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The EU's dependency on critical materials

Meeting decarbonisation targets in the context of geopolitical risks

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Summary

The economic transformation required to reach global net zero goals relies on the mining and transformation of certain minerals and metals for the production of low-carbon technologies. Increasing global demand for these critical materials, combined with their uneven geographical distribution, raise potential supply issues that pose economic security and transition risks for the European Union. This report sets out the nature of the challenge, the policy responses and ways forward for the bloc.

The low-carbon transition relies heavily on access to critical materials

Minerals and metals such as cobalt, copper, lithium and nickel are critical to the manufacture of the clean technologies needed to transition from a carbon-intensive to a low-carbon economy: including solar panels, batteries for electric vehicles, and electrical generators for wind turbines. Increasing demand for these technologies is bringing into focus the need for countries and regions to secure supplies of critical minerals, which is subject to various geopolitical factors. Extraction and refining of these minerals are concentrated in just a few countries. For countries without their own mineral supplies or operations, their economic security and prospects for a successful low-carbon transition become dependent on trade with supplying nations.

The EU is behind the curve

The EU represents a relatively small proportion of global mineral production. By contrast, countries including China, Australia and the Democratic Republic of the Congo occupy dominant positions in this market. Political instability in some mineral-supplying countries creates risks for EU supply and the EU is exposed to the possibility that such countries will implement policies and strategies like resource nationalism, whereby exports are restricted or prices are raised to reap the economic benefits of having control over mineral supply chains.

In the wake of recent disruptions to mineral supply and increasing geo-economic fragmentation, the EU has started to acknowledge that its dependency on critical minerals that are extracted or transformed for manufacturing elsewhere in the world could result in vulnerability and risks, such as a loss of economic competitiveness or a delay in the pace of its low-carbon transition.

Critical material policies raise complex issues

The EU passed the Critical Raw Materials Act in March 2024 in response to the challenges of future mineral supply. The Act aims to develop resilient and sustainable critical mineral supply chains by shoring up domestic capacities in the extraction, processing and recycling of critical minerals. However, many issues need to be overcome if its aims are to be successful. These include the ability, in terms of technical and economic capacity and public acceptability, to expand domestic mining. EU countries will also have to closely consider the benefits and limitations of recycling and stockpiling strategies, and recognise the need for approaches such as 'sufficiency' measures to reduce its overall consumption of raw critical minerals.

1. Introduction

It is fair to say that we [the EU] lost our competitive edge in mining and processing […] because we have [for] maybe too long considered that decarbonizing meant relocating outside of the EU […]. We cannot replace a fossil fuel dependence with a raw material one. We know that some can weaponize this dependence against us.

Thierry Breton, European Commissioner for Internal Market
(International Energy Agency, 2023a)

Critical materials and the low-carbon transition

Transitioning to a decarbonised economy requires a massive deployment of clean energy technologies in power generation, electrification and mobility, along with far-reaching lifestyle changes across society. To achieve a low-carbon transformation that is consistent with the goals of the Paris Agreement, by 2050 wind energy generation needs to be scaled up globally by an estimated 15%, solar energy by 25%, and electric vehicle (EV) and battery manufacturing by 60% (Energy Transition Commission, 2023).

These low-carbon technologies rely on a wide range of critical materials – minerals and metals, including cobalt, copper, lithium and nickel for EV batteries, rare earth elements (REEs) for permanent magnets used in wind turbines, and copper and nickel for solar photovoltaics (PV) (see Tables 1.1 and 1.2).

There is no universal or fixed definition of critical materials, as different organisations and countries define them based on specific criteria and factors. These include the importance and potential substitutability of a material for different technologies, potential scarcity in the face of anticipated future demand (Miller et al., 2023) and risks of supply disruption caused by geopolitical events (European Commission, 2023). Copper, for example, is highly important to the manufacture of many low-carbon technologies (see Table 1.2) and it is projected that nearly 90% of currently known copper resources may be extracted by 2050 (IFPEN, 2024). This high demand and potential scarcity categorises it firmly as a critical mineral.

For the purpose of this report, ‘critical materials’ refer to those listed in Table 1.1.

Table 1.1. Critical materials and their uses in the manufacture of low-carbon technologies

Critical material	Use	
	Main	Other
Cobalt	EV batteries	Battery storage; bioenergy; electrolysers
Copper	Electricity grid; EV batteries; solar PV	Battery storage; bioenergy; Concentrated Solar Power (CSP); electrolysers; geothermal energy; hydropower
Dysprosium	EV motors; wind energy	N/A
Graphite	EV batteries	Battery storage
Iridium	Proton exchange membrane (PEM) electrolysers	N/A
Lithium	EV batteries	Battery storage
Manganese	EV batteries	Battery storage; CSP; electrolysers; geothermal energy; hydropower; wind energy
Neodymium	EV motors; wind energy	N/A
Nickel	Electrolysers; EV batteries	Battery storage; bioenergy; CSP; geothermal energy; hydropower; solar PV
Platinum	PEM electrolysers	N/A

Source: IRENA (2023).

Table 1.2. Importance of critical materials to selected clean energy technologies

	Copper	Cobalt	Nickel	Lithium	REEs	PGMs
Solar PV	+++	+	+	+	+	+
Wind	+++	+	++	+	+++	+
Hydropower	++	+	+	+	+	+
CSP	++	+	++	+	+	+
Bioenergy	+++	+	+	+	+	+
Geothermal energy	+	+	+++	+	+	+
Electricity networks	+++	+	+	+	+	+
EVs and battery storage	+++	+++	+++	+++	+++	+
Hydrogen	+	+	+++	+	++	+++

Source: IEA (2023b). Notes: +++ = high importance; ++ = moderate importance; + = low importance. PGM = platinum group metals (ruthenium, rhodium, palladium, osmium, iridium and platinum).

Purpose and structure of this report

The EU is likely to face challenges to the supply of the critical materials desribed above, due to increasing global demand combined with their uneven geographical distribution and geopolitical challenges – which in turn could pose risks to economic security and the ability of the EU to make a successful transition to net zero. This report sets out the nature of the challenge, policy responses and ways forward for the bloc.

Section 2 summarises the literature on critical materials and their supply risks which could hinder the smooth implementation of the EU's transition to net zero emissions by 2050.

Section 3 uses data compiled by the European Commission to shed light on the EU's dependencies on countries with highly developed critical material mining and refining sectors – some of which display relatively high levels of political instability and/or non-transparent governance.

Section 4 turns to the aims within the EU's recently adopted Critical Raw Materials Act and the challenges inherent in achieving them.

2. From critical materials to economic vulnerabilities

A rapidly growing literature shows that limited or precarious access to critical materials could generate new forms of vulnerability for some countries, regions and sectors in the context of the low-carbon transition. This section outlines the three main sources of such vulnerability: geological and technological limitations; unequal geographical distribution; and the market structure of minerals.

Geological and technological limitations

Constraints relating to the availability of minerals and metals, and the technology required to access or process them could generate bottlenecks in the supply of critical materials, threatening countries' ability to meet increasing demand and potentially slowing down of the pace of the low-carbon transition (Miller et al., 2023).

In its Baseline Decarbonisation scenario,[1] the Energy Transition Commission (ETC) identifies that expected increases in the supply of copper and nickel may be insufficient to meet demand, and that improvements to efficiency and increased recycling are unlikely to fully overcome this problem (ETC, 2023). Another potential source of supply bottlenecks comes from declining ore quality at new mining sites. The productivity index for Australian mining has fallen by 50% over the last 12 years (CGGD, 2023), for example, and global copper production is currently facing a decline in ore quality (Mudd et al., 2013). Declining ore quality could lead to higher energy consumption and technical costs for mineral extraction, and greater quantities of mining waste (Calvo et al., 2016).

While these issues could potentially be mitigated through a combination of discovering new mineral reserves, technological innovation (e.g. finding other materials that could replace those facing shortages), and better recycling and resource efficiency, they represent real problems in the short to medium term. One reason for this is the long lead times for the exploration and extraction of minerals prior to opening a mine, which are on average 18 years but vary between different minerals (S&P, 2024).[2]

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[1] The ETC's Baseline Decarbonisation scenario assumes an aggressive deployment of clean energy technologies by 2050 but no large increases in the intensity of materials usage or recycling, which would instead follow recent patterns.

[2] For example, lead times for opening new lithium mines are typically much shorter than for copper and nickel mines (S&P, 2024). Lead times are also influenced by technical, regulatory and organisational factors. Recent increases to average lead times are due to longer exploration phases and delays in securing financing and construction permits (ibid.). Measures can be taken to mitigate some of these delays. For example, the US introduced the FAST-41 process in 2015 which aims to accelerate the development of major infrastructure projects, including those in the mining sector (FPISC, 2022). It is important to ensure that delays are not detrimental to environmental and social considerations.

Greenbushes lithium mine, Australia. Photo: Calistemon/Wikimedia Commons

Unequal geographical distribution

A second source of vulnerability risks is the geographical location of critical materials. The high concentration of mineral and metal extraction and refining operations in certain countries – which is even more pronounced than for oil and gas in some cases (IEA, 2021) – raises the possibility of political conflict. China, Australia and the Democratic Republic of the Congo (DRC) account for 25%, 14% and 10% respectively of global critical material extraction (European Commission, 2023);[3] China for around 70% of rare earth element (REE) and graphite mining; Australia for around 50% of lithium extraction; and DRC for over 60% of cobalt extraction (ibid.).

The geographical concentration of mineral processing is even higher at the refining stage than at extraction. China refines over 40% of the critical materials required for the low-carbon transition, including 60% of cobalt, manganese and lithium, and as much as 95% of REEs (ibid.). China's dominance in this sector is largely due to its pursuit of energy autonomy and prioritisation of technological sectors such as renewable energy, as demonstrated in its 10-year *Made in China 2025* plan (McBride and Chatzky, 2019). China's advantage in refining is also rooted in the low labour costs and relaxed labour and environmental regulations it has offered to Western companies since the mid-1980s. This approach has enabled China to absorb foreign technologies, stay ahead of its competitors and boost domestic production, although this has meant that China has taken on the often significant ecological burden of mining operations (Filho, 2016). The liberalisation of global capital flows has further fuelled China's growth in the mining sector (Bonnet et al., 2022).

Some nations have expanded their roles beyond mineral extraction to include higher value-added refining processes (Hook et al., 2023). For example: Chile has become the world's second-largest refiner of copper (10% market share) and lithium (32%); Argentina accounts for 11% of global lithium refining capacity; India is the world's second-largest refiner of manganese; South Africa is the world's largest refiner of platinum metals; and Indonesia is a key player in nickel mining and refining (European Commission, 2023).

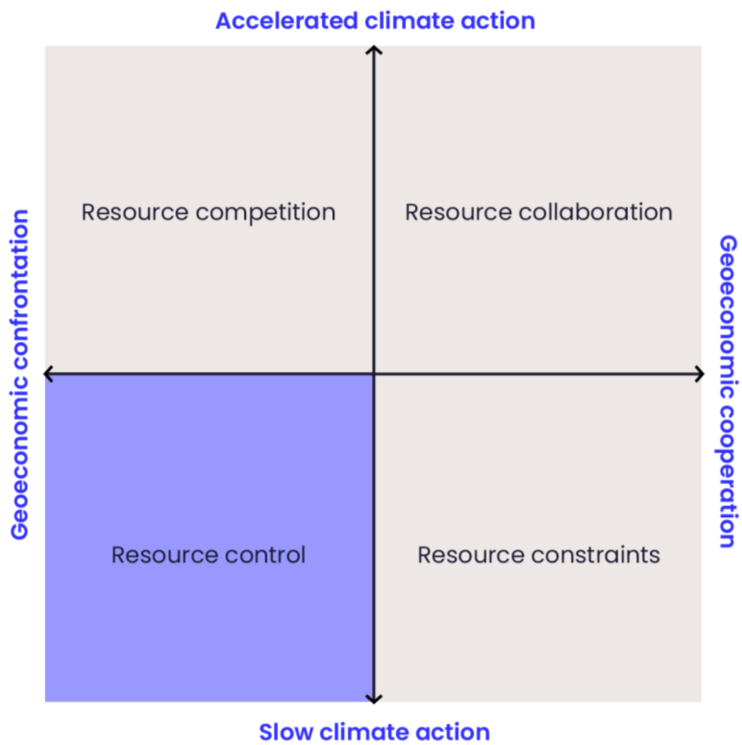
[3] The shares cited as 'European Commission (2023)' are the authors' own calculations based on this source.

Although the mineral refining sector does not rely on endowments of resources, making it less geographically constrained than mineral extraction, its success is influenced by several factors. Metal refining requires specific and well-developed infrastructure, reliable and affordable energy, and an available workforce. A favourable economic and regulatory environment can also encourage the growth of metal refining activities. Additionally, refining activities are often located close to mineral extraction sites to minimise transport costs, giving such locations a competitive advantage.

The geographical concentration of critical material extraction and refining could become a source of vulnerability both for countries that do not have critical mineral deposits and for those that do not currently engage in the extraction or refining of critical materials. This is a particular source of concern in the current context of increased geo-economic fragmentation (World Economic Forum, 2023), which could lead countries with an advantage in the extraction or refining of critical materials to seek control over the natural resources located within their territories for strategic and economic reasons. These countries could leverage their positions by restricting or blocking the export of certain critical materials, and/or increasing their price, thus adopting 'resource control' strategies (see Figure 2.1) or 'resource nationalism'.

The motivations behind resource control strategies are numerous and varied. There may be a desire to maintain global influence and hinder competitors, factors at play in the current geoeconomic competition between the US and China, for example (Harper, 2023). Resource nationalism may be employed by emerging markets and developing countries in particular, to help them foster economic growth, climb up value chains, generate more value added, and become more competitive on the international stage. Chile provides an illustrative example (Hook et al., 2023; see Box 2.1). Assessing the motivations behind resource control or nationalism is important, as they can significantly affect scope for negotiation.

Figure 2.1. Motivating factors behind resource control strategies



Source: World Economic Forum (2023).

Actions that fall under the category of resource control, and tensions related to these, may have already started to unfold for some critical minerals, albeit more in relation to IT technologies than low-carbon transition technologies (see Box 2.1 for a non-exhaustive list of examples). Export restrictions on critical materials have already increased five-fold since 2009 (Kowalski and Legendre, 2023). Many governments have sought to increase economic benefits from resource extraction and promote domestic capacity to process these materials and use them in manufacturing. Policies to achieve these aims include taxes, royalties, export bans, preferential treatment of state-owned enterprises and nationalisation (IRENA, 2023).

Box 2.1. Examples of the rise in resource control strategies related to critical materials

China
Between September and November 2010, China imposed an informal ban on raw shipments of REEs to Japan in response to the detention of a Chinese fisherman in disputed waters in the East China Sea. China also imposed in the same year strict export quotas, taxes and price controls on these materials, leading to a significant reduction in supply to the US and the EU. Consequently, REE prices soared by up to 500% the following year (Seaman, 2019).

United States
In response to the passing of the 2022 CHIPS and Science Act, which seeks to promote high-tech developments while impeding China's access to semiconductor technologies (Weaver, 2022), restrictions were introduced in August 2023 on the export of gallium and germanium: two critical minerals needed to make semiconductor chips and, to a lesser extent, solar panels (Harper, 2023). In October 2023, following the announcement of a series of new restrictions on semiconductor exports to China by the US, China imposed additional restrictions on its graphite exports (Benson and Denamiel, 2023). China is responsible for 67% of global extraction of graphite, an essential component for the manufacture of EV batteries (authors' calculation based on European Commission [2023]).

Chile
In April 2023, Chilean President Gabriel Boric announced plans to nationalise the lithium industry in a bid to boost the economy, stating, "this is the best chance we have at transitioning to a sustainable and developed economy. We can't afford to waste it" (Villegas and Scheyder, 2023). This came after Mexico nationalised its lithium deposits in April 2022 and Zimbabwe banned the export of unprocessed lithium in December 2022 (Reuters, 2022a; 2023a).

Indonesia
In recent years the Indonesian government has been phasing out the export of nickel ore, which was halted completely in April 2022 (IEA, 2022). A new regulation requires nickel to be processed domestically before being exported (ibid.).

The 'Lithium Triangle'
Alongside nationalisation strategies, mineral exporting countries are considering the creation of cartels to regulate trade, which would be similar to the Organization of the Petroleum Exporting Countries (OPEC). One such example is the so-called 'Lithium Triangle' countries, comprising Argentina, Bolivia and Chile, that recognise their power in holding lithium deposits that together are equivalent to more than half of global lithium resources.

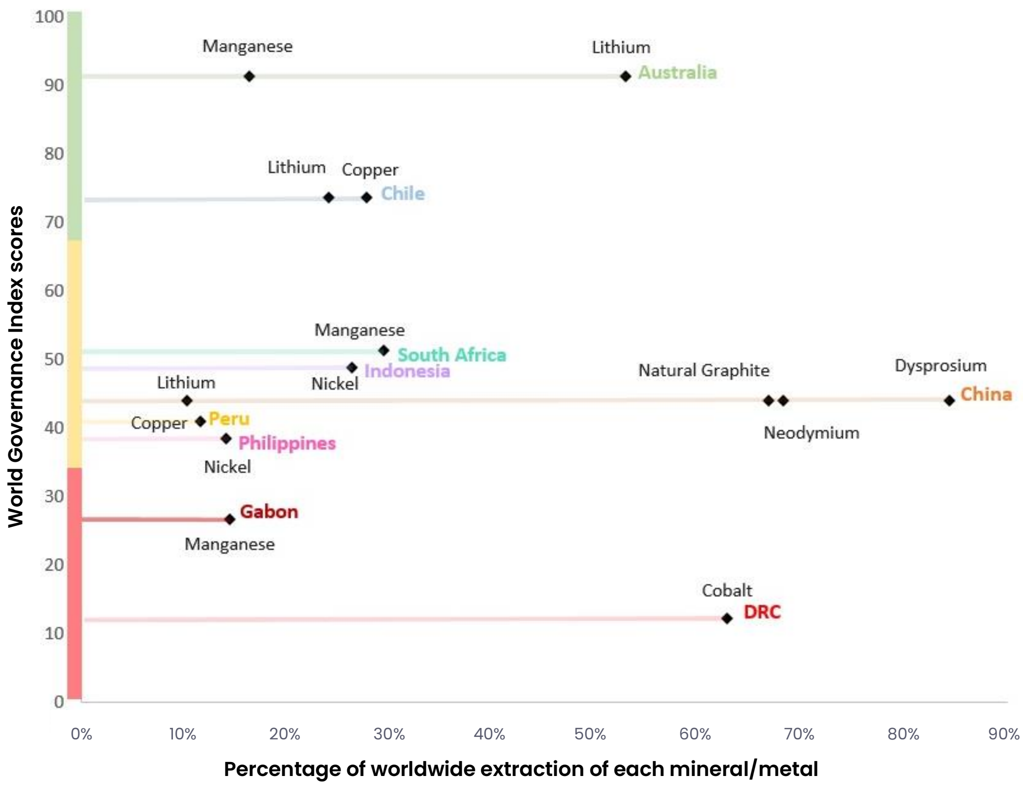
Due to the significant power of a few producers, it is possible that cartels will be created for other critical minerals such as platinum (Russia and South Africa being the main producers) and nickel (mostly present in Indonesia, Australia, Canada and the Philippines) (IRENA, 2023). However, for most critical minerals, including those named above, the conditions for creating successful cartels are rarely met, making it unlikely that they will form rapidly (Kooroshy and Siân, 2014).

Sources of political instability

Countries or jurisdictions with little involvement in producing or extracting critical materials, such as the EU, have to take into account the political stability and geopolitical objectives of supplying countries. For example, in 2017 Chile experienced a labour strike that led to disrupted production and shortages of supply in the global copper market after workers disputed the plans of international mining and metals company BHP to cut benefits such as private healthcare for employees (Cambero, 2017; Iturrieta, 2017). In another example, in early 2023 anti-government protests hit Peru, also leading to disruption and instability in the copper mining sector (Aquino, 2023; Attwood, 2023). DRC is also highly vulnerable to political and governance risks due to various political and social challenges. Serious human rights violations have also been perpetrated in the country, which could generate reputational risks for foreign firms operating in the country (IRENA, 2023).

Countries with strong extraction or refining capacities in the production of selected critical materials tend to exhibit low scores on the World Governance Index (WGI), which indicate high levels of political risk. The index, maintained by the World Bank, provides a risk proxy for countries by aggregating six indicators across the following dimensions: voice and accountability;[4] political stability and absence of violence/terrorism; government effectiveness; regulatory quality; rule of law; and control of corruption.

Figure 2.2. World Governance Index scores for critical mineral-extracting countries and their share of extraction

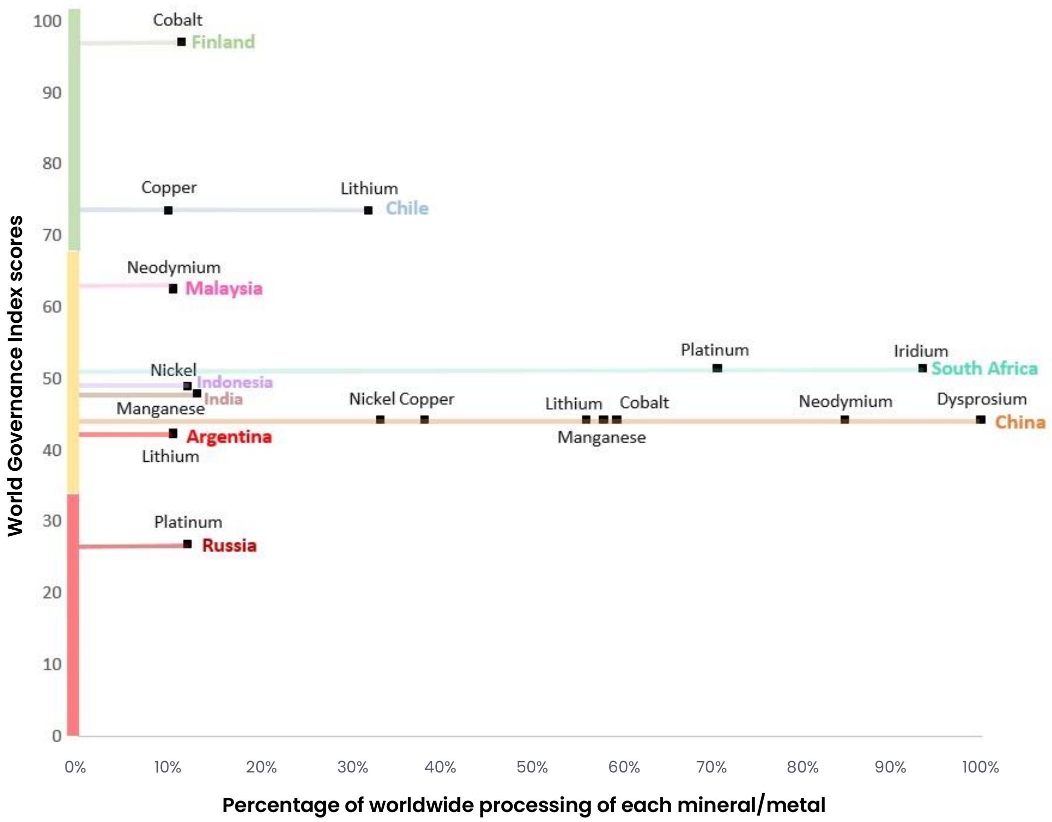


Source: Authors, based on European Commission (2023) and Kaufmann and Kraay (2023).

Figure 2.2 shows that of the eight selected critical materials, five are mainly extracted in countries with a medium–low WGI score (below 50), and four represent more than 50% of the global supply share.

[4] According to the World Bank, 'voice and accountability' captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

Figure 2.3. World Governance Index scores for critical mineral-processing countries and their share of processing



Source: Authors, based on European Commission (2023) and Kaufmann and Kraay (2023).

Figure 2.3 shows that processing tends to take place in countries with a low WGI score: only three of the nine critical materials listed are processed in countries with a high political stability score (i.e. of above 70).

Market structure

The third source of risks for critical material supply relates to the market structure for the different materials, which being opaque, specific to each mineral and dominated by a few large players could generate price volatility and financial instability. These characteristics make it challenging to track a range of mineral transactions. Some companies, such as BHP, Glencore and Rio Tinto, are diversified across multiple materials, while others, such as China Molybdenum, First Quantum Minerals and Southern Copper, focus on specific materials (IEA, 2023b).

Furthermore, materials are generally not traded in a transparent manner. Several metals lack sufficient liquidity to be traded on exchanges and are therefore traded ‘over the counter’, i.e. through direct agreements between two parties without the intervention of a third, such as a central exchange. The level of information on these exchanges available to the public therefore depends on the voluntary disclosure of the buyer and seller. Some major metals that are traded on exchanges are not free from risks either, as seen with nickel when the London Metal Exchange (LME) suspended nickel trading in March 2022 due to a price spike of over 250%. This spike was attributed to Chinese tycoon Xiang Guangda, who had speculated that nickel prices would fall before the onset of the war in Ukraine (Farchy et al., 2022), leading to a sudden price increase. The regulation of markets on which critical materials are traded is a topic of importance for the future, especially as the Shanghai Metals Market increasingly seeks to compete with the LME on the trading of critical materials.

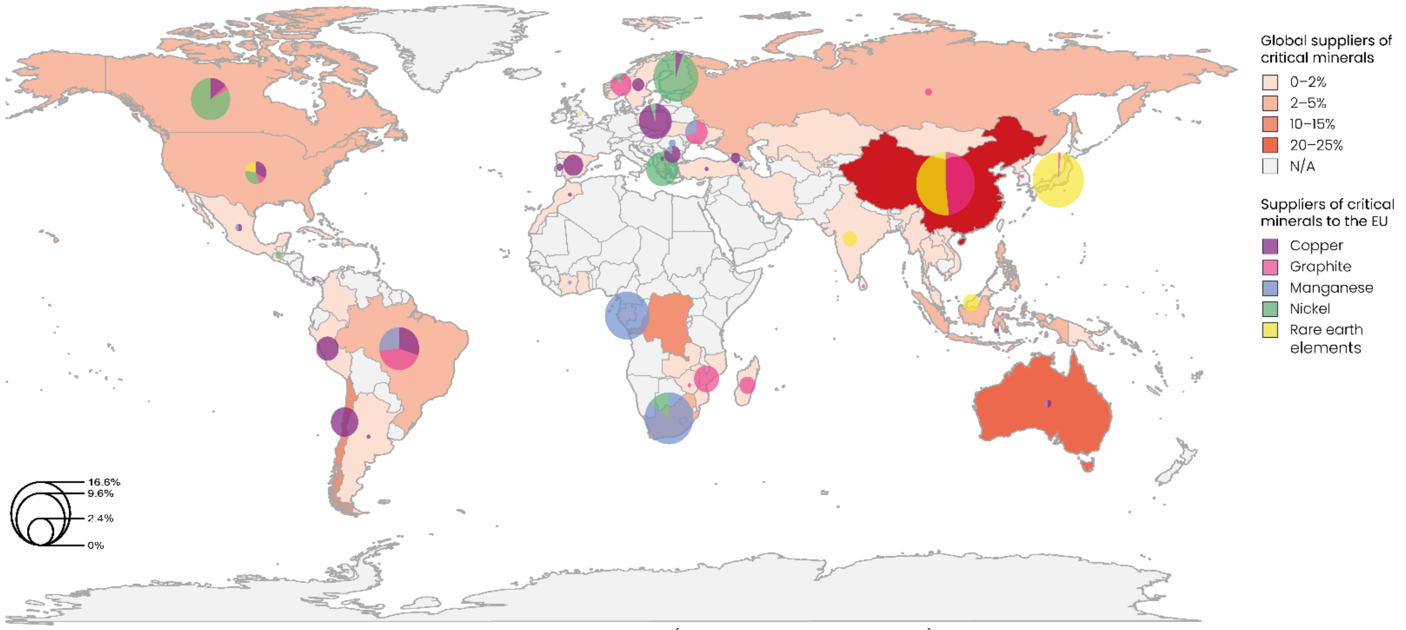
3. The EU’s position in the scramble for critical materials

With limited domestic capacity in the production of critical materials, the EU is highly dependent on imports. This section identifies the region’s key suppliers of selected minerals and metals and highlights their projected increase in demand as pressure mounts during the low-carbon transition.

As acknowledged by Thierry Breton, European Commissioner for Internal Market, the EU is far behind the curve with regard to the mining and processing of critical materials and is therefore highly vulnerable to the impacts of strategies that critical mineral-supplying countries may implement in a context of increased geoeconomic fragmentation (IEA, 2023a).

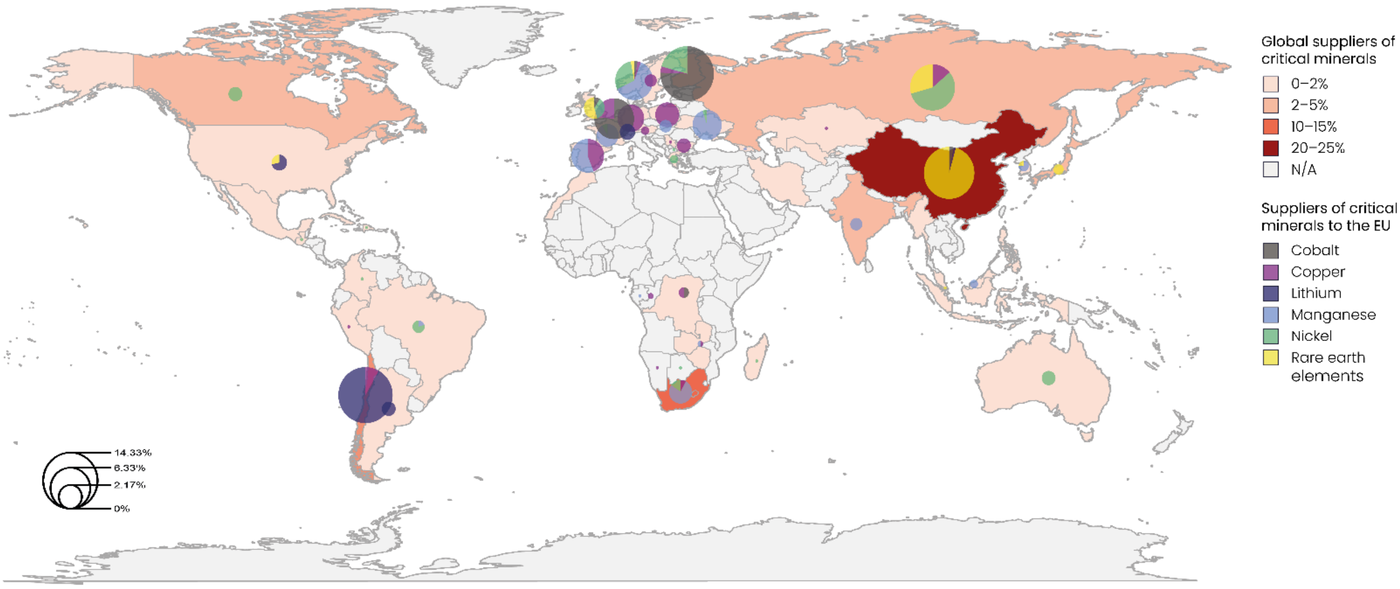
The two maps below, based on data from the European Commission (2023), illustrate the EU’s vulnerability to critical mineral supply issues. They depict the major suppliers of critical materials (red shading) and the main countries supplying the EU with critical materials (pie charts). The red to pink shading illustrates the weight of a given country in the total supply of critical materials, both for mining (Figure 3.1) and processing (Figure 3.2). The pie charts show the contribution of each country to the EU’s supply of critical materials.

Figure 3.1. Extraction of critical materials by country and their supply to the EU



Source: Authors’ calculations, based on European Commission (2023: Appendix 7 and 8).
Notes: The critical materials represented in the Figure are those listed in Table 1.1 above. The red shading of countries illustrates the total global supply of extracted critical materials. For example, China extracts approximately 20-25% of these critical materials. The pie charts display the average contribution of a given country’s supply of critical materials to the EU. For example, the pie chart for China shows that it is a major supplier to the EU of rare earth elements (yellow) and graphite (pink). The size of the pie chart, as indicated by the legend, represents the total critical mineral supply to the EU. In the case of China, this is approximately 16%. Countries not included and greyed out are those for which the European Commission has no data.

Figure 3.2. Processing of critical materials by country and their supply to the EU



Source: Authors’ calculation based on European Commission (2023: Appendix 7 and 8).
Notes: The selected critical materials included in this Figure are those listed in Table 1.1 above, plus dysprosium and neodymium. The red shading of countries illustrates the total global supply of refined critical materials. The pie charts display the countries’ average supply of refined critical materials to the EU. The size of the pie chart, as indicated by the legend, shows the country’s overall critical material supply to the EU. Countries not included and greyed out are those for which the European Commission has no data.

For critical mineral extraction, China, Australia, DRC, Chile and South Africa are the five main actors, and European countries are lagging behind. However, the presence of mining activity in Spain, Greece and Scandinavian countries is noteworthy, amounting to a combined global share of over 0.5%.

The EU’s global position in mineral refining is better than its position in extraction. In particular, it has a 17% share of global cobalt mining, 11% coming from Finland and the remainder from Belgium and France. Also notable is the EU’s position in nickel refining, with 4% of the global supply refined in Finland, Greece and France; much of Europe’s nickel supply comes from Finland (38%) and Greece (19%).

The EU has a level of autonomy at the mineral processing stage: Belgium and Finland account for 91% of the EU’s supply of processed cobalt. However, emerging market economies dominate this space, and the EU is highly dependent on critical raw material imports from China in particular, which provides the EU with about 90% of its supply of REEs (European Commission, 2023).

The EU’s ability to meet its forecasted critical material demand with secure supply could be at risk, especially in a context of increasing geopolitical tensions. Demand for all the 10 minerals of focus in this report is set to significantly increase from a 2020 baseline (see Table 3.2), posing particular challenges where the EU currently has little or no domestic mining or refining capacity. This is the case for six of the 10 minerals: dysprosium, graphite, iridium, lithium, neodymium and platinum.

Table 3.1. The EU's critical material demand forecast compared with its share of current domestic sourcing

Critical material	EU demand in 2030 (baseline 2020)	EU demand in 2050 (baseline 2020)	EU domestic supply – mining	EU domestic supply – refining
Cobalt	x 6	x 5	0%	91%
Copper	x 6	x 10	40%	68%
Dysprosium	x 6	x 7	0%	0%
Graphite	x 14	x 26	0%	0%
Iridium	x 3	x 9	0%	0%
Lithium	x 12	x 21	0%	0%
Manganese	x 6	x 5	3%	30%
Neodymium	x 5	X 6	0%	0%
Nickel	x 10	x 16	58%	21%
Platinum	x 4	x 4	0%	0%

Source: European Commission Joint Research Centre (2023) and European Commission (2023).
Notes: The selected critical materials are those listed in Table 1.1 above. The projection for EU demand represents the material needs for all sectors under the High Demand Scenario (European Commission Joint Research Centre, 2023). This scenario assumes rapid technology deployment, the EU's achievement of its REPowerEU targets by 2030, and full decarbonisation by 2050. Sectors included in the projection encompass renewables, electric mobility, industry, IT technology, aerospace and defence (ibid.). The forecasts for iridium and manganese specifically address EU material demand for electrolyser and battery technology, as comprehensive data are not available for all sectors (ibid.). EU domestic supply is defined as the sum of the mining/refining shares originating from one or more of its member countries and supplied to the EU (European Commission, 2023: Annex 8).

4. EU policy and next steps

This section reviews recent steps taken to date by the EU to address the critical materials supply challenge in its Critical Raw Minerals Act and identifies ways in which the bloc could further minimise risks and vulnerabilities.

The EU's Critical Raw Materials Act (CRMA) was formally adopted by the Council of the European Union in March 2024 (European Council, 2024). The CRMA establishes three ambitious benchmarks for the EU's annual consumption of raw critical materials, to be achieved by 2030:

- 10% of critical raw minerals should be extracted locally, i.e. within the EU
- 40% should be processed in the EU
- 25% should come from recycled materials.

The CRMA has the potential to reduce geopolitical risks for the EU, enhance mineral independence, and increase national and regional strategic autonomy. However, the Act has arrived at a late stage and its implementation faces at least four significant challenges: the ability to return critical mineral production to the EU; public acceptability of mining in the EU; the efficacy of recycling and stockpiling strategies; and the need for complementary solutions to scaling up production, such as addressing overconsumption. These are discussed in turn below.

Reshoring mining capacity

In 2021, the European Raw Materials Alliance (ERMA) proposed €1.7 billion of subsidies for regional mining and processing projects, which aims to reshore 20% of the EU's needs for magnets made from rare earth elements by 2030 (ERMA, 2021). The European Commission's science and research programme, Horizon Europe, has invested almost €900 million in critical material sectors to reduce EU dependence, but current levels of funding are likely to be insufficient for reshoring critical materials production. This is evidenced by the deal that French mining group Eramet concluded in September 2023 with China's Tsingshan, the world's largest stainless steel producer, which according to Eramet, was pursued due to a lack of EU funding (Dempsey and Hancock, 2023).

Further, the 2022 US Inflation Reduction Act (IRA), a legislative package aiming to invest US$391 billion in clean energy over the course of 10 years through measures such as tax credits, could incentivise EU companies to outsource their operations to the US. For example, Northvolt, a Swedish battery manufacturer, announced its intention to prioritise expansion in the US over Europe as it expects to receive up to €800 million in US Government support to build an EV battery plant (Reuters, 2023b). However, the magnitude of such effects is uncertain (Kleimann et al., 2023). It is possible that the EU could benefit from positive spillovers through the declining cost of global clean technologies and thereby become more competitive with China, as the IRA would induce companies to move away from Chinese inputs.

Public acceptability of domestic mining

Social opposition to mining could be a major obstacle to EU plans to revive the domestic mining sector. Mining operations have significant social and environmental impacts, often leading to social and political resistance. Instances of resistance have been reported in various countries including Serbia, which withdrew permitting licences for Rio Tinto's mining of lithium amid social protests (Sekularac, 2022), and Portugal, where a surge of social unrest was triggered by a lithium and iron extraction project at Mina do Barrosso (Bailey, 2023). Governments will have to navigate the negative social and environmental impacts of mining on local communities as they seek to increase domestic critical mineral production. EU member states should therefore exert significant control over mining and refining companies to ensure they meet environmental and social standards.

Recycling and stockpiling strategies

EU countries can use recycling as a strategy to mitigate potential vulnerabilities from critical mineral supply, boosting access and production by transforming used materials into new products. But recycling has limitations: it will not be able to keep up with the sharp and rapid growth in critical material demand; and the critical metals present in current technologies will not be available for recycling until they need to be replaced, which could be in many years' time. Furthermore, the process of initial material recapture is complex, and in some cases not possible for technical and economic reasons. Nevertheless, recycling can play a part in reducing demand tensions and European vulnerabilities (ERMA, 2021).

A stockpiling strategy would see the EU anticipating future scarcity of critical materials and bulk-purchasing them in advance. In March 2023, the EU published a proposal for regulation in this area which is still under discussion. It says that a stockpiling strategy would need to meet several conditions, including a long-term financial plan, a continuous and agile assessment of critical needs, and a transparent regulatory framework. Meanwhile, it must avoid the dispersal of efforts, to the detriment of consolidating supply or recycling efforts in the medium to long term (Hache and Jeannin, 2023).

There is no evidence that shows that such a stockpiling policy would provide sufficient guarantees and flexibility to respond effectively to a material supply crisis (Hache and Jeannin, 2023). Where metal production is low, building a stockpile might considerably distort markets and push up prices, thereby creating higher costs for the EU in addition to greater market volatility. Furthermore, countries with considerable market power could respond to and take measures against such a move from the EU, possibly necessitating a stockpiling strategy that would have to include complex considerations (Bourgery-Gonse, 2023).

Sufficiency measures

The EU could attempt to reduce its demand for critical materials by promoting 'sufficiency': a "set of measures and daily practices that avoid a demand for energy, raw materials, land, and water, while ensuring the wellbeing of all [and] respecting planetary limits" (IPCC, 2022). According to Hache (2023), sufficiency measures could be a central part of the solution to the critical mineral supply challenge, yet they remain a blind spot in European politics. Building lighter EVs, for example, would reduce the size of batteries, thereby reducing the extent of dependence on the critical materials needed for cars and electricity generation. This would also bring geopolitical benefits: controlling demand can help reduce the effects of interdependence and thus increase the EU's power on the world stage (ibid.).

Reducing the EU's critical raw material footprint by consuming less and more efficiently could limit European dependency while reducing the negative environmental externalities associated with the deployment of low-carbon technologies. This path, which invites a revision of material consumption patterns, would require the low-carbon transition to deeply embed environmental and economic justice considerations so that poor households are not excluded from access to the technologies they depend on for essential needs such as housing, transport and heating.

References

Aquino M (2023) Peru copper mines rev back up to full power after protest hit, data show. Reuters, 4 March. www.reuters.com/markets/commodities/peru-copper-mines-rev-back-up-full-power-after-protest-hit-data-show-2023-03-04/

Attwood J (2023) Peru's Violent Protests Imperil 30% of Its Copper Output. Bloomberg, 27 January. www.bloomberg.com/news/articles/2023-01-27/protest-surge-imperils-30-of-copper-supply-in-no-2-miner-peru

Bailey C (2023) Portugal's Barroso lithium mine project faces villagers' ire. BBC World Service, 19 October. https://www.bbc.co.uk/news/world-europe-67135047

Benson E and Denamiel T (2023) China's New Graphite Restrictions. Blog Post, 23 October. Center for Strategic and International Studies. www.csis.org/analysis/chinas-new-graphite-restrictions

Bonnet T, Grekou C, Hache E et al (2022) Métaux stratégiques : la clairvoyance chinoise. *La Lettre du CEPII. N°428*. Paris : Centre d'études prospectives et d'informations internationales. Métaux stratégiques : la clairvoyance chinoise (cepii.fr)

Bourgery-Gonse T (2023) Experts: Stockpiling may be EU's blind spot in critical raw materials debate. Euractiv, 20 October. www.euractiv.com/section/circular-economy/news/stockpiling-may-be-eus-blind-spot-in-critical-raw-materials-debate-experts-say/

Calvo G, Mudd G, Valero A et al. (2016) Decreasing Ore Grades in Global Metallic Mining: A Theoretical Issue or a Global Reality? *Resources* 5(36). https://doi.org/10.3390/resources5040036

Cambero F (2017) Workers strike at BHP's Escondida copper mine in Chile. Reuters, 9 February. www.reuters.com/article/us-bhp-billiton-ltd-chile-idUSKBN15O2VN

CGGD [Commissariat général au développement durable] (2023) *Les ressources minérales critiques pour les énergies bas-carbone. Chaînes de valeur, risques et politiques publiques*. https://side.developpement-durable.gouv.fr/Default/doc/SYRACUSE/881845/les-ressources-minerales-critiques-pour-les-energies-bas-carbone-chaines-de-valeur-risques-et-politi?_lg=fr-FR

Energy Transitions Commission [ETC] (2023) *Material and Resource Requirements for the Energy Transition*. London. www.energy-transitions.org/wp-content/uploads/2023/07/ETC-Material-and-Resource-Requirements_vF.pdf

Dempsey H and Hancock A (2023) France's Eramet blames lack of EU funds for deeper partnership with Chinese. Financial Times, 30 July. www.ft.com/content/5a9b2b3a-5c31-4d38-b88e-95b3305ae3b6

European Commission (2023) *Study on the critical raw materials for the EU 2023 – Final report*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2873/725585

European Commission Joint Research Centre (2023) *Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight* study. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/386650

European Council (2024) Strategic autonomy: Council gives its final approval on the critical raw materials act. Press release. www.consilium.europa.eu/en/press/press-releases/2024/03/18/strategic-autonomy-council-gives-its-final-approval-on-the-critical-raw-materials-act/

Farchy J, Cang A and Burto M (2022) The 18 minutes of trading chaos that broke the nickel market. Bloomberg, 14 March. www.bloomberg.com/news/articles/2022-03-14/inside-nickel-s-short-squeeze-how-price-surges-halted-lme-trading

Filho W (2016) An analysis of the environmental impacts of the exploitation of rare earth metals. In De Lima I and Filho W (Eds.) *Rare Earth Industry*. Amsterdam: Elsevier.

FPISC [Federal Permitting Improvement Steering Council] (2022) The Federal Permitting Improvement Steering Council (Permitting Council). www.permits.performance.gov/sites/permits.dot.gov/files/2022-09/FPISC_090922.pdf

Hook L, Dempsey H and Nugent C (2023) The new commodity superpowers. Financial Times. www.ft.com/content/0d2fba79-940f-4a28-8f4f-68f1e755200f

Hache E (2023) La sobriété, impensé de la politique européenne sur les matériaux critiques. The Conversation. https://theconversation.com/la-sobriete-impense-de-la-politique-europeenne-sur-les-materiaux-critiques-209077

Hache E and Jeannin F (2023) Synthèse. Les stocks stratégiques de métaux critiques. Observatoire de la sécurité des flux et des matières énergétiques.

Harper G (2023) China's gallium and germanium controls: what they mean and what could happen next. The Conversation. https://theconversation.com/chinas-gallium-and-germanium-controls-what-they-mean-and-what-could-happen-next-209156

International Energy Agency [IEA] (2023a) IEA Critical Minerals and Clean Energy Summit. 28 Sep 2023. www.iea.org/events/iea-critical-minerals-and-clean-energy-summit

IEA (2023b) *The Role of Critical Minerals in Clean Energy Transitions. Mineral requirements for clean energy transitions*. Paris. www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions

IEA (2022) Prohibition of the export of nickel ore. www.iea.org/policies/16084-prohibition-of-the-export-of-nickel-ore

IFPEN (2024) Metals in the Energy Transition. IFP Energies Nouvelles. www.ifpenergiesnouvelles.com/issues-and-foresight/decoding-keys/climate-environment-and-circular-economy/metals-energy-transition

Intergovernmental Panel on Climate Change [IPCC] (2022) Annex I: Glossary [van Diemen R, Matthews J, Möller V et al. (eds)]. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Shukla P, Skea J, Slade R et al. (eds.)]. Cambridge and New York: Cambridge University Press. Doi. 10.1017/9781009157926.020

IRENA [International Renewable Energy Agency] (2023) *Geopolitics of the energy transition: Critical materials.* Abu Dhabi.

Iturrieta F (2017) Tired but satisfied, Escondida miners pack up after historic strike. Reuters, www.reuters.com/article/us-chile-copper-escondida-idUSKBN16V2E1

Kaufmann D and Kraay A (2023) Worldwide Governance Indicators: 2023 Update. The World Bank. www.worldbank.org/en/publication/worldwide-governance-indicators

Kleimann D, Poitiers A, Sapir S et al. (2023) How Europe should answer the US Inflation Reduction Act. *Policy Contribution 04/2023*. Brussels: Bruegel. www.bruegel.org/policy-brief/how-europe-should-answer-us-inflation-reduction-act

Kooroshy J and Siân B (2014) *Cartels and Competition in Minerals Markets: Challenges for Global Governance*. London: Chatham House. www.chathamhouse.org/sites/default/files/field/field_document/20141219CartelsCompetitionMineralsMarketsKooroshyPrestonBradleyFinal.pdf

Kowalski P and Legendre C (2023) Raw materials critical for the green transition: Production, international trade and export restrictions. *OECD Trade Policy Papers* No. 269, Paris. https://doi.org/10.1787/c6bb598b-en

McBride J and Chatzy A (2019) *Is 'Made in China 2025' a Threat to Global Trade?* New York: Council on Foreign Relations. www.cfr.org/backgrounder/made-china-2025-threat-global-trade

Miller H, Dikau S, Svartzman R et al. (2023) *The stumbling block in 'the race of our lives': transition-critical materials, financial risks and the NGFS Climate Scenarios*. Centre for Climate Change Economics and Policy Working Paper 417/Grantham Research Institute on Climate Change and the Environment Working Paper 393. London: London School of Economics and Political Science. www.lse.ac.uk/granthaminstitute/wp-content/uploads/2023/02/working-paper-393_Miller-et-al.pdf

Mudd G, Weng Z and Jowitt S (2013) A Detailed Assessment of Global Cu Resource Trends and Endowments. *Economic Geology* 108: 1163-1183. https://doi.org/10.2113/econgeo.108.5.1163

Reuters (2023a) Mexico's Lopez Obrador orders ministry to step up lithium nationalization. News article, 19 February. www.reuters.com/world/americas/mexicos-lopez-obrador-orders-ministry-step-up-lithium-nationalization-2023-02-19/

Reuters (2023b) How companies are reacting to the U.S. Inflation Reduction Act. www.reuters.com/markets/company-reaction-us-inflation-reduction-act-2023-02-23/

Reuters (2022a) Zimbabwe bans raw lithium exports to curb artisanal mining. News article, 21 December. www.reuters.com/world/africa/zimbabwe-bans-raw-lithium-exports-curb-artisanal-mining-2022-12-21/

Seaman J (2019) *Rare Earth and China – A Review of Changing Criticality in the New Economy*. IFRI. www.ifri.org/en/publications/notes-de-lifri/rare-earths-and-china-review-changing-criticality-new-economy

Sekularac I (2022) Serbia revokes Rio Tinto lithium project licences amid protests. Reuters, 20 January. www.reuters.com/business/retail-consumer/serbian-government-revokes-rio-tintos-licences-lithium-project-2022-01-20/

S&P (2024) Average lead time almost 18 years for mines started in 2020–23. Blog Post. www.spglobal.com/marketintelligence/en/news-insights/blog/japan-ma-by-the-numbers-q4-2023

Villegas A and Scheyder E (2023) Chile plans to nationalize its vast lithium industry. News article, 21 April. Reuters. www.reuters.com/markets/commodities/chiles-boric-announces-plan-nationalize-lithium-industry-2023-04-21/

Weaver J (2022) Clampdown on chip exports is the most consequential US move against China yet. The Conversation. https://theconversation.com/clampdown-on-chip-exports-is-the-most-consequential-us-move-against-china-yet-192738

World Economic Forum (2023) *Global Risks Report 2023*. www.weforum.org/publications/global-risks-report-2023/