molybdenum', 3 Dec. 2015.

[34] Chinese Government, '激发要素活力，释放发展潜力——访自然资源部部长王广华' [Stimulate dynamic factors, unleash development potential—Interview with Wang Guanghua, minister of natural resources], 4 Jan. 2023 (author translation).

[35] Chinese National Development and Reform Commission (NDRC) and Ministry of Commerce, '外商投资准入特别管理措施（负面清单）' [Special administrative measures related to foreign investment access (negative list)]', 2020 edition, 23 June 2020.

[36] '中华人民共和国出口管制法' [Export Control Law of the People's Republic of China], promulgated 17 Oct. 2020.

[37] Chinese Ministry of Commerce, Bureau of Security and Control, '关于对镓、锗相关物项实施出口管制的公告' [Announcement on export control on gallium- and germanium-related items], Ministry of Commerce General Administration of Customs Announcement no. 23 of 2023, 3 July 2023.

[38] Liang, A. and Marsh, N., 'Gallium and germanium: What China's new move in microchip war means for world', BBC, 2 Aug. 2023.

[39] Chinese Ministry of Commerce '商务部、科技部修订发布《中国禁止出口限制出口技术目录》' [The Ministry of Commerce and the Ministry of Science and Technology revise and issue the Catalogue of Technologies Banned and Restricted for Export from China], 21 Dec. 2023.

[40] Chang, C. et al., 'China's global reach grows behind critical minerals', S&P Global, Aug. 2023.

[41] Wang, C. N., 'China Belt and Road Initiative (BRI) investment report 2023 H1', Green Finance and Development Center, 1 Aug. 2023.

private enterprises.[42] Chinese analysts have noted that, in the past several years, a rise in resource nationalism in developing countries has had a negative impact on the operations and profits of Chinese SOEs.[43]

The European Union

Unlike the three other powers covered in this report, the EU is not a sovereign state. This restricts the tools it has at its disposal. For example, lack of fiscal authority limits its ability to directly intervene with tax exemptions, and some legislation that has an impact on the mineral sector is designed at the member state level. Even if it originates from the same EU directive, national implementation legislation may lead to policies that differ across states. The process of negotiation between the member states means that EU mineral policies and strategies need to balance competing objectives, and it also slows down EU-level policy reactions. In some cases, member states may still diverge, as exemplified in the attempt to centrally coordinate imports of liquefied natural gas (LNG) following Russia's full-scale invasion of Ukraine.

That being said, the EU as a whole is dependent on imports to meet its demand for many minerals, in particular those used for low-carbon technologies and digitalization. Import dependence and risks to access were identified as causes for concern by the European Commission (the EU's executive) in its raw material initiative launched back in 2008.[44] One of the identified responses was to define what a critical raw material is and identify those that are critical for the EU. This process resulted in the EU's first list of critical raw materials, published in 2011.[45] The list has since been updated every third year. The topic has moved up the EU's political agenda in this time, demonstrated by the fact that it was the president of the Commission, Ursula von der Leyen, who launched the Critical Raw Materials Act during her State of the Union speech in 2022.[46]

The EU's definition of critical raw material focuses on the economic value and importance of raw materials for industry. The assessment method has been developed by researchers at the EU's Joint Research Centre (JRC) and is transparently documented.[47] Materials are screened on their risk of supply disruption from imported sources and their economic importance. Originally, the adopted methodology used only historic data. This was identified as a shortcoming when demand increases rapidly, such as for some materials used in low-carbon technologies.[48] Mitigating supply risks (e.g. by expanding domestic mining and increasing resource efficiency) can be lengthy and complex. To enable early warning, the 2023 edition of the list therefore also incorporates foresight analysis for possible supply problems for 15 technologies and 5 sectors perceived as strategic.[49] These include low-carbon technologies, uncrewed

[42] Ericsson, M., Löf, O. and Löf, A., 'Chinese control over African and global mining—Past, present and future', *Mineral Economics*, vol. 33, nos 1–2 (July 2020).

[43] Wang (note 17).

[44] European Commission, 'The raw materials initiative—Meeting our critical needs for growth and jobs in Europe', Communication to the European Parliament and the Council, COM(2008) 699 final, 4 Nov. 2008.

[45] European Commission, 'Tackling the challenges in commodity markets and on raw materials', Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2011) 25 final, 2 Feb. 2011.

[46] von der Leyen, U., 'State of the Union address 2022', European Commission, 14 Sep. 2022, p. 14. The act was adopted in Apr. 2024. Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials (Critical Raw Materials Act), *Official Journal of the European Union L*, 3 May 2024, para. 7.

[47] Blengini, G. A. et al., *Study on the EU's list of Critical Raw Materials (2020): Final Report* (European Commission: Luxembourg, 2020).

[48] Carrara, S. et al., *Supply Chain Analysis and Material Demand Forecast in Strategic Technologies and Sectors in the EU—A Foresight Study* (European Commission: Luxembourg, 2020).

[49] The 2023 edition is part of the Critical Raw Materials Act (note 46), para. 7.

vehicles and the military sector. Based on the foresight analysis, copper and nickel were classified as strategic for the EU and added to the list of critical raw materials, although they also met the thresholds for being classified as critical according to other criteria.[50]

Over time, the number of raw materials on the EU's critical raw materials list has increased. The first list included 14 raw materials while the latest includes 34.[51] It is worth nothing that three of the listed materials are actually material groups: platinum group elements, light REEs and heavy REEs. If counted individually, as in the USA, the total number of raw materials on the list is 55.

Although the general trend has been to include more materials, some have also been removed, at least temporarily. Helium was removed from the critical raw materials list in 2020 following a decline in its economic importance. However, it was reintroduced already in the subsequent version, released in 2023.[52] It is worth nothing that, during the period in which helium was absent from the list, it was used for the same purpose: to reach low temperatures. This is needed for some cryogenic laboratory equipment and magnetic resonance imaging (MRI) scanners. This illustrates some of the limitations of using economic importance to value criticality as it obscures vulnerability in some sectors and overlooks non-economic values (e.g. for health, hard security, safety, etc.).

The first versions of the EU's critical raw materials list were not backed by legislation. However, the list still contributed to soft governance of the issue by raising awareness and initiating coordination processes within member states' national governments. It has also had an impact on the allocation of public research funding as some of the EU's research calls were channelled to critical raw material-related research. The 2023 version of the list is part of the Critical Raw Materials Act, which also includes several goals for a more rapid permitting processes (less than two years to start a new mine), domestic primary extraction (at least 10 per cent of the EU's annual consumption), domestic processing (at least 40 per cent of the EU's annual consumption), domestic recycling (at least 15 per cent of the EU's annual consumption) and diversification (no more than 65 per cent of the annual consumption from a single non-member state).[53]

The Critical Raw Materials Act, adopted in April 2024, is just one of a recent tranche of EU policies that together integrate industrial policymaking, security and sustainability. It is thus not the minerals per se that are important but the supply chains and capabilities they enable. The success of the EU's Green Deal Industrial Plan and Net-Zero Industry Act hinges on a reliable supply of raw materials.[54] The economic value of imported materials is comparatively low compared to the wealth creation it enables. The concern of EU policymakers for raw material security should therefore be seen in terms of the prospective wealth creation of the future industries that the materials enable. The high-profile 2024 report by Mario Draghi on the future of European competitiveness devotes

[50] Carrara, S. et al., *Supply Chain Analysis and Material Demand Forecast in Strategic Technologies and Sectors in the EU—A Foresight Study* (European Commission: Luxembourg, 2023).

[51] Critical Raw Materials Act (note 46), annex II.

[52] European Commission, 'On the 2017 list of critical raw materials for the EU', Communication to the European Parliament etc., COM(2017) 490 final, 13 Sep. 2017; European Commission, 'Critical raw materials resilience: Charting a path towards greater security and sustainability', Communication to the European Parliament etc., COM(2020) 474 final, 3 Sep. 2020; and European Commission, 'Proposal for a regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials', COM(2023) 160 final, 16 Mar. 2023.

[53] Critical Raw Materials Act (note 46).

[54] European Commission, 'A green deal industrial plan for the net-zero age', COM(2023) 62 final, Communication to the European Parliament etc., 1 Feb. 2023; and European Commission, 'Proposal for a regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act)', COM(2023) 161 final, 16 Mar. 2023.

a whole chapter to critical raw materials, further highlighting its perceived importance as an enabler of domestic industries and economic growth.[55]

Some of the challenges for the EU when designing its critical raw materials policies can be traced to competition between its traditional value of support for international free trade and liberalization—in which trade and interdependence are promoted—and the emerging quest for strategic autonomy and having the freedom to make decisions independent of non-member states.[56] The EU's concept of strategic autonomy does not entail decoupling from international trade; targets set by EU policymakers indicate that they envision that the vast majority of EU resource consumption will continue to be met by imports.[57] However, the EU's targets for supporting domestic production, processing and recycling instead of aiming for market deregulation sends the signal that support for liberalization and free trade has moved down policymaker's priority list.

Another source of internal friction is the division of responsibilities between the European Commission, member states and industry. For example, the German automotive industry was, for a long time, reluctant to secure its own mineral supplies and was outbid by Asian companies that received more direct state support.[58] Some EU member states have developed their own strategies to support industries in their efforts to secure imports.[59] However, this comes with a risk of member states competing with one another, in opposition to the EU principles of 'speaking with one voice' externally and having a common internal market. The Critical Raw Materials Act notably establishes a European Critical Raw Materials Board to help internally coordinate the range of mineral-related policy tools and ambitions—both within and outside the EU.[60] External partnerships are also a key pillar of the strategy in the Critical Raw Materials Act, although overseas mining interests and stakes differ across member states, and are held largely through private, multinational corporations.[61] However, a proposed Critical Raw Materials Club aims to help strengthen overseas supply chains and the implementation of strategic projects with 'like-minded countries'.[62]

The Russian Federation

Russia is home to vast raw material resources and geological deposits of nearly all known elements. According to a 2019 Russian government estimate, mineral reserves were worth $1.44 trillion; the bulk of this value was in oil, gas and coal.[63] Mineral and other natural resource extraction is guided by the 1992 Law on Subsoil along with a 2008 law that restricts ownership and mining rights for industries of 'strategic importance

[55] Draghi, M., *The Future of European Competitiveness*, part B, *In-depth Analysis and Recommendations* (European Commission: Brussels, Sep. 2024).

[56] Demen, M., 'EU strategic autonomy 2013–2023: From concept to capacity', European Parliamentary Research Service, July 2022.

[57] Helwig, N. and Sinkkonen, V., 'Strategic autonomy and the EU as a global actor: The evolution, debate and theory of a contested term', *European Foreign Affairs Review*, vol 27, special issue (Apr. 2022).

[58] Schmid, M., 'Challenges to the European automotive industry in securing critical raw materials for electric mobility: The case of rare earths', *Mineralogical Magazine*, vol. 84, no. 1 (Feb. 2020).

[59] Schmid, M., 'The revised German raw materials strategy in the light of global political and market developments', *Review of Policy Research*, vol. 38, no. 1 (Jan. 2021).

[60] Critical Raw Materials Act (note 46), articles 35–36.

[61] Garside, M., 'Leading mining companies in Europe in 2023, based on revenue', Statista, 15 May 2024.

[62] European Commission, 'European Critical Raw Materials Act', [n.d.].

[63] Safirova, E., 'The mineral industry of Russia', US Geological Survey (USGS), *2019 Minerals Yearbook*, vol. 3, *Area Reports—International—Europe and Central Eurasia* (USGS: Reston, VA, Feb. 2023), p. 38.1; and Tkachev, I. and Fadeeva, A., '55 триллионов в запасе: как власти оценили все природные ресурсы России' [55 trillion in reserve: How the authorities have estimated all of Russia's natural resources], RBC, 14 Mar. 2019.

for defence and national security'.[64] Oil and gas are largely nationalized industries that have tended to be the mainstay of state attention to mining over the past two decades. Mineral resources other than fuel are largely controlled by private corporations, although such companies may nevertheless be close to channels of state authority.[65]

The 2024 Mineral Resources Development Strategy notes that the mineral resource base serves as a 'basis for national security of the state' and a 'tool for achieving the strategic interests of the country' and is part of Russia's 'long-term natural competitive advantage'.[66] Indeed, although Russia is most prominent as a fossil fuel and energy power, it is also a key global supplier of several metals and mineral commodities such as palladium, platinum, scandium, titanium, aluminium, nickel, antimony, neon, enriched uranium, precious metals such as gold, diamonds and industrial fertilizers.

However, Russian efforts to ensure mineral security are inseparable from much wider efforts around import substitution. Import substitution has been a priority since at least the first imposition of sanctions by the EU, the USA and other states in 2014 after Russia's invasion and annexation of Crimea.[67] In its 2015 National Security Strategy, Russia listed the creation of reserves of strategic minerals, sufficient to 'guarantee mobilization needs', as a national security imperative.[68] This was repeated in the more recent 2021 National Security Strategy.[69] Russian concerns over supply dependence have only accelerated in the past decade; one-third of Russia's strategic minerals are imported according to one estimate, with almost complete foreign supply dependence on manganese, chromium, titanium and lithium.[70]

A 2022 government meeting on import substitution of minerals noted 'supply vulnerabilities for imported minerals, including titanium, chromium and lithium'.[71] The meeting also placed particular focus on minerals necessary for the defence industry, including molybdenum. Later in 2022 the government updated its list of strategic minerals, significantly expanding the previous list, published in 1996.[72] This list is set to be updated every three years. As noted in chapter 2, the list also contain minerals in which Russia has competitive advantages, including oil and gas.

Russia's mineral security strategy is guided in part by the Mineral Resources Development Strategy, first published in 2018 (with an outlook to 2035) and updated and extended in 2024 (up to 2050). Both versions categorize minerals based on metrics of scarcity, specifically whether domestic reserves are deemed sufficient to meet goals

[64] Russian Federal Law no. 2395-I 'О недрах' [On subsoil], 21 Feb. 1992 as amended to Aug. 2024; and Russian Federal Law no. 57-FZ 'О порядке осуществления иностранных инвестиций в хозяйственные общества, имеющие стратегическое значение для обеспечения обороны страны и безопасности государства' [On procedures for foreign investments in the business entities of strategic importance for Russian national defence and state security], 29 Apr. 2008.

[65] Kennedy, J., 'How are Russia's industries adapting to Western economic pressure? The case of gold', *Post-Communist Economies*, vol. 35, no. 8 (2023).

[66] Russian Government Order no. 1838-r, 'Стратегия развития минерально-сырьевой базы Российской Федерации до 2050 года' [Strategy for the Development of the Mineral Resource Base of the Russian Federation to 2050], 11 July 2024, section II (author translation).

[67] Russian Government, 'First meeting of the government commission on import substitution', 11 Aug. 2015.

[68] Russian Presidential Decree no. 683, 'О Стратегии национальной безопасности Российской Федерации' [On the National Security Strategy of the Russian Federation], 31 Dec. 2015, para. 62 (author translation).

[69] Russian Presidential Decree no. 400, 'О Стратегии национальной безопасности Российской Федерации' [On the National Security Strategy of the Russian Federation], 2 July 2021, para. 34.

[70] Milkin, V., Nikolaev, N. and Volobuev, A., 'Россия столкнулась с необходимостью создать свою добычу редких металлов' [Russia is faced with the need to establish its own rare metals mining operation], *Vedomosti*, 12 Sep. 2022.

[71] Shugaev, G., 'Виктория Абрамченко провела совещание по импортозамещению в геологии' [Viktoria Abramchenko held a meeting on import substitution in geology], Lenta.ru, 2 Apr. 2022 (author translation).

[72] Russian Government Order no. 2473-r, 'Перечень основных видов стратегического минерального сырья' [List of the main types of strategic mineral], 30 Aug. 2022; and Russian Government Order no. 50, 'Утверждении перечня основных видов стратегического минерального сырья' [List of the main types of strategic mineral raw materials], 16 Jan. 1996.

for domestic consumption by the end of the relevant period or whether there will be a deficit.[73] The category 'scarce minerals' (дефицитные виды полезных ископаемых) denotes minerals for which Russia is import-dependent or lacks sufficient supply or reserves; it most resembles EU and US definitions of criticality. The majority of these scarce minerals are strategic according to the 2022 list.[74] For the scarce minerals category, the 2018 strategy established a minimum permissible level of 50 per cent self-sufficiency in production by 2035, and a target of 75 per cent.[75] Indicators and targets for the 2024 strategy are still being established. The new version pays greater attention to the impact of international sanctions and formulates new targets related to developing large deposits in difficult-to-reach regions of Russia, including the Arctic and the Far East, and seabed extraction.[76] Related to this strategy is also a Strategy for the Development of the Metallurgical Industry to 2030, published in 2023—which overlaps with several strategic minerals, including rare earth elements.[77] The industrial strategy also includes lithium projects to be supported between 2023 and 2030 and reiterates a need to 'ensure independence' in matters of raw materials supply chains.[78] The Ministry of Natural Resources and Environment has also published other sector-specific guidelines for expanding the mineral resource base of Russia and increasing geological exploration.

At least two directions of policy concern feature in Russian policy documents and efforts related to minerals development. One is stimulating investment, both foreign and domestic. This includes through simplified procedures but is mainly through multiple rounds of tax breaks for mineral extraction and lowered one-time fees paid to the state.[79] Russia lacks both extraction and processing technology for many metals, in addition to other shortages, and has made recent overtures to non-Western countries for bilateral technology transfers and technological partnerships.[80]

However, a main official concern relates to 'generating' domestic demand for strategic minerals, which is low in Russia—related to stalled and even failed efforts to structurally transform the Russian economy away from its current dependence on low-value-added raw materials and commodity exports, towards advanced industries and technologies. Policy documents acknowledge this dual challenge: to not only produce minerals but to also move along their supply chains into their downstream applications.[81] Stimulating

[73] Russian Government Order no. 1838-r (note 66).

[74] Russian Government Order no. 2473-r (note 72).

[75] Russian Government Order no. 1838-r (note 66).

[76] Russian Government, 'Оперативное совещание с вице-премьерами' [Operational meeting with deputy prime ministers], 29 July 2024; Ignateva, A., 'Утверждена обновленная Стратегия развития минерально-сырьевой базы РФ до 2050 г' [An updated Strategy for the Development of the Mineral Resource Base of the Russian Federation to 2050 was approved], Neftegaz.ru, 29 July 2024; and Russian Government, 'Правительство актуализировало и продлило Стратегию развития минерально-сырьевой базы до 2050 года' [The government updated and extended the Mineral Resource Base Development Strategy until 2050], 29 July 2024.

[77] Russian Government Order no. 4260-r, 'Стратегия развития металлургической промышленности Российской Федерации на период до 2030 года' [Strategy for the Development of the Metallurgical Industry of the Russian Federation to 2030], 28 Dec. 2022.

[78] Russian Government Order no. 4260-r (note 77), section 2 (author translation).

[79] Safirova, E., 'The mineral industry of Russia', US Geological Survey (USGS), *2017–2018 Minerals Yearbook*, vol. 3, *Area Reports—International—Europe and Central Eurasia* (USGS: Reston, VA, Aug. 2023), p. 39.5; and Russian Ministry of National Resources and Environment, 'Минприроды России опубликовало доклад о реализации в 2021 году Стратегии развития минерально-сырьевой базы' [Russian Ministry of Natural Resources publishes a report on the implementation in 2021 of the Mineral Resource Base Development Strategy], AK&M, 22 June 2022.

[80] Russian Government Order no. 1838-r (note 66); and Interfax, 'Russia proposing platform analogous to OPEC for solid minerals', 9 Jan. 2024.

[81] President of Russia, 'Перечень поручений по результатам проверки исполнения законодательства и решений Президента, направленных на развитие перспективной минерально-сырьевой базы' [List of instructions on the results of the audit of the implementation of legislation and presidential decisions aimed at the development of a promising mineral resource base], 28 June 2022.

domestic demand for minerals, both for processing and final high-technology products, is one of the main envisaged incentives for minerals development. Notably, that demand is expected to come from the military-industrial complex, in addition to metallurgical, chemical and construction industries.[82]

However, in addition to an emphasis on import substitution and even autarky, Russia also has export ambitions. For instance, in 2020 the Russian government announced its ambitions to become the world's second largest supplier of REEs, behind China.[83] Russia's political economy—distinct from the other three cases—is marked by a high degree of resource rent and a state budget dependent on exports of raw materials. Mineral extraction accounted for half of the government budget in 2022 and more than half of Russia's total exports.[84] While this was due primarily to oil and gas, mining and metals also contributed: 40 per cent of metal exports were precious metals, which adds to their importance and their inclusion in the strategic minerals list.[85] Western sanctions following Russia's full-scale invasion of Ukraine have affected Russian exports of metals in addition to those of fuel minerals through progressively tightened tariffs, import bans and more recent restrictions on Russian metals in Western-based metal exchanges.[86] In addition to trade restrictions that can have an immediate impact on resource rents, some Western service and exploration companies have withdrawn from Russia. This will make it more difficult for Russia to uphold and expand its production in the long term.

Outside the oil and gas sector, Russian mining companies have important international as well as domestic footprints.[87] With regards to public mineral security strategies, however, it is relevant that the Russian state has also occupied and controls areas in Ukraine with valuable mineral deposits. It has also engaged in the minerals trade abroad through its state-controlled private military companies in African states (see chapter 5).

The United States

The USA was a major mineral powerhouse and global exporter in the first half of the 20th century.[88] Early policy attention to minerals as a strategic matter came from the defence sector in relation to external events. In the lead-up to World War II, the National Defense Stockpile was established in 1939 for wartime and other national emergencies.[89] The post-war 1950 Defense Production Act also incentivized major investments in national mining and production capacity at the outbreak of the Korean War and emergent cold war tensions.[90] Legislation in 1980 intended to create a 'coherent national materials and minerals policy'.[91] But, together with the National Defense

[82] Russian Government, [Operational meeting with deputy prime ministers] (note 76).

[83] Lyrchikova, A. and Stolyarov, G., 'Russia has $1.5 billion plan to dent China's rare earth dominance', Reuters, 12 Aug. 2020.

[84] Russian Government Order no. 1838-r (note 66).

[85] Kennedy (note 65), p. 802.

[86] Carvalho, D. et al., 'How do Western sanctions on Russia impact the global metals, mining and coal markets?', Wood Mackenzie, 29 May 2024.

[87] Vidal, F., *Russia's Mining Strategy: Geopolitical Ambitions and Industrial Challenges*, Russie.Eurasie.Reports, no. 43 (French Institute of International Relations (IFRI): Paris, Apr. 2023).

[88] Wischer, G. and Bazilian, M., 'The rise of great mineral powers', *Journal of Indo-Pacific Affairs*, vol. 7, no. 2 (Mar.–Apr. 2024).

[89] Keys, C. M., *Emergency Access to Strategic Materials: The National Defense Stockpile*, Congressional Reservice Service (CRS) Report for Congress R47833 (US Congress, CRS: Washington, DC, 14 Nov. 2023); and 1939 National Defense Stockpile Act, US Public Law 76-117, signed into law 7 June 1939.

[90] 1950 Defense Production Act, US Public Law 81-774, signed into law 8 Sep. 1950.

[91] 1980 National Materials and Minerals Policy, Research and Development Act, US Public Law 98-479, signed into law 21 Oct. 1980.

Stockpile, this was largely hollowed out by the mid-1990s in lieu of expanding open trade, reducing state intervention in markets and capitalizing on the peace dividend.[92]

By the early 2000s the USA had offshored much of its production of minerals, including rare earth elements, to places where environmental standards and economic costs were much lower. According to a recent assessment, in 2023 the USA was entirely import-reliant for 12 of the 50 minerals on its current critical mineral list and was more than 50 per cent net import-reliant for an additional 29 of those minerals.[93] There is also significant supplier concentration: in 2023 China was the leading producer of 24 of 43 of the critical minerals for which reliable estimates were available.[94]

More dedicated national attention to growing dependencies began to emerge in 2010, when China threatened to impose export restrictions on REEs; that year, the US Department of Energy published the first Critical Materials Strategy, which it updated again in 2011.[95] Rebuilding the National Defense Stockpile also began to attract attention.[96] Dedicated government attention emerged during the 2017–21 administration of President Donald J. Trump. A 2017 executive order required the secretary of the interior, acting through the US Geological Survey (USGS), to draw up a critical minerals list.[97] This list was published in 2018 and updated again in 2022.[98] Pursuant to another executive order, the Department of Defense (DOD) in 2018 expressed concerns related to 'gaps in America's manufacturing and defense industrial base', particularly in the context of Chinese strategic industrial policies and potential threats of 'economic aggression'.[99] This was then followed in 2020 by a further executive order in which President Trump declared that

> [The USA's] undue reliance on critical minerals, in processed or unprocessed form, from foreign adversaries constitutes an unusual and extraordinary threat, which has its source in substantial part outside the United States, to the national security, foreign policy, and economy of the United States. I hereby declare a national emergency to deal with that threat.[100]

This perspective has been upheld and expanded upon by his successor, President Joe Biden. This has included an invocation of the Defense Production Act to boost domestic production of critical minerals related to large-capacity batteries.[101]

[92] US Government Accounting Office (GAO), *The National Defense Stockpile: Views on DOD's 1992 Report to the Congress and Proposed Legislation*, GAO/NSIAD-93-60 (GAO: Washington, DC, Mar. 1993).

[93] US Geological Survey (note 12), p. 6. The 15 lanthanides, a category of REE, are listed as separate minerals.

[94] US Geological Survey (note 12), p. 6.

[95] US Department of Energy (DOE), *Critical Materials Strategy: December 2010* (DOE: Washington, DC, 17 Dec. 2010); and US Department of Energy (DOE), *Critical Materials Strategy: December 2011* (DOE: Washington, DC, 10 Jan. 2012).

[96] US Under Secretary of Defense for Acquisition, Technology and Logistics, 'Strategic and critical materials operations report to Congress: Operations under the Strategic and Critical Materials Stockpiling Act during the period October 2009 through September 2010', US Department of Defense (DOD), Jan. 2011.

[97] US Executive Order no. 13 817, 'A federal strategy to ensure secure and reliable supplies of critical minerals', 20 Dec. 2017, *Federal Register*, 26 Dec. 2017.

[98] US Department of the Interior, 'Final list of critical minerals 2018', *Federal Register*, 18 May 2018; and US Department of the Interior, 'Final list of critical minerals 2022', *Federal Register*, 24 Feb. 2022.

[99] US Interagency Task Force in Fulfillment of Executive Order 13 806, *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States* (Department of Defense: Washington, DC, 2018), pp. 20, 29. See also US Executive Order no. 13 806, 'Assessing and strengthening the manufacturing and defense industrial base and supply chain resiliency of the United States', 21 July 2017, *Federal Register*, 26 July 2017.

[100] US Executive Order no. 13 953, 'Addressing the threat to the domestic supply chain from reliance on critical minerals from foreign adversaries and supporting the domestic mining and processing industries', 30 Sep. 2020, *Federal Register*, 5 Oct. 2020.

[101] US Executive Order no. 14 017, 'America's supply chains', 24 Feb. 2021, *Federal Register*, 1 Mar. 2021; and White House, 'Memorandum for the secretary of defense: Presidential determination pursuant to section 303 of the Defense Production Act of 1950, as amended', Presidential Determination no. 2022-11, 31 Mar. 2022, *Federal Register*, 6 Apr. 2022.

As legislated by the 2020 Energy Act, a mineral—notably excluding fuels—is deemed to be 'critical' by the secretary of the interior on the basis of it being essential to US economic and national security, having a vulnerable supply chain and serving an essential function in the manufacturing of a product whose absence would have 'significant consequences for the economic or national security of the United States'.[102] In addition to the list drawn up for the secretary of the interior by the USGS, there are also several agency-specific critical mineral lists, including from the Department of Energy and the DOD.[103] Critical minerals are prioritized in a myriad of agency and inter-agency support policies as well as assessment and reporting requirements.

Critical mineral designations are subject to change. For example, the 2022 list includes nickel and zinc, which did not appear in the 2018 list, but it excludes helium, potash, rhenium, strontium and uranium, which did appear in the previous list.[104] Efforts have been made in the US Congress to amend the assessment methodology used by the USGS in drawing up the list in order to include minerals such as copper, phosphate, potash or uranium, which are all excluded by the current methodological criteria.[105] A national assessment of each critical mineral is due by the end of 2024.[106]

A more comprehensive US national minerals policy in thus being developed, with significant legislative and executive policy attention. As of March 2024 the 2023–24 US Congress had introduced 136 bills, amendments and resolutions related to critical minerals.[107] The idea that critical minerals are an element of national security has been invoked by two successive administrations as part of efforts to reshore manufacturing and supply chains. Under the Biden administration, domestic mining has also been explicitly linked to clean energy transition, to address the 'existential threat' of climate change.[108]

The Biden administration has earmarked significant financing to enhance mineral security that is being disbursed through large-scale initiatives. These provide grants and tax credits for industries and support for related scientific research and a myriad policy interventions. For example, the 2021 Infrastructure Investment and Jobs Act (IIJA) allocates over $75 billion for energy- and mineral-related programmes, including several mapping project for critical minerals.[109] The 2022 Inflation Reduction Act (IRA) authorizes $500 million under the Defense Production Act to accelerate clean-energy supply chains, which involve critical minerals.[110] It also offers a clean vehicle tax credit; to qualify, at least 50 per cent of the value of minerals in the battery components of an electric vehicle must come from the USA or one of its partners in a free trade agreement (FTA) in 2024, with the share increasing each year until reaching 80 per cent by the

[102] 2021 Consolidated Appropriations Act, US Public Law 116-260, signed into law 27 Dec. 2020, division Z, 2020 Energy Act, title VII.

[103] US Government, Critical Minerals Subcommittee, 'Critical minerals lists', [n.d.].

[104] Rowan, L. R., *Critical Mineral Resources: National Policy and Critical Minerals List*, Congressional Research Service (CRS) Report for Congress R47982 (US Congress, CRS: Washington, DC, 8 Apr. 2024), p. 12.

[105] Rowan (note 104), p. 20.

[106] Rowan, L. R., *Critical Mineral Resources: The U.S. Geological Survey (USGS) Role in Research and Analysis*, Congressional Research Service (CRS) Report for Congress R48005 (US Congress, CRS: Washington, DC, 5 Apr. 2024).

[107] Rowan (note 106), p. i.

[108] White House, *National Security Strategy* (White House: Washington, DC, Oct. 2022); and White House, 'Remarks by President Biden on actions to tackle the climate crisis', 20 July 2022.

[109] 2021 Infrastructure Investment and Jobs Act, US Public Law 117-58, signed into law 1 Nov. 2021; and Yacobucci, B. D. et al., *Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*, Congressional Research Service (CRS) Report for Congress R47034 (US Congress, CRS: Washington, DC, 31 Mar. 2023).

[110] 2022 Inflation Reduction Act, US Public Law 117-169, signed into law 16 Aug. 2022; and Columbia University Sabin Center for Climate Change Law and Environmental Defense Fund, 'IRA Section 30001—Enhanced use of the Defense Production Act of 1950', IRA tracker, 2024.

end of 2027.[111] The 2022 CHIPS and Science Act authorizes $280 billion for civilian investment in research and development for critical sectors in which minerals are key upstream components.[112] New efforts have also been made to streamline 150-year old regulations on public lands, to advance domestic mining for critical minerals.[113] The 2023 National Defense Authorization Act (NDAA) made the largest financial authorization for stockpile acquisition in 30 years, 'to acquire strategic and critical materials required to meet the defense, industrial, and essential civilian needs of the United States'.[114] Most recently, the 2024 NDAA introduces new provisions directing the DOD towards a strategy of 'critical mineral independence' from putative adversaries including China and Russia.[115]

Many of the US efforts to decrease Chinese mineral inputs in supply chains encompass not only domestic production but also diversification of suppliers and intensification of ties with partner countries. A so-called friendshoring of mineral supply chains to the USA's allies and other partner countries is a complex and ongoing effort.[116] It includes, for instance, making FTA partners eligible for US tax credits.[117] The USA signed a critical mineral-specific FTA with Japan in March 2023 for this purpose. Bilateral agreements have also been signed with Australia and Canada, two major mineral producers, reducing barriers for their entry into US markets.[118] Other non-binding but mineral-specific initiatives include the Mineral Security Partnership, which is a public coordination and cooperation platform that includes some of the world's largest producers of mineral resources.[119]

[111] Buffie, N. E., 'Foreign entity of concern requirements in the section 30D clean vehicle credit', Insight IN12322, US Congress, Congressional Research Service, 28 Feb. 2024.

[112] 2022 CHIPS and Science Act, US Public Law 117-167, signed into law 9 Aug. 2022.

[113] US Department of the Interior, 'Biden–Harris administration report outlines reforms needed to promote responsible mining on public lands', 12 Sep. 2023.

[114] US Senate, Committee on Armed Services, 'Summary of the Fiscal Year 2023 National Defense Authorization Act', 2022.

[115] National Defense Authorization Act for Fiscal Year 2024, US Public Law 118-31, signed into law 22 Dec. 2024.

[116] Atlantic Council, 'Transcript: US Treasury Secretary Janet Yellen on the next steps for Russia sanctions and "friend-shoring" supply chains', 13 Apr. 2022.

[117] Hendrix, C., 'The push for made-in-America batteries comes with its own risks', Barron's, 16 May 2024.

[118] Natural Resources Canada, 'Canada and U.S. finalize joint action plan on critical minerals collaboration', News release, 9 Jan. 2020; and Australia–United States Climate, Critical Minerals and Clean Energy Transformation Compact, 20 May 2023.

[119] US Department of State, 'Minerals Security Partnership', [n.d.].

4. Beyond minerals: Cross-cutting policy drivers

Governments' evaluations of mineral criticality and pursuit of mineral security relates to the diverse functions that minerals serve in relation to much wider goals, priorities and ambitions. Among these, several cross-cutting themes emerge: national development and industrial policy; clean energy transition and environmental concerns; economic security, resilience and competitiveness; and military and defence matters. This chapter briefly explores each of these themes.

Notably, these imperatives are not always entirely distinct; they are often discussed in combination. Moreover, of course, these drivers vary across time in the four cases and are not equally emphasized. Russia has demonstrated much less policy interest in the clean energy transition than the other cases, while holding a much more rigorous and long-standing economic security agenda than the European Union or the United States. With a different starting point for national development, China's priorities have—more than in the other cases—been heavily oriented towards economic development, although its efforts are now converging with EU and US efforts to protect as well as promote competitive edge in emerging technologies.

That being said, consideration of these various drivers offers an opportunity to better understand the aims towards which mineral security is in fact oriented, as well as whether mineral security policies are fit for these purposes. Notably, different drivers may interact in complex ways—in some cases in tandem, in other cases at cross-purposes—at domestic and international levels.[120] For example, in the cases of China and the EU—the world's largest energy importers—clean energy transition serves dually to enhance economic security and resilience. For the EU and the USA, reducing reliance on Chinese mineral supply chains is likely to raise costs for consumers and certain industry actors, at least in the short term, but it is deemed to enhance national security in geopolitical terms. The nature of politics, however, is such that goals can also be conflated and obfuscated in public messaging—again allowing for multiple priorities, even contradictory ones, to coexist simultaneously.

National development and industrial policy

The four cases in question are marked by distinct but also changing political economies. For instance, Western concerns about state capitalism—eschewed only a decade ago—have given way to growing consensus on the need for coherent industrial policies and market interventions, both to remain competitive globally and to support social welfare.[121] Indeed, EU and US efforts to reverse previous offshoring, including in mineral-related sectors, are discussed in terms of contributing to domestic employment and welfare. This is explicit in the text, framing and other measures around the USA's IIJA and IRA: to offer infrastructure- and clean energy-related jobs.[122] Similarly, the EU's Green Deal Industrial Plan is a 'growth strategy', which marks a shift towards greater enthusiasm for public financing and state aid in support of clean energy and decarbonization targets, with provisions also to protect social welfare in legacy carbon-intensive sectors. This brings policies more in line with China, however, where for the past

[120] Leonelli, G. C., 'Critical raw materials, the net-zero transition and the "securitisation" of the trade and climate change nexus: Pinpointing environmental risks and charting a new path for transnational decarbonisation', LSE Law, Society and Economy Working Papers no. 25/2023, London School of Economics and Political Science (LSE) Law School, 2023.

[121] Alami, I. and Dixon, A. D., 'The strange geographies of the "new" state capitalism', *Political Geography*, vol. 82 (2020).

[122] White House, 'The bipartisan infrastructure deal', Fact sheet, 6 Nov. 2021.

four decades public policy attention has been preoccupied with domestic economic development.[123]

As one USGS analysis notes, a country's mineral consumption traditionally relates to its stage of national development.[124] Progressive emphasis on basic infrastructure construction, heavy or light industrial manufacturing, domestic consumption or services, and advanced industries require different volumes and types of mineral input.[125] However, progress through these stages is not necessarily linear: current US efforts to boost domestic mining production essentially seek to revive what was already considered a declining industry. Since the collapse of the Soviet Union, significant degradation in Russia's mining infrastructure and the necessary transport infrastructure has resulted in a reverse modernization.[126] Meanwhile, a focus in the USA on leading in advanced and emerging technologies is also coupled with imperatives related to basic public infrastructure.[127]

In the case of China, the developmental trajectory is somewhat more distinct.[128] Only a decade ago, China's main exports were still low-end and semi-manufactured goods, dependent on large amounts of imports of not only raw materials but also foreign capital and technologies.[129] This highlights the relevance of China's strategic emphasis on bulk minerals such as iron, copper and aluminium—this reliance is assessed by some Chinese experts as being indicative of China's industrialization process still being decades behind that of the West.[130] Support for localized manufacturing and downstream integration of supply chains in China has over the years contributed to the country's rise up global value chains, and even poverty alleviation.[131] The success of industrial policies in that regard has led to progressive emphasis on consumption-driven growth and on emerging technologies, many categories of which China already dominates.[132] However, this economic upgrading undermines arguments that China should retain the status and privileges of a developing country that it holds in such multilateral forums as the WTO and United Nations Framework Convention on Climate Change (UNFCCC).

Meanwhile, Russia's political economy in the mineral sector is unique among the four cases. In addition to being inputs for the national economy, mineral resources—primarily oil and gas—also contribute significantly to the Russian state budget—which explains in part their inclusion in Russia's strategic minerals list. However, mineral development also intersects with other motives, including those related to the development of resource-rich but significantly underdeveloped regions such as the Russian Far East. These regions have nominally been a priority for developmental policy since at least the early 2010s.[133] However, the major challenges of Russian development of its non-fuel mineral sector include a lack of not only domestic capacity but also domestic demand; this contrasts, for instance, with China's globally significant industrial demand for non-fuel minerals. Despite policy ambitions, Russia produces few high-value-added

[123] Wang, H., '"Security is a prerequisite for development": Consensus-building toward a new top priority in the Chinese Communist Party', *Journal of Contemporary China*, vol. 32, no. 142 (2022).

[124] Menzie, D. et al., 'China's growing appetite for minerals', US Geological Survey, 2004.

[125] Menzie et al. (note 124).

[126] Vidal (note 87).

[127] 2021 Infrastructure Investment and Jobs Act (note 109); and 2022 Inflation Reduction Act (note 110).

[128] World Bank and Chinese State Council Development Research Center, *Four Decades of Poverty Reduction in China: Drivers, Insights for the World, and the Way Ahead* (World Bank: Washington, DC, 2022).

[129] Menzie et al. (note 124).

[130] Wang and Yuan (note 22), p. 1154.

[131] World Bank and Chinese State Council Development Research Center (note 128).

[132] Gaida, J. et al., *ASPI's Critical Technology Tracker: The Global Race for Future Power*, Policy Brief Report No. 69/2023 (Australian Strategic Policy Institute (ASPI): Canberra, Feb. 2023).

[133] Fortescue, S., 'Territories of accelerated development: Another case of policy failure in Russia?', *Post-Communist Economies*, vol. 34, no. 2 (2022).

goods and technologies, and efforts to upgrade the Russian economy from a low-value-added commodity-export model have largely been unsuccessful.[134] This had now been exacerbated by a war economy and heavy Western sanctions.

A factor related to developmental capacity is environmental management and enforcement. Historically, industries in developed countries have offshored not only production but also associated environmental costs to other countries, where the trade-off for development may be more politically expedient or otherwise difficult to counter.[135] This was evident in the case in the USA, where domestic environmental regulations in addition to lower costs in China led to the wholesale offshoring of the production of rare earth elements to China. Two decades later, many of China's heavy REE mines have also closed due to environmental regulations, and its supply has, in turn, been offshored to foreign sources such as Myanmar.[136]

Clean energy transition and environmental concerns

Clean energy applications and supporting technologies are now the main driver of demand growth for several minerals, including lithium, copper, graphite, cobalt, nickel and REEs.[137] All four polities have target dates for the transition to net zero emissions of carbon: 2050 in the cases of the EU and the USA and 2060 for China and Russia. Chinese, EU and US mineral security strategies in particular are increasingly framed around green transition, both stimulating and capitalizing on growing markets for clean energy technologies. Energy transition-related minerals feature on the critical and strategic minerals lists of all four powers, although the inclusion of copper is still being debated in the USA (as noted in chapter 3).

Green transition goals motivate in part the industrial strategies mentioned above, and drive in part also the rush for critical and strategic minerals. The IEA has estimated that global demand for energy transition-related minerals will double by 2040 based on announcement energy policies, with a sixfold increase in demand required in order to reach global net zero.[138] Some preliminary assessments suggest that the EU's Green Deal Industrial Plan will require up to 35 times more lithium and 7–26 times more REEs by 2050.[139] Post-IRA, the USA's demand for lithium, cobalt and nickel may grow up to 23 times by 2035 and copper demand may double.[140] For China, meeting its carbon neutrality targets will entail serious mineral supply shortages based on domestic supply alone for chromium, copper, manganese, tellurium, gallium and cobalt.[141]

Decarbonization efforts are notably more muted in Russia. For instance, its current Energy Strategy to 2035—although subject to update—continues to focus almost exclusively on promoting extraction, consumption and export of fossil fuels.[142] In the

[134] Szakonyi, D., 'Russia as a failed developmental state: Economic policy and predation under sanctions', Stanford University, Freeman Spogli Institute for International Studies, Sep. 2020.

[135] Saussay, A. and Zugravu-Soilita, N., 'International production chains and the pollution offshoring hypothesis: An empirical investigation', *Resource and Energy Economics*, vol. 73 (June 2023).

[136] Chen, W. et al., 'Reshaping heavy rare earth supply chains amidst China's stringent environmental regulations', *Fundamental Research*, in press, available online 26 Jan. 2024.

[137] International Energy Agency (IEA), *Global Critical Minerals Outlook 2024* (IEA: Paris, 2024).

[138] International Energy Agency (note 137).

[139] Gregoir, L. and van Acker, K., *Metals for Clean Energy: Pathways to Solving Europe's Raw Materials Challenge* (KU Leuven: Leuven, 2022).

[140] Yergin, D., *Inflation Reduction Act: Impact on North America Metals and Minerals Market* (S&P Global Market Intelligence: New York, Aug. 2023).

[141] Wei, W. et al., 'Toward carbon neutrality: Uncovering constraints on critical minerals in the Chinese power system' *Fundamental Research*, vol. 2, no. 3 (May 2022).

[142] Russian Government Order no. 1523-r, 'Энергетическая стратегия Российской Федерации на период до 2035' [Energy Strategy of the Russian Federation to 2035], 9 June 2020; and Climate Action Tracker, 'Russian Federation', 9 Nov. 2022.

USA, the pace and direction of federal government support for clean energy might also be subject to policy reversal, depending on the outcome of the November 2024 elections.[143]

There are currently sufficient global reserves to meet all transition goals, although this, of course, requires a growth in extraction rates.[144] Aggregate global mineral resources directly translate neither to economic recovery nor to access. Uneven geographic concentrations of these minerals, as well as different levels of corporate or national control, can also serve to restrict access. Complex demand- and supply-side dynamics also interact with changing technological variables such as mineral intensity, recycling rates and substitution. These all have an impact on whether, and how, mineral availability might represent a bottleneck in green transition nationally or globally.[145] More remains to be understood, however; for example, constraints on mineral supplies are often not even incorporated in modelling of decarbonization pathways.[146]

Yet, climate change is only one subset of an array of environmental problems on the agendas of national governments. Mining and mineral refining are among the most environmentally damaging industrial activities—contaminating soil, water and air, reducing biodiversity, and creating other social and environmental hazards in and beyond mining areas.[147] Processing 1 tonne of REEs can, for instance, create 2000 tonnes of toxic waste.[148] Contradictions lie also in the fact that the mining of energy-transition minerals is currently emissions intensive, often using fossil-fuel based grid electricity.[149]

Economic security and competitiveness

In addition to greater demand, a significant impetus and prominent justification for attention to minerals is growing concern—particularly in the EU and USA—over potential supply chain disruptions. In the 1990s, concerns about mineral security focused on the possibility of disruption driven by political instability, while China barely registered as a supplier.[150] Several cases in which natural disasters and labour strikes affected global supplies of chemical material and minerals in the 2010s highlighted again the possibility of incidental shocks to supply chains. The major economic disruption of the Covid-19 pandemic, which had an impact on all supply chains, has also played a role in efforts to redress dependencies and enhance resilience to shocks.[151]

However, today much of the Western policy discussion concerns the possibility, and reality, of deliberate and targeted trade disruptions. The Russia–Ukraine War—which, in addition to triggering Western sanctions and 'decoupling' from Russia, also disrupted supply chains and commodity markets—has exacerbated both political tensions and concerns related to trade dependency. China–USA strategic tensions have since 2017 also been playing out in the economic arena. All this has led to growing convergence—in

[143] 'Trump pledges to end the "green new scam"', Bloomberg, 19 July 2024.

[144] Månberger, A. and Stenqvist, B., 'Global metal flows in the renewable energy transition: Exploring the effects of substitutes, technological mix and development', *Energy Policy*, vol. 119 (Aug. 2018).

[145] Calderon, J. L. et al., 'Reviewing the material and metal security of low-carbon energy transitions', *Renewable and Sustainable Energy Reviews*, vol. 124 (May 2020).

[146] Moerenhout, T., Lee, L. Y. and Glynn, J., 'Critical mineral supply constraints and their impact on energy system models', Colombia University, Center on Global Energy Policy, May 2023.

[147] International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions*, revised (IEA: Paris, Mar. 2022).

[148] Chemin, M.-C., 'Rare earth elements exploitation, geopolitical implications and raw materials trading', *Geophysical Research Abstracts*, vol. 17 (2015).

[149] International Energy Agency (note 147).

[150] Hendrix (note 117).

[151] Akcil, A., Sun, Z. and Panda, S., 'Covid-19 disruptions to tech-metals supply are a wake-up call', *Nature*, 17 Nov. 2020.

all four cases—around the need to ensure 'economic security' and resilience, including in mineral-related supply chains.

Security is a contested concept, including in the economic realm. However, a common understanding has emerged around the pursuit of economic security—defined in terms of mitigating foreign dependencies, both in general as well as in relation to specific countries, in order to guard against forms of economic leverage or coercion. It is being pursued through a growing array of measures to restrict trade and investment.[152]

In the USA, the Trump administration from 2017 onwards began to securitize the economy. The idea that 'national security is economic security' was used to justify a range of import-restricting measures.[153] While this antagonized the EU, it precipitated more serious and long-standing trade tensions with China. Tariffs on Chinese products have largely been maintained—and in some cases expanded—under the Biden administration. As part of wider China–USA geostrategic competition, the USA has also imposed new targeted restrictions on Chinese access to technology, equipment and markets—from advanced semiconductors to electric vehicles.

Nearly all of the emerging technologies in question have critical minerals embedded in their supply chains—minerals deemed to be critical by virtue of being 'essential to the economic or national security of the United States'.[154] However, no precise or official definition of economic security has been published.[155] This suggests that minerals will continue to be caught up in wider and widening processes of securitization of the economy.

The EU has taken a more cautious and less unilateral approach to economic security, including through a 'de-risking' concept that simultaneously emphasizes risk mitigation and continued interdependence.[156] In 2023 the European Commission published an Economic Security Strategy, which among other tasks will assess and begin to address risks to supply chains and risks of weaponization of economic dependencies.[157] Downstream applications of critical minerals, specifically in critical technology areas that are deemed essential to the EU's economic security, are currently being assessed across the EU and its member states for vulnerabilities.[158] Other EU measures to enhance economic security in recent years also include a mechanism for the screening of foreign direct investment (FDI) and an anti-coercion instrument to respond to deliberate economic pressure.[159] Both onshoring and diversification feature in the EU's Critical Raw Materials Act.[160]

As market economies that have long championed open global trade, the economic security agenda is comparatively new for the EU and the USA. As it relates to minerals in particular, concerns about vulnerability have been somewhat less prominent for China and Russia, which are major producers of several of the critical minerals with which the

[152] Goldberg, P. K. and Reed, T., 'Is the global economy deglobalizing? And if so, why? And what is next?', Brookings Papers on Economic Activity, Brookings Institution, spring 2023.

[153] Navarro, P., 'Why economic security is national security', White House, 10 Dec. 2018.

[154] 2020 Energy Act (note 102).

[155] Benson, E., Mouradian, C. and Palazzi, A. L., *Toward a U.S. Economic Security Strategy: Twenty-First-Century Guidance for Domestic and International Policymaking* (Center for Strategic and International Studies: Washington, DC, July 2024).

[156] Zhou et al. (note 1).

[157] European Commission, High Representative of the Union for Foreign Affairs and Security Policy, 'European Economic Security Strategy', Joint communication to the European Parliament, the European Council and the Council, JOIN(2023) 20 final, 20 June 2023.

[158] European Commission, 'List of 10 critical technology areas for the EU's economic security', C(2023) 6689 final annex, 3 Dec. 2023.

[159] European Commission, 'New tool to enable EU to withstand economic coercion enters into force', Press release, 27 Dec. 2023; and European Commission, 'An EU approach to enhance economic security', Press release, 20 June 2023.

[160] Critical Raw Materials Act (note 46).

EU and the USA are concerned. But the Russian state has long considered the economy as being integrated with national security. Its 2017 Economic Security Strategy defines economic security as the 'protection of the national economy from external and internal threats', with aims that include preventing 'crisis' in the resource and raw materials sphere.[161] Notably, the strategy lists the development of 'green technologies' among its list of challenges and threats to economic security due to diminished global demand for fossil fuels. It includes depletion of the raw material resource base as another threat. As noted above, import-substitution policies have widely accelerated in the context of the Western sanctions that Russia has faced since its annexation of Crimea 2014, necessitating policies for the diversification of both foreign markets and suppliers.

China has benefited immensely from opening its economy to the world, including much needed foreign capital and technology in the mining sector. However, with its own growing and largely irreversible import dependencies, it has become much more concerned with potential geopolitical as well as market risks. More securitized understandings of the economy have emerged since at least the start of Xi Jinping's presidency, in 2013. A 'holistic security concept'—which includes dimensions of energy and resource security—has over the past decade had an impact on more and more sectors of the Chinese economy.[162] Diversification of trade partners, suppliers and even supply routes—including for minerals—has driven the ongoing BRI.[163] Protecting its current market share as well as responding to current and future economic measures against it also motivate China's above-mentioned trade and technology restrictions in the minerals sphere.

Related to the concept of economic security is economic resilience. Security and resilience are often discussed in combination in the West, but—whereas security emphasizes specific threats and may invite harder policy responses to eliminate them—resilience suggests a greater emphasis on capacity and flexibility to allow adaptation to disruptions in a dynamic environment that may still work to maintain connectivity.[164]

Finally, defensive measures to enhance economic security are often coupled with more active, even offensive, forms of economic policy. The latter may have domestic drivers (as mentioned in the chapter on energy transition), but they are also motivated by a desire for competitive edge and even dominance in relation to foreign competitors or adversaries. This conjunction of defensive and offensive economic policy is particularly prominent for the emerging technologies that mineral supply chains serve.

The conjunction of technological advancement and economic security is evident in the concept of 'technological sovereignty', a term that is growing in use across different policy spaces.[165] For instance, Russia is explicitly prioritizing new national projects tied to metallurgy and development of advanced materials in so far as they contribute to the technological sovereignty of Russian industry.[166] REE independence has also been tied

[161] Russian Presidential Decree no. 208, 'О Стратегии экономической безопасности Российской Федерации на период до 2030 года' [On the Economic Security Strategy of the Russian Federation for the period to 2030], 13 May 2017, para. 7(1) (author translation).

[162] Chen, Y. (陈一新), 'Fully implement the overall national security outlook 全面贯彻总体国家安全观', Interpret: China, Center for Strategic and International Studies (CSIS), 15 Apr. 2024.

[163] Farooki, M., 'China's mineral sector and the Belt & Road Initiative', Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE) Policy Brief no. 2, Mar. 2018.

[164] Radebe, N. and Chipangamate, N., 'Mining industry risks, and future critical minerals and metals supply chain resilience in emerging markets', *Resources Policy*, vol. 91 (Apr. 2024).

[165] March, C. and Schieferdecker, I., 'Technological sovereignty as ability, not autarky', *International Studies Review*, vol. 25, no. 2 (June 2023).

[166] President of Russia, 'Opening metallurgical plants in the regions', 15 July 2024; and Russian Government Resolution no. 603, 'Об утверждении приоритетных направлений проектов технологического суверенитета и проектов структурной адаптации экономики Российской Федерации' [On approval of priority areas of projects on technological sovereignty and structural adaptation of the economy of the Russian Federation], 15 Apr. 2023.

to a Russian governmental road map for high-tech development.[167] The USA's export controls now cover 'emerging and foundational technologies', which have in several cases been directed only towards China.[168] The Biden administration's 2022 National Security Strategy is explicit on the need to maintain an 'enduring competitive edge' over China, particularly in the military-technological domain.[169] In the EU, as well, the concept of technological sovereignty has gained credence as a political priority.[170] In China, goals related to technological self-reliance and competitiveness in technology-related matters have also become entangled with national security, as well as a more wholesale move towards an innovation-led economic growth strategy.[171]

Military and defence matters

Economics also tie into more traditional national security concerns related to defence and warfighting, which may in cases of real or perceived crises receive higher urgency and priority than the civilian sector. Minerals are important inputs into the military-industrial base. This includes basic structural materials such as steel, copper, aluminium, titanium, composites and ceramics for manufacturing military platforms and components for aircraft, vehicles and ships. It also extends to more specialized minerals that are essential inputs to weapon systems, navigation instruments and sensors.

Military demand for non-fuel minerals is generally acknowledged to be much less significant than for civilian industries. However, there remains a dearth of systematic analysis of overall mineral requirements. Although some information is known about the mineral needs of particular defence systems, there are also several layers of complexity and often low transparency in military supply chains.[172] US assessments in the early 2010s about the supply of REEs were unable to determine in detail how much was consumed by the military sector—although one estimate was that the DOD used less than 5 per cent of the USA's total REE consumption.[173]

Some analysis suggests that there may be sectorial competition for minerals, between civilian and military industries. One EU study suggests that long-lasting defence demand would be 'detrimental' to commercial sectors, especially aeronautics and space.[174] The extent of the detriment can be difficult to assess with precision, given the various tiers of suppliers that feed into the military-industrial complex of the EU member states and the USA. Notably, the US DOD assesses that—given the smaller quantity requirements of the US military and its stockpiling policies—it would be the

[167] Russian Federation Council, 'А. Жуков: К 2030 году планируется полностью уйти от зависимости России в импорте редких и редкоземельных металлов' [Zhukov: By 2030 it is planned to completely eliminate Russia's dependence on imports of rare and rare-earth metals], 22 Dec. 2023.

[168] US National Science and Technology Council, Fast Track Action Subcommittee on Critical and Emerging Technologies, 'Critical and emerging technologies list update', White House, Feb. 2024.

[169] White House, *National Security Strategy* (White House: Washington, DC, Oct. 2022), p. 23.

[170] Breton, T., European Commissioner for Internal Market, 'Sovereignty, self-assurance and solidarity: Europe in today's geopolitics', Speech, 5 Sep. 2022.

[171] Arcesati, R., Chimits, F. and Hmaidi, A., 'Keeping value chains at home: How China controls foreign access to technology and what it means for Europe', Mercator Institute for China Studies (MERICS), Aug. 2024; and Jie, Y., 'China's third plenum marks a sea change in growth model', Chatham House–Royal Institute of International Affairs, 11 July 2024.

[172] Arkell, J. and Hicks, N., 'Mitigating critical minerals supply chain risks in aerospace and defence', Deloitte, 2024.

[173] Bailey Grasso, V., *Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress*, Congressional Research Service (CRS) Report for Congress R41744 (US Congress, CRS: Washington, DC, 23 Dec. 2013), p. 10.

[174] Carrara et al. (note 50).

civilian sector that would bear the brunt of disruptions to the supply of strategic and critical materials and minerals.[175]

However, in several respects, mineral inputs for the military sector can be more vulnerable than general civilian use; military applications often have much higher purity requirements than civilian applications, therefore with more specific bottleneck risks and substitution challenges.[176] Self-reliance for military procurement for strategic military systems and their components is a growing concern. For instance, the USA's 2024 NDAA mandates the DOD to establish a strategy to ensure that its critical mineral supply chains are not dependent on adversarial states by 2035.[177]

The four polities in question have different military capacities, ambitions, industrial bases and policy tools to address military-related mineral supply concerns. The total military spending of the EU member states is greater than Russia's. However, the EU is not a uniform actor comparable to the other three cases, with nationally fragmented and parallel military-industrial bases and markets. There have been long-standing attempts to better unify them, most recently through the European Defence Industrial Strategy announced in March 2024.[178] Analysis of risks for the EU aerospace and military industry has identified potential bottlenecks at two points in the supply chain: the upstream level of mineral inputs and the assembly level.[179] The upstream concerns largely parallel the wider concerns that the EU holds about civilian industries regarding the concentration of suppliers and dependencies, specifically in relation to China.[180]

The USA has by far the world's largest military in terms of military expenditure and requirements.[181] It also has significant policy tools at its disposal, including the Defense Production Act, which, as noted above, has been used for mineral procurement. In March 2023 the National Defense Stockpile was assessed to hold stockpiled material worth just over $912 million, mitigating only about 40 per cent of the military demand shortfalls for strategic and critical minerals.[182] National security arguments have also channelled significant DOD funds into mining and industry specifically to help mitigate supply risks.[183]

Finally, while China and Russia are assessed by SIPRI to be the second and third largest military spenders globally, they are much less transparent than the USA. In China the concept of civil–military fusion encapsulates efforts to enhance its military through advanced and emerging technological developments and innovations in the civilian sector—although less is known about how this affects mineral supply chains.[184] For China, information about stockpiling for several mineral categories is not public, particularly in cases where there is import demand; however, as noted above, China's stockpiles serve economic in addition to presumed military purposes.[185]

For Russia, military demand for minerals is of interest to policymakers. In 2016, REEs were described by Russian President Vladimir Putin as 'critically important to

[175] US Department of Defense, 'The Defense Department's strategic and critical materials review', Press release, 8 June 2021.

[176] Arkell and Hicks (note 172).

[177] Jacobs, J. and Broberg, D., 'What's in the FY2024 NDAA for critical minerals?', Bipartisan Policy Center, 30 Oct. 2023.

[178] European Commission, Directorate-General for Defence Industry and Space, 'EDIS: Our common defence industrial strategy', [n.d.].

[179] Carrara et al. (note 50).

[180] Carrara et al. (note 50).

[181] Tian, N. et al., 'Trends in world military expenditure', SIPRI Fact Sheet, Apr. 2024.

[182] Keys (note 89); and Wicher, G., 'The U.S. military and NATO face serious risks of mineral shortages', Carnegie Endowment for International Peace, 12 Feb. 2024.

[183] Jacobs and Broberg (note 177).

[184] Fritz, A., 'China's evolving conception of civil–military collaboration', Center for Strategic and International Studies (CSIS), 2 Aug. 2019.

[185] White House (note 29).

[Russia's] defence capabilities', a concern that has no doubt advanced since the full-scale war started in 2022.[186] At present, the degree to which mineral supplies serve as a bottleneck for the replenishment of Russian military stocks and military-industrial production is unclear.

[186] Latukhina, K., 'Путин обсудил с чиновниками производство редкоземельных металлов' [Putin discussed the production of rare earth metals with officials], *Rossiiskaya Gazeta*, 29 July 2016 (author translation).

5. Global risks and implications

As discussed in chapter 4, mineral security is tied to and driven by much wider political dynamics, from national efforts to address climate change and decarbonize economies, to growing strategic and geopolitical tensions that are playing out in the economic sector. Critical and strategic mineral markets are both affected by and affect developments related to each of those wider national dynamics. Disaggregating the imperatives that drive mineral security measures can help in understanding whether those measures are fit for purpose in the service of the stated national goals.

But the pursuit of mineral security by China, the European Union, Russia and the United States does not occur in isolation; they have an impact on each other as they do on the rest of the world—in environmental, economic and geopolitical terms. This chapter discusses possible interaction effects, highlighting some ways in which national mineral security policies as they are currently formulated can work at cross-purposes to produce suboptimal outcomes and, by some metrics, even reduce global and national security. Examples of such potential risks covered here are those for the green transition, for multilateral economic cooperation and for geopolitical tension. The chapter then discusses impacts and potential implications for developing countries.

Risks for green transition

Critical and strategic mineral security has been driven in part by governments' imperatives around clean energy transition—in service of addressing the globally shared challenge of anthropogenic climate change. Reaching global and national targets for decarbonization and net zero entails significant investments in industries, technologies and goods that all require significant amounts of energy transition minerals—minerals that remain to be extracted. Growing policy and industry attention and investments in critical mineral supply chains are in this regard necessary to address climate change. However, as outlined above, current mineral security strategies are also oriented towards fragmentation—rather than integration—of minerals and mineral supply chains along geopolitical fault lines. Herein lie several potential risks for green transition at the global and national levels.

Several studies point out that fragmentation of markets into different trade blocs can make decarbonizing more difficult at national and global levels and slow the pace of the green transition.[187] Autarky for the mineral inputs necessary for economy-wide energy transformation is not possible for any of the four cases, all of which depend on some degree of international trade—particularly in the short and medium terms, as scaling up mining and processing capacity can take significant time.[188] Fragmentation of mineral markets, however, would mean that shocks that could be buffered in a wider market would be magnified, driving up costs and price volatility.

One study estimates that, due to these costs, full fragmentation of markets into two geopolitical blocs would lead to lower global investment in and production of renewables and clean technology goods such as electric vehicles.[189] While the econometric study is based on a hypothetical scenario, in practice states are locking out competitors and putative adversaries from mineral supply chains and associated

[187] Davidson, M. R. et al., 'Risks of decoupling from China on low-carbon technologies', *Science*, 15 Sep. 2022.

[188] Kowalski, P. and Legendre, C., *Raw Materials Critical for the Green Transition: Production, International Trade and Export Restrictions*, Organisation for Economic Co-operation and Development (OECD) Trade Policy Paper no. 269 (OECD: Paris, Apr. 2023).

[189] International Monetary Fund (IMF), *World Economic Outlook: Navigating Global Divergences* (IMF: Washington, DC, Oct. 2023).

markets. Stipulations on the sources of electric vehicle batteries in the USA's IRA, for instance, are intended to incentivize onshoring and, to a lesser extent, friendshoring of mineral production. However, its restrictive requirements can have a negative impact on automotive producers and the potential consumers to whom higher costs can also be transferred, the latter also due to the USA imposing new, and prohibitively restrictive, tariffs on imports of Chinese electric vehicles.

In this regard, it is notable that draft plans in the EU's Net-Zero Industry Act to help reshore clean energy supply chains through a 'buy European' procurement system were ultimately rejected as being too economically and environmentally costly.[190] Similar arguments about the costs of reshoring US manufacturing have also been made in the USA, including the negative impact on consumer demand and clean technology uptake.[191]

Part of EU and US efforts to counter Chinese dominance in clean energy supply chains and products is based on assessments that China has for a long time engaged in unfair subsidization of these industries.[192] However, the EU has also made similar arguments about the USA's IRA, referring to the 'market-distorting boost' of US subsidies as 'titling the global level playing field and turning a common global objective—fighting climate change—into a zero-sum game'.[193] Similar charges are now being directed back at the EU and the USA by China, which has made requests for the WTO to adjudicate on their tariffs on Chinese electric vehicles.[194] These economic security-centred disputes distract attention from more global-level imperatives to both scale-up and speed-up deployment and adoption of renewables. Geoeconomic tensions also fragment the global space for research and development and innovation for green transition, potentially slowing down new technological developments.[195]

Risk of geoeconomic escalation

Measures to domesticate or diversify mineral supplies are nominally intended to enhance a polity's economic security and resilience. However, these efforts are also accompanied by a generally more restrictive trade environment for minerals trade. Between 2009 and 2020 there was a fivefold increase in export restrictions related to critical and strategic minerals, and far more restrictions have been introduced since—led by China but also including other major producers such as Argentina, India, Kazakhstan, Russia and Viet Nam.[196] As well as the direct trade-related impact of restrictions, they can and often do lead to a spiralling dynamic of escalatory trade responses, further fragmenting markets and raising costs, not least for consumers.

The restrictions also raise wider economic and political tensions. This can happen even among allies: US imposition of tariffs on EU aluminium and steel products in 2018 led the EU to take retaliatory measures, and even provided impetus for the

[190] Leonelli (note 120); and Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724 (Net-Zero Industry Act), *Official Journal of the European Union L*, 28 June 2024.

[191] Hufbauer, G. C. and Jung, E., 'The high taxpayer cost of "saving" US jobs through "Made in America"', Peterson Institute for International Economics, 5 Aug. 2020.

[192] European Commission, 'Commission investigation provisionally concludes that electric vehicle value chains in China benefit from unfair subsidies', Press release, 12 June 2024; and White House, 'President Biden takes action to protect American workers and businesses from China's unfair trade practices', Fact sheet, 14 May 2024.

[193] EU Delegation to the USA, 'Submission by the European Union on the Inflation Reduction Act', Nov. 2022, p. 2.

[194] World Trade Organization (WTO), 'China initiates WTO dispute complaint regarding EU subsidy duties on electric vehicles', 14 Aug. 2024.

[195] Davidson (note 187).

[196] Kowalski and Legendre (note 188).

development of the EU's anti-coercion instrument.[197] In other words, trade disputes can amplify—in addition to being amplified by—the much-heightened geostrategic tensions. This is most sharp in the tensions and latent conflict between the EU and the USA on one side and China on the other. This, again, has already been playing out in sectors where critical and strategic minerals serve as key inputs, including advanced semiconductors, dual-use items and clean energy technologies. US restrictions have also led to what are widely considered to be retaliatory export controls by China in the case of gallium, germanium and graphite (see chapter 3). Chinese commentators have also made explicit references to rare earth elements as an 'ace' in China's hand in dealing with USA.[198]

Precedent for geopolitically motivated trade restrictions on REEs stem from a dispute between China and Japan in 2010 that was presumed to have led to Chinese export restrictions.[199] Spiralling economic warfare, however, often does not necessarily lead to successful outcomes, even unilaterally; in 2010, the threat alone, for instance, led Western states and allies to take robust and to some extent successful diversification efforts away from Chinese REE suppliers. This lost China overseas markets and politicized the minerals space, which continues today.[200] Efforts to punish through mineral trade restrictions are also complicated by the distributed nature of trade and by sanctions leakage: new Western sanctions and efforts to decouple Russian metals from Western markets have also had the effect of raising prices of aluminium, copper and nickel, while increasing Chinese access to cheap metals.[201] Non-fuel minerals are also not particularly expedient weapons of coercion, as disruption of supply largely affects only new production, not the operating and functioning of already deployed goods or energy systems. These minerals also constitute much smaller markets, reducing the effective pain of economic sanctions.

Risk of violent conflict and military confrontation

Whether growing geoeconomic fragmentation and weaponization can itself lead to heightened possibilities of conflict remains unclear. Empirical evidence on the relationship between trade interdependence and interstate conflict has long been mixed.[202] However, resources have historically had a significant impact on the foreign policy, if not the military posture, of states—not least in relation to fossil fuels.[203] Between the four cases, it is not likely that competition for critical and strategic minerals will itself precipitate conflict. However, minerals do have relevance for warfighting between them, through their value as inputs into the military sector (as noted above).

These dynamics are already evident in the Russia–Ukraine War, where depletion of EU and US stocks of materiel, platforms and munitions through support to the Ukrainian military have highlighted the importance of minerals for the military-industrial

[197] European Commission, 'Impact assessment report accompanying the document Proposal for a Regulation of the European Parliament and of the Council on the protection of the Union and its Member States from economic coercion by third countries', Commission Staff Working Document, 8 Dec. 2021.

[198] Hu, W., 'US need for rare earths an ace in Beijing's hand', *Global Times*, 16 May 2019.

[199] Evenett, S. and Fritz, J., 'Revisiting the China–Japan rare earths dispute of 2010', Centre for Economic Policy Research, 19 July 2023.

[200] '中美贸易战：中国的稀土战略和"稀土牌"的正反两面' [China–USA trade war: China's rare earth strategy and the positive and negative sides of the rare earth card], BBC, 18 June 2019.

[201] Hache, E., 'Geopolitics of metals: A strategic chessboard', Institut de Relations Internationales et Stratégiques (IRIS), 22 Apr. 20214.

[202] Lee, J. and Pyun, J. H., 'Does trade integration contribute to peace?', *Review of Development Economics*, vol. 20, no. 1 (Feb. 2016); and Martin, P., Mayer, T. and Thoenig, M., 'Make trade not war?', *Review of Economic Studies*, vol 75, no. 3 (July 2008).

[203] Council on Foreign Relations, 'Oil dependence and U.S. foreign policy 1850–2023', [n.d.].

base.[204] In 2022 the US DOD official in charge of military-industrial policy made explicit reference to supply chain vulnerabilities and bottlenecks for raw materials in relation to the war in Ukraine.[205] It goes without saying that these factors also have an impact on Russia's military-industrial base as the war goes on.

As it relates to the war in Ukraine, Russian-occupied areas are known to hold valuable mineral deposits, including titanium, iron, lithium and coal—although the locations of the deposits have since been classified by the Ukrainian government.[206] Russia has already begun to appropriate mineral production from occupied and annexed territories in Ukraine and subsumed them into its national supply chains, with further plans to revive and invest in mining facilities there.[207] Disruptions of Ukraine's mining and metals complex, which represented one-third of its exports prior to the war and one-tenth of its GDP, also feed into war dynamics.[208] In this regard, exploration and exploitation of significant mineral deposits in other occupied or contested territories, including the South China Sea, are also worth monitoring.

In the context of the Russia–Ukraine War and wider geopolitical tensions, concerns about worst-case military contingencies in this vein have become more prominent. For instance, Jens Stoltenberg, secretary general of the North Atlantic Treaty Organization (NATO), warned of dependencies on Chinese 'raw materials' as a parallel to vulnerabilities that the West faced due to imports of Russian oil and gas.[209] The US DOD has also estimated that, in a large-scale conventional China–USA conflict, the USA would have shortfalls in 69 minerals and that the current stockpile would cover only about 40 per cent of the projected military shortfall in a one-year conflict.[210]

Interestingly, many mineral supply chains still operate normally, with complex relations of interdependence entangling both suppliers and buyers across significant tensions. In this regard, vulnerabilities mark not only EU and US military procurement but also mineral exporters such as China and Russia that may—directly or indirectly—be supplying inputs into the supply chain of strategic systems that are or may be targeted against them.[211]

While minerals are by no means the driver of these geopolitical tensions, it is evident that existing tensions between major powers are playing out in the minerals sector, even if they are not being exacerbated by mineral security strategies. Spiralling tensions can and do shrink the space for multilateralism—which is itself necessary for broadening the space for peaceful relations between the states, creating common rules and providing the guardrails that prevent economic and political tensions from turning into much more direct, military confrontation.

Impacts on developing countries

An imminent issue is the folding of critical and strategic minerals into wider great power competition for influence, not least in resource-rich states. Bloc dynamics are already emerging in relation to Western allies and their partners, as they expand both their own production and their restrictions on adversaries. But there are open questions regarding

[204] Wicher (note 182).

[205] Gould, J., 'Vital mineral markets "not functioning" in wake of Ukraine war, says DoD industrial policy chief', *Defense News*, 20 June 2022.

[206] Faiola, V. and Bennett, D., 'In the Ukraine war, a battle for the nation's mineral and energy wealth', *Washington Post*, 10 Aug. 2022.

[207] President of Russia (note 166).

[208] Katser-Buchkovska, N., 'The future of critical raw materials: How Ukraine plays a strategic role in global supply chains', World Economic Forum, 9 July 2024.

[209] Stoltenberg, J., NATO secretary general, Speech, Atlantik-Brücke, 25 Apr. 2024.

[210] Wicher (note 182); and Keys (note 89).

[211] Villalobos, F. and Bazilian, M., 'Militaries, metals, and mining', New Security Beat, Wilson Center, 18 Apr. 2023.

how this zero-sum competition will play out in the developing world. One study finds that 11 minerals essential to emerging technologies may be subject to overseas competition for supply between China and the USA, with competition potential in Africa and South America.[212]

Indeed, major industrial powers have sought mineral-related partnerships and alignments throughout the developing world. Mining has, for instance, been an important target sector of Chinese investment and loans to states in Africa over the past two decades, in addition to being the largest source of Chinese imports from the continent.[213] China's model of state-led investment is relatively distinct, but all four powers have been keen to incorporate different constellations of resource-rich developing countries into their own production networks.[214] Resource competition between the four powers in other states and regions, which are already subject to great power manoeuvring and a battle for influence, could be destabilizing if not carefully managed. Poor governance indicators and weak institutions in these other countries can be exacerbated and, in some cases, even exploited by major powers; strategies to secure minerals may come at the expense of local communities or the local environment, or may entail trade-offs paid for by them.

Russia, for instance, has a military footprint in several mineral-rich African countries, where it has provided informal and formal security services and assistance to regimes, contributing to documented human rights abuses.[215] In several cases payments have been rendered in precious metals and gems such as gold and diamonds—and to an extent may also serve the purpose of sanctions evasion.[216] Political instability also more widely discourages investment. At the extreme end of such examples, Russia's full-scale invasion of Ukraine has ended prospective mining projects and foreign investment interest in Ukraine by Australian, Chinese and European companies, at least in the short and medium terms.[217]

All four powers studied in this report remain reliant on inputs from developing and other mineral-rich countries. The EU and the USA have made high-level commitments to upholding environmental, social and governance (ESG) standards for overseas mining cooperation. China has also published pronouncements and guidelines that encourage the application abroad of its domestic environmental standards and, in the same vein, has created a BRI International Green Development Coalition with various external stakeholders.[218] However, the occasionally incompatible imperatives that mark current formulations of mineral security may in practice loosen environmental due diligence in the name of securing supplies.[219]

Of course, resource-rich developing and middle-income countries have much more agency than during the cold war and few seem keen to pick sides. But even if it is unlikely that there will be an entirely bipolar global trade order, even greater fragmentation is

[212] Gulley, A. L., Nassar, N. T. and Xun, S., 'China, the United States, and competition for resources that enable emerging technologies', *Proceedings of the National Academy of Sciences*, 2 Apr. 2018.

[213] Moses, O. et al., *China–Africa Economic Bulletin*, 2024 edn, Boston University Global Development Policy Center, Apr. 2024.

[214] Schindler, S. et al., 'The second cold war: US–China competition for centrality in infrastructure, digital, production, and finance networks', *Geopolitics*, vol. 29, no. 4 (2024).

[215] Caparini, M., 'The role of the Wagner Group and other Russian private military and security companies in armed conflicts in 2023', *SIPRI Yearbook 2024: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2024).

[216] US Department of State et al., 'Africa gold advisory', 27 June 2023.

[217] King, E., 'Mining goes critical: Russia, Ukraine and US mineral supply chains', Prospector, 21 Mar. 2022.

[218] Chinese Ministry of Ecology and Environment and Chinese Ministry of Commerce, '关于印发《对外投资合作建设项目生态环境保护指南》的通知' [Circular on the issuance of guidelines on ecological environmental protection for foreign investment and cooperation construction projects], 5 Jan. 2022.

[219] Leonelli (note 120).

a risk.[220] For example, resource nationalism is growing in many resource-rich states. Since 2014 Indonesia has placed restrictions and even bans on the export of nickel ore—of which it is the world's largest producer—in addition to other minerals such as bauxite, coal, tin ore and copper ore.[221] Ghana, Namibia, Nigeria and Zimbabwe have also banned exports of unprocessed mineral.[222] Similarly, other major mineral exporters in the developing world—including Bolivia, Burkina Faso, Cameroon, Chile, the DRC, Gabon, Guinea, Kenya, Mali, Peru and Zambia—have significantly increased mineral export taxes, mining taxes, royalties, deposits and other fees.[223] Key mineral-producing states in Latin America have also made pronouncements about nationalizing mineral industries.[224]

These states' measures are understandable efforts to retain locally a greater proportion of the value-added and processing steps in mineral supply chains and to support their own industrial policies.[225] However, restrictive measures can also feed into the risks mentioned above, of slower green transition, global price volatility, and heightened trade and even political tensions. In this regard, there remain risks that growing resource nationalism and, indeed, mercantilism—pursued by developed and developing countries alike—may also shrink the space for the dialogue necessary to establish wider multilateral safeguards for ensuring stable, secure and sustainable mineral supplies for all.

[220] 'The new non-aligned: How to survive a superpower split', *The Economist*, 11 Apr. 2023.

[221] Hertanti, R., 'Between a mineral and a hard place: Indonesia's export ban on raw minerals', Transnational Institute, 15 June 2023.

[222] Reilly, T., 'African raw material export bans: Protectionism or self-determination?', Covington, Global Policy Watch, 21 May 2024.

[223] Wang (note 17).

[224] E.g. Villegas, A. and Scheyder, E., 'Chile plans to nationalize its vast lithium industry', Reuters, 21 Apr. 2023.

[225] Diene, P. D. et al., *Triple Win: How Mining Can Benefit Africa's Citizens, Their Environment and the Energy Transition* (Natural Resource Governance Institute: New York, Nov. 2022).

6. Conclusions

Mineral security is a policy pursuit that is laden with social and political values that go far beyond the materiality of these naturally occurring elements and compounds. Policy strategies combine, for instance, developmental, environmental and geostrategic imperatives and ambitions—the balance and direction of which are evolving and are still subject to change. They are also a window into how (and for whom) polities understand, address and prioritize threats. As explored in this report, mineral security as pursued by individual states can be zero-sum in framing if not in substance. This does not need to be the case. At global rather than national levels of analysis, aggregate reserves exist to meet the developmental, industrial and environmental needs of states—and meeting these needs is impeded by far more factors than lack of minerals alone.[226] Mineral-related tensions are connected to much deeper political and economic—rather than material or technical—barriers between polities. As they are currently formulated and pursued, mineral security strategies may even exacerbate these international differences and tensions; they are unlikely to help fundamentally resolve them. However, there are, broadly, also opportunities to channel mineral security competition into more constructive directions. This report concludes by outlining those opportunities.

First, all four cases—China, the European Union, Russia and the United States—are concerned with critical and strategic minerals as an input into economic development in addition to security outcomes. Whether or not this can be mutually acknowledged among them as a legitimate pursuit, trade with and supply dependence on other states and regions necessarily widens this discussion into partner perspectives. This includes the views of developing countries, where significant mineral resources are currently being sourced or explored. As mineral supply chains have become more politicized, there are the above-mentioned risks of these latter countries becoming subsumed into parochial geopolitical competition. However, genuine partnership and conversation with non-aligned, developing and emerging powers may direct perspectives towards addressing also the concerns and priorities of these other—particularly developing—countries. This can include addressing mineral-related environmental, social and governance risks, improving contract terms, and increasing local value-added processing—all in the service of globally shared sustainable development. For example, participation in minilateral initiatives such as the USA's Minerals Security Partnership (MSP) and the EU's proposed Critical Raw Materials Club overlaps with that of China's BRI, and the powers share some stated principles around sustainability. Rather than fragmentation and duplication, the individual initiatives should consider an open dialogue, with an eye towards wider multilateral consensus and stronger application of ESG principles and guidelines.

Second, as it relates to climate action, there is nominal political agreement among the four powers that action taken to address climate change is a global public good. Trade restrictions in the clean energy sphere have turned some of the climate action space into an interstate battleground. But the scope of already existing cooperative agreements can and should be widened to include the minerals sector and to continue to reduce both the economic and environmental costs of green transition. Through discussions in multilateral settings such as the UNFCCC or the WTO, free flow of the critical and strategic minerals necessary for the green transition could be better ensured through (mandatory or voluntary) rules and guidelines. In particular, these would include

[226] Jowitt, S. M., Mudd, G. M. and Thompson, J. F. H., 'Future availability of non-renewable metal resources and the influence of environmental, social, and governance conflicts on metal production', *Communications Earth & Environment*, vol. 1, no. 13 (1 Sep. 2020).

reporting requirements for transparency and information-sharing related to transition minerals and their associated supply chains.

Third, while all four cases strongly emphasize economic security, there must be greater acknowledgement that the pursuit of economic security—given necessary interdependencies—does not have to be zero-sum. Aiming for sufficient economic resilience represents a more reasonable metric, with less escalatory overtones and therefore better outcomes. In this regard, countries should seek to diversify supply chain dependencies and increase recycling as well as material efficiency, rather than wholesale decoupling from other national mineral markets. This will also facilitate a wider global market and reduce global price volatility.

Finally, there should be acknowledgement that security is both multifaceted and contested. This report focuses on perspectives of mineral security from particular polities. But there are other state and non-state stakeholders in mineral supply chains that face other forms of social, economic and environmental risk. Geopolitical contest and great power competition of course extends far beyond the minerals sector, but these tensions should not obfuscate other forms of insecurity—many of which are far more immediate. In this regard, the pursuit of national mineral security should again open, not close, debate about how to pursue shared benefits for global and human security, including green transition and economic development beyond borders. Competition, in other words, can still be oriented around a positive-sum race to the top, rather than a destructive race to the bottom. Not inconceivably, the former may even contribute to a reduction, rather than an exacerbation, of interstate tensions.

About the authors

Dr Jiayi Zhou is a researcher in the Conflict, Peace and Security Programme at Stockholm International Peace Research Institute (SIPRI). Her research places particular focus on the intersection of great power competition and sustainable development. She holds a PhD in environmental science. Before joining SIPRI, she worked as a policy analyst on China–US nuclear relations and was also a research assistant at the NATO Parliamentary Assembly.

Dr André Månberger is senior lecturer in energy and environmental systems studies, Lund University. His research focuses on interactions between low carbon transitions and security, using interdisciplinary approaches to study impacts of changing resource flows. Månberger leads the geopolitics of decarbonization work package in Mistra Geopolitics (www.mistra-geopolitics.se) and is the programme director of Mistra Mineral Governance (www.mistramineralgovernance.se).

STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE
Signalistgatan 9
SE-169 72 Solna, Sweden
Telephone: +46 8 655 97 00
Email: sipri@sipri.org
Internet: www.sipri.org