Security of Supply for Critical Raw Materials

Vulnerabilities and Areas for G7 Coordination

G7 Leaders' Summit
26-28 June 2022
Schloss Elmau

OECD
BETTER POLICIES FOR BETTER LIVES

Security of Supply for Critical Raw Materials: Vulnerabilities and Areas for G7 Coordination

Summary

- **Severe disruptions to global markets have exposed common vulnerabilities to the security of supply of critical raw materials for G7 members, in the context of the green transition, digital transformation and the manufacturing of key technologies.**
- **G7 members share these supply chain vulnerabilities, caused by concentration of production, export restrictions, bilateral dependencies, a lack of transparency and persistent market asymmetries.**
- **There is some potential to diversify sourcing through expanded production and accessing known reserves.**
- **A collective and coordinated G7 approach can contribute to economic security, while preserving the benefits of open markets and a rules-based international trading system.**
- **Areas for coordination include:**
    - **Disciplining export restrictions;**
    - **Collective supply risk assessment and scenario-based stress testing;**
    - **Responsible sourcing of minerals;**
    - **Consistency with environmental protection objectives;**
    - **Reducing refining and processing bottlenecks;**
    - **Keeping markets open; and**
    - **Coordination with the private sector.**

Security of Supply for Critical Raw Materials:

Vulnerabilities and Areas for G7 Coordination

Introduction

1. The COVID-19 pandemic and Russia's invasion of Ukraine have caused severe disruptions to global markets for critical raw materials and exposed vulnerabilities in supply chains essential for the G7's economic security. This note aims to identify and assess shared vulnerabilities in critical raw materials supply chains, and to provide a common base of evidence to inform G7 policy considerations. It focuses on materials with high market concentration, low substitutability and high importance for the green transition, digital transformation and for the manufacturing of key technologies.

2. High concentration of supply makes markets particularly vulnerable to supply chain shocks and the impacts of uncertainty. Disruptions caused by Russia's invasion of Ukraine have spiked prices of oil, gas and certain agricultural products, intensifying inflationary pressures and threatening food security in developing economies.[1] Uncertainty also pervades metals markets involving Russian production or processing, many of which are indispensable in the supply chains of modern manufacturing production. Prices of aluminium and nickel, for example, reached their 10-year high in February 2022. The price of potash, an essential input into fertilizer production, jumped almost 80% in February 2022 compared to the previous months because 35% of its global production is in Russia and Belarus.

Raw materials critical to G7

3. The transition to a climate neutral economy is at the heart of industrial strategies of the G7. It requires an expansion of certain key technologies that underpin electric mobility, renewable energy generation, and energy storage. Lithium-ion batteries power electric vehicles and electronic equipment, they also find use in renewable energy storage. Traction motors for electric vehicles rely on strong permanent magnets. Renewable energy solutions include wind turbines and photovoltaics. Fuel cells that turn hydrogen directly to electricity have applications in both electric mobility and stationary energy generation and storage.

4. While the green transition will reduce the global dependence on fossil fuels, it will generate pressure on the production of other raw materials because clean technologies make generally more intensive use of minerals than their fossil fuel counterparts. According to the International Energy Agency (IEA), "a typical electric car requires six times the mineral inputs of a conventional car and an onshore wind plant requires nine times more mineral resources than a gas-fired plant".[2] The IEA estimates that the scaling up of green technologies necessary to meet the Paris Agreement goals would increase the global demand for lithium 42 times between 2020 and 2040, 25 times for graphite, 21 times for cobalt and magnesium, 19 times for nickel, 7 times for rare earth minerals and 3.5 times for borates.[3] The projected changes are even more striking for materials that are currently used in very small quantities in industrial applications, such as the platinum group metals (Figure 1).

---

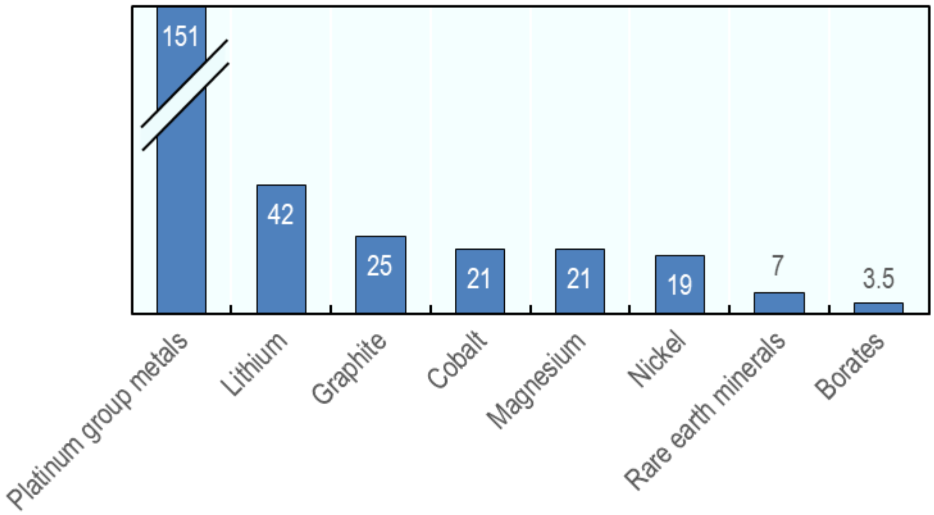
[1] OECD (2022), *OECD Economic Outlook, Interim Report March 2022: Economic and Social Impacts and Policy Implications of the War in Ukraine*, OECD Publishing, Paris.

[2] IEA (2021), *The Role of Critical Minerals in Clean Energy Transitions*, International Energy Agency, Paris.

[3] Ibid.

Figure 1. Projected global demand growth between 2020 and 2040, selected critical raw materials

Index (2020 = 1)



Note: Projections based on the International Energy Agency's Sustainable Development Scenario, which indicates what would be required in a trajectory consistent with meeting the Paris Agreement goals. The platinum group metals include palladium, platinum, ruthenium, rhodium, osmium, and iridium
Source: International Energy Agency

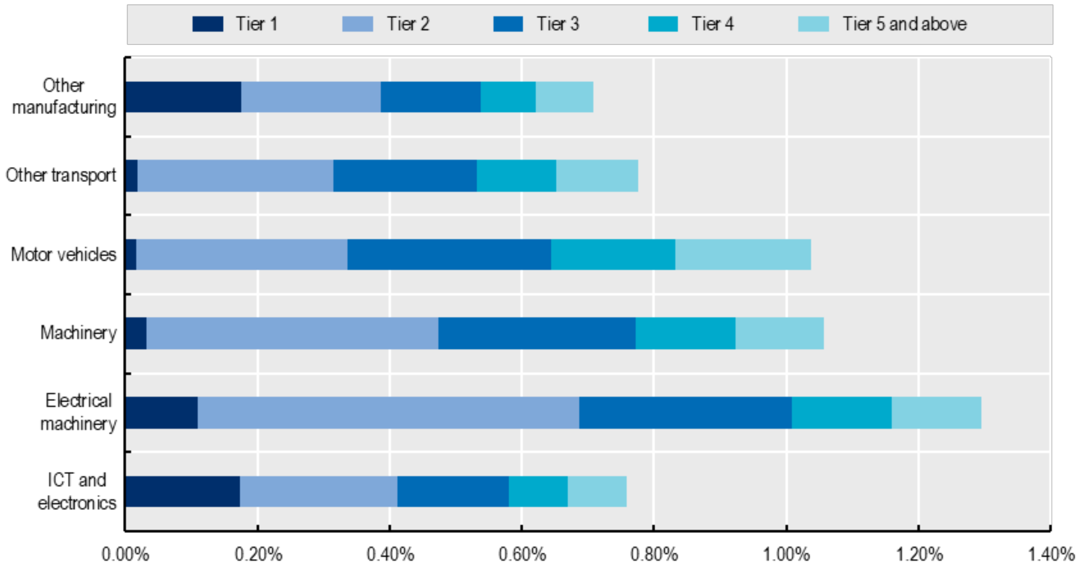
5. Digitalisation and automation are key drivers of productivity and industrial applications in modern economies. These new technologies include robotics, 3D printing and an increasing use of information and communication technology (ICT) equipment. Digital technologies are also used in most green sectors while automation will play an important role in scaling up the production of renewable energy generators.[4] Materials needed for the production of semiconductors, digital screens and data storage technologies are therefore essential for modern industrial applications as well as the green transition.

6. Imported raw materials generally account for a very small share of the output of manufacturing supply chains. As illustrated with data from the OECD Trade in Value Added database, foreign inputs from the 'mining and quarrying, non-energy products' industry account for less than 1.5% of the value of output in the G7, with some variations across industries (Figure 2). The contribution of raw materials is also indirect, through upstream production stages rather than direct imports by G7 members. The vulnerability to supply shocks is more related to the fact that some of these materials may be absolutely necessary to the production process.

[4] Bobba, S., Carrara, S., Huisman, J., Mathieux, F., and Pavel, C. (2020), *Critical Raw Materials for Strategic Technologies and Sectors in the EU – A Foresight Study*, Publications Office of the European Union.

Figure 2. Value-added contribution of foreign inputs from the 'mining and quarrying, non-energy products' sector to G7 manufacturing industries, by production stage (Tiers 1 to 5 and above)

As a share of output



Note: Data for 2018.
Source: OECD TiVA database.

7. Table 1 lists the critical raw materials that are the focus of this note. It shows that borates, cobalt, rare earth minerals, nickel and the group of minerals including germanium, niobium, gallium, vanadium, indium and hafnium have a broad use in many new technologies. Natural graphite, magnesium, lithium, palladium and platinum, and phosphates are necessary for the production of batteries, automation technologies and ICT equipment. Bismuth is a critical material for robotics and ICT equipment. This list of critical raw materials is identified on the basis of information in the OECD Inventory of Export Restrictions on Industrial Raw Materials.[5] It has been checked against critical materials lists of the EU and the United States, and excludes materials which, despite their widespread applications, have a very low supply risk.

Table 1. List of critical raw materials and their applications

Sorted by the number of technologies in which the raw material is applied

Material	Li-ion battery	Fuels cells	Wind energy	Electric traction motors	Photo-voltaic	Robotics	3D printing	ICT equipment	Number of technologies
Borates		x	x	x	x	x	x	x	7
Germanium*	x	x	x		x	x	x	x	7
Cobalt	x	x	x			x	x	x	6
Rare earths	x	x	x	x		x		x	6
Nickel	x	x			x	x	x		5
Graphite	x	x				x		x	4

5 https://qdd.oecd.org/subject.aspx?Subject=ExportRestrictions_IndustrialRawMaterials

Magnesium		x				x	x	x	4
Lithium	x	x				x			3
Palladium		x				x		x	3
Platinum		x				x		x	3
Phosphates	x					x		x	3
Bismuth						x		x	2

Note: * Here, for ease of reading, the label Germanium has been used to denote the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium.
Source: Based on Bobba et al. (2020).[6]

The G7's supply chain vulnerabilities

8. The availability of critical raw materials that drive industrial applications, digitalisation and the green transition can be compromised by a number of factors, including production concentration, economic, political and social constraints in expanding production capacities, and pervasive export restrictions. The risks on the security of supply can also be compounded by lack of transparency in minerals supply chains and governance challenges in producing and processing countries. In addition, the impacts of foreseen international investments on the political economy of producing countries can drive systemic risks and lead to major geopolitical destabilisation, fuelling local, regional and international conflicts.

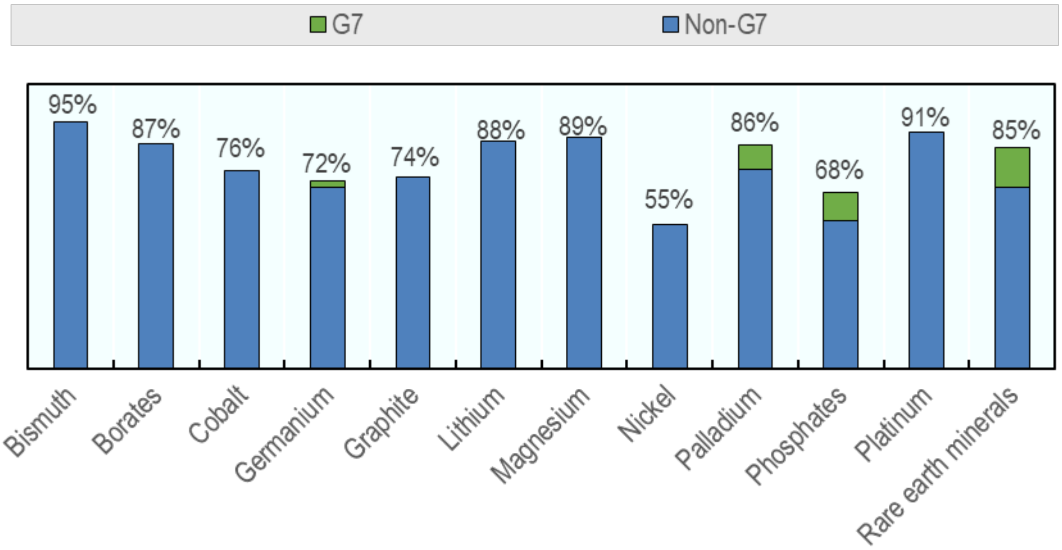
Concentration of production and exports

9. The production of some minerals critical to new technologies is more geographically concentrated than that of oil and gas. Therefore, the vulnerabilities generated by material reliance in the modern economy may be even more pronounced than in the fossil fuel-powered economy. For instance, 83% of global bismuth production and 82% of global magnesium production is in China, 78% of global lithium production is in Australia, and 71% of global platinum production is in South Africa (see the Annex for detailed tables). **Overall, Figure 3 shows that for most critical raw materials more than 80% of global production is concentrated among only three countries**. Moreover, most production is concentrated outside the G7. Only palladium, phosphates and rare earth minerals have more than 10% of global production within the G7 (Canada and the United States). Other than Canada and the United States, no G7 member is among the three largest producers in any of the selected critical raw materials.

[6] Bobba, S., Carrara, S., Huisman, J., Mathieux, F., and Pavel, C. (2020), *Critical Raw Materials for Strategic Technologies and Sectors in the EU – A Foresight Study*, Publications Office of the European Union.

Figure 3. Concentration of global production of critical raw materials

The share of global production concentrated among three largest producers

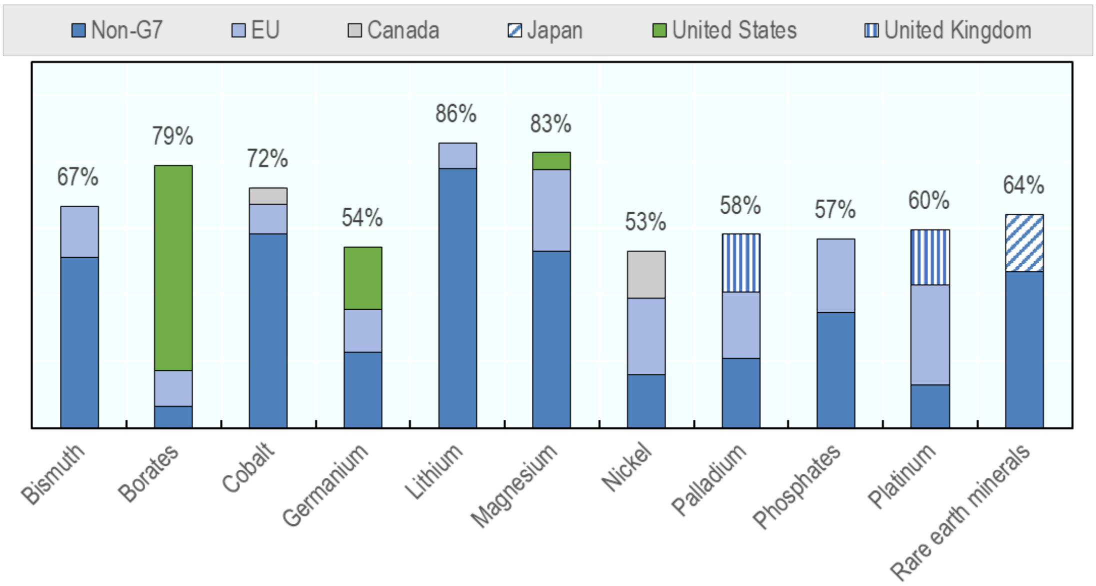


Note: Data for 2020. Here, for ease of reading, the label Germanium has been used to denote the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium.
Source: United States Geological Survey

10. Processing of critical raw materials is also highly concentrated, albeit less than production. Figure 4 presents the concentration of global exports of processed materials. Notably, more than 80% of global exports of lithium and magnesium are concentrated among only three exporters (of which the European Union is one). While 30% of processed magnesium exports are from the European Union and the United States, processed lithium is mostly exported by Chile and China. In general**, the G7 plays a more important role in the supply of processed raw materials than in raw material production.** They account for most exports of processed borates and at least one third of exports of processed platinum, palladium and nickel. Exports of processed lithium, cobalt, bismuth, and rare earth minerals, on the other hand, originate mostly from outside the G7.

Figure 4. Concentration of global exports of processed critical materials

The share of global exports concentrated among three largest exporters



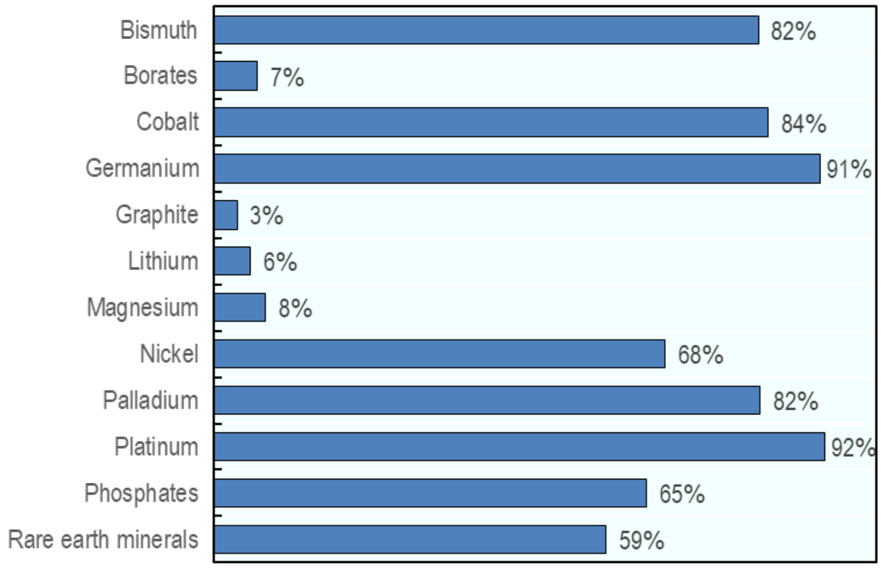
Note: Data for 2020. Here, for ease of reading, the label Germanium has been used to denote the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium. European Union is considered as one exporter.
Source: UN Comtrade.

Export restrictions

11. Since the supply of critical raw materials is highly concentrated, export restrictions are the most widespread trade policy measure applied in these sectors. They are put in place for a variety of important policy objectives, however such measures can have distorting effects on international markets by reducing global supply and raising prices, while creating uncertainty for importers. These are important policy objectives, however, such measures can have distorting effects on international markets by reducing global supply and raising prices, while creating uncertainty for importers. Platinum, germanium, cobalt, bismuth, and palladium are among the materials that are most affected by export restrictions by volume (Figure 5); cobalt and nickel those that sustain the most restrictive measures in the form of outright export prohibitions.

Figure 5. The incidence of export restrictions on critical materials

The share of global exports of critical materials subject to an export restriction, by material

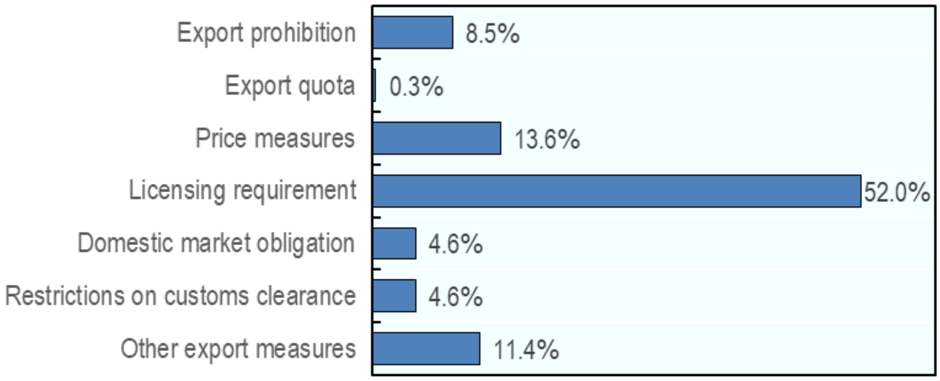


Note: Data for 2020. Here, for ease of reading, the label Germanium has been used to denote the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium.
Source: OECD Inventory of Export Restrictions on Industrial Raw Materials

12. Non-automatic export licensing is the most prevalent among the export restrictions affecting critical materials (Figure 6). Beyond the extra costs for obtaining the licence, non-automatic export licensing generates significant uncertainty for involved firms and provides leeway for government authorities to control the quantity of export and the destination of the material on a case-by-case basis. Directly price-affecting measures in the form of export taxes concern in particular cobalt, phosphates, nickel, platinum, borates, magnesium and palladium (Annex Table A.3).

Figure 6. The type of export restrictions applied to critical materials

The average share of global exports of critical materials subject to an export restriction, by the type of restriction



Note: Data for 2020. Price measures include export tax, export surtax and fiscal tax on exports.
Source: OECD Inventory of Export Restrictions on Industrial Raw Materials

Bilateral dependencies

13. Bilateral dependencies of individual countries can be more pronounced than suggested by global market shares. As highlighted in Table 2, China accounts for more than two thirds of Germany's sourcing of bismuth and more than 90% of Japan's sourcing of natural graphite and magnesium. Turkey accounts for more than 70% of borates imports to Italy and the United States. The United States, in turn, is a major supplier of borates to Japan, illustrating the role of supply chains in critical material supply.

14. Direct dependencies may conceal the complexity of raw material supply chains. For instance, while Italy imports only 19% of graphite directly from China, its main supplier, Germany, relies heavily on China for its own imports. Therefore, Italy's ultimate dependence on China's graphite supply is larger than what is suggested by the direct trade statistics.

15. Raw materials supply chains are complex and internationally interwoven. While mining and ore extraction are typically bound to specific locations, further refining and processing can occur elsewhere and often requires specific technologies and know-how. Avoiding trade hampering policies, such as export restrictions, and fostering smooth functioning through reducing the costs of technical barriers to trade will be important for assuring that international supply chains for critical raw materials can work smoothly.

Table 2. Bilateral import dependencies of G7 members

The % share of three largest suppliers in total imports by G7 members, by material

	Bismuth		Borates		Cobalt		Germanium		Graphite		Lithium	
Canada	G7	57.1	G7	59.0	G7	61.6	G7	97.1	G7	44.5	Chile	27.3
	Thailand	13.8	Turkey	36.9	Madagascar	15.7	China	2.2	China	35.2	China	27.1
	China	12.8	Panama	1.3	Switzerland	12.6	Korea	0.3	Madagascar	7.3	Russia	27.0
EU	G7	46.1	Turkey	52.3	G7	75.7	G7	64.2	G7	44.1	Chile	53.4
	China	38.2	G7	43.0	China	6.6	China	26.5	Korea	13.9	G7	31.0
	Korea	7.4	China	1.3	Madagascar	3.7	Australia	3.0	China	13.4	Russia	8.0
France	G7	89.2	G7	96.6	G7	97.7	China	54.6	G7	90.8	G7	73.8
	China	10.8	Turkey	2.2	Switzerland	1.5	G7	25.0	Brazil	5.4	Argentina	19.8
			China	0.4	China	0.3	Australia	15.7	China	3.3	China	5.5
Germany	**China**	**76.4**	G7	48.2	G7	83.4	G7	80.6	China	29.9	Chile	68.3
	G7	13.8	Turkey	44.9	China	6.1	China	16.5	Brazil	28.5	G7	27.7
	Lao PDR	4.7	Russia	2.4	South Africa	2.4	Korea	1.5	G7	19.1	Argentina	3.8
Italy	G7	97.5	**Turkey**	**71.3**	G7	95.7	G7	61.7	G7	66.9	G7	97.8
	Switzerland	2.5	G7	17.4	Switzerland	2.4	China	32.0	China	19.0	China	2.2
			China	5.5	China	1.4	Russia	3.3	Ukraine	9.0		
Japan	China	66.2	G7	74.5	G7	73.3	China	56.4	**China**	**91.6**	China	57.2
	Korea	25.7	Turkey	19.0	China	6.2	G7	30.7	G7	3.8	Chile	27.1
	G7	8.1	China	3.6	Morocco	5.4	Australia	10.5	Sri Lanka	2.0	G7	12.2
United Kingdom	G7	98.8	Turkey	57.4	G7	86.7	G7	53.7	China	50.2	G7	92.3
	China	0.8	G7	36.4	Russia	4.0	China	43.9	G7	44.6	Russia	3.8
	Australia	0.4	China	2.8	China	2.9	Australia	1.1	Sri Lanka	2.4	Argentina	3.4
United States	China	49.9	**Turkey**	**76.1**	G7	54.9	G7	57.0	China	38.4	Chile	44.7
	Korea	25.6	Bolivia	7.1	Norway	21.6	China	18.6	G7	25.2	Argentina	44.0
	G7	9.7	G7	6.6	Australia	6.6	Russia	10.6	Brazil	12.0	Russia	7.1

	Magnesium		Nickel		Palladium		Platinum		Phosphates		Rare earths	
Canada	China	61.4	G7	84.8	G7	53.0	G7	71.0	G7	71.0	China	60.8
	G7	32.0	Brazil	3.4	South Africa	34.5	Switzerland	21.6	Morocco	11.6	G7	37.9
	Israel	5.4	Switzerland	3.4	Russia	12.3	South Africa	6.8	China	9.3	Switzerland	0.7
EU	G7	51.8	G7	59.8	G7	53.2	G7	62.0	G7	39.1	G7	44.0
	China	41.0	Russia	26.0	Russia	19.9	South Africa	10.9	Morocco	15.1	China	23.6
	Israel	2.1	Australia	3.8	South Africa	5.8	Switzerland	9.0	Israel	9.9	Norway	16.7
France	G7	73.4	G7	99.1	G7	79.4	G7	83.8	G7	73.0	G7	44.2
	China	17.0	China	0.2	Switzerland	20.6	Switzerland	14.0	Morocco	18.7	China	43.8
	Israel	6.1	Turkey	0.2	Colombia	0.0	Brazil	1.2	TUN	2.7	MYS	6.1
Germany	China	47.0	G7	61.4	G7	46.5	G7	48.2	G7	44.7	G7	58.0
	G7	46.5	Russia	25.5	Russia	20.6	South Africa	18.6	Kazakhstan	12.3	China	37.5
	Israel	1.8	Norway	6.8	South Africa	7.2	Switzerland	5.2	Russia	5.1	India	1.7
Italy	G7	60.0	G7	87.9	G7	51.8	G7	55.7	G7	41.9	G7	89.0
	China	30.1	South Africa	5.9	Russia	25.8	Switzerland	16.9	Israel	13.7	China	10.0
	India	3.3	China	2.6	China	11.2	Russia	14.0	Lebanon	13.3	Korea	0.7
Japan	**China**	**90.6**	Indonesia	27.8	Russia	43.2	South Africa	62.2	Vietnam	43.1	China	40.5
	G7	4.8	Philippines	22.1	South Africa	42.4	G7	19.9	China	34.3	Vietnam	26.4
	Israel	2.1	G7	19.5	G7	13.2	Other Asia	8.3	G7	8.1	G7	16.6
United Kingdom	G7	66.6	G7	52.9	G7	48.4	South Africa	45.0	G7	62.0	G7	81.5
	China	25.5	Indonesia	38.5	Russia	30.5	G7	28.4	Israel	18.0	China	15.3
	Israel	2.3	Norway	2.8	South Africa	9.7	Russia	19.4	China	7.3	India	1.7
United States	G7	33.7	G7	74.7	Russia	37.4	G7	36.3	G7	34.5	China	48.8
	Israel	15.7	Australia	7.0	South Africa	30.9	Switzerland	26.1	Peru	22.5	G7	43.4
	Turkey	14.4	Norway	6.3	G7	27.7	South Africa	23.7	Morocco	7.8	Russia	2.3

Note: Data for 2020. Here, for ease of reading, the label Germanium has been used to denote the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium. In red are non-G7 exporters whose supply share to a G7 member is larger than 70%.
Source: UN Comtrade.

Reserves and the potential to diversify supply

16. Production patterns of critical raw materials follow in general the patterns of known reserves (but are less geographically concentrated than current exploitation): Turkey holds 63% of global production and almost all global reserves of borates; the Democratic Republic of the Congo has 68% of global production and half of the global reserves of cobalt; China produces 57% of rare earths minerals while having the largest known reserves. Nevertheless, there are raw materials where major reserves are not yet exploited, providing potential alternatives for diversification. For instance, despite being small suppliers compared to China, Brazil and Turkey hold large reserves of natural graphite. Brazil and Vietnam also hold substantial reserves of rare earths minerals. Australia holds as many reserves of nickel as Indonesia, the world's major nickel producer. While China currently produces 40% of global supply of phosphates, most global reserves are located in Morocco.

17. Some G7 members hold smaller but yet unexploited reserves. United States has known reserves of borates and lithium; Austria, Greece, Slovakia and United States hold together 10% of global magnesium reserves; Finland has small reserves of phosphates; and Canada and Greenland have some rare earth mineral reserves. Importantly, there may be several reasons why some reserves have remained untapped, notably environmental implications, social concerns and economic viability, and therefore this list is only indicative of potential sources of diversification.

18. It is important to acknowledge that G7-wide reserves alone will not be able to satisfy the demand for critical minerals. Therefore, international investments will need to flow into existing and new producing countries. These investments will need to be materialised in line with international standards on responsible business conduct, such as the OECD Guidelines for Multinational Enterprises and related sector due diligence guidance. Longer term approaches to recycling, secondary raw materials and the circular economy also have the potential to mitigate supply concentration.

Figure 7. Known reserves of critical raw materials

	Borates	Cobalt	Graphite	Lithium	Magnesium	Nickel	Phosphates	Rare earths
Algeria							3.19%	
Argentina				9.05%				
Australia		19.72%		13.33%	4.21%	22.47%	1.59%	3.42%
Austria					0.64%			
Brazil			21.88%		2.63%	17.98%	2.32%	17.50%
Canada		3.10%		2.52%		3.15%		0.69%
Chile	2.92%			43.81%				
China	2.00%	1.13%	22.81%	7.14%	13.16%	3.15%	4.64%	36.67%
Cuba		7.04%				6.18%		
North Korea			0.63%		30.26%			
DRC		50.70%						
Egypt							4.06%	
Finland							1.45%	
Greece					3.68%			
Greenland								1.25%
India			2.50%		1.08%		0.07%	5.75%
Indonesia						23.60%		
Jordan							1.16%	
Madagascar		1.41%	0.81%			1.80%		
Morocco		0.20%					72.46%	
Mozambique			7.81%					
New Caledonia						7.53%		
Other areas		7.89%		10.00%	5.26%	15.73%	1.22%	0.26%
Philippines		3.66%				5.39%		
Russia	3.33%	3.52%			30.26%	7.75%	0.87%	10.00%
Saudi Arabia							2.03%	
Slovakia					4.87%			
South Africa		0.56%				4.16%	2.03%	0.66%
Syria							2.61%	
Tanzania			5.31%					0.74%
Turkey	91.67%		28.13%		2.70%			
United States	3.33%	0.75%		3.57%	0.46%		1.45%	1.25%
Uzbekistan			2.38%				0.14%	
Viet Nam			2.38%				0.04%	18.33%

Note: The list includes countries with at least 1% of known global reserves in at least one of the eight materials. Green frame shows known reserves that are not exploited (at least 1000x current annual production) and are located in the G7.
Source: United States Geological Survey.

Areas for G7 policy coordination

19. The G7 can promote the sustainability and resilience of supply chains through national and collective action to anticipate risks, minimise exposure, build public-private trust and open markets. Specific areas for G7 policy coordination regarding the security of supply for critical raw materials include*:*

- **Increase G7 coordination to understand and address issues of security of supply,** which is essential due to the concentration of production, export restrictions, and the chronic lack of transparency and persistent market asymmetries.
- **Provide specific attention to the rest of the value chain** and in particular refining and processing of raw materials, which is not geographically bound. Bottlenecks and risks can exist in all parts of the value chain, including within G7 economies.
- **Take collective approaches to supply risk assessment and scenario-based stress testing** would strengthen capacity to anticipate risks and minimize exposure to future shocks by improving transparency and identifying market asymmetries.
- **Coordinate risk management strategies among G7 economies** when a specific risk materialises. These should also be co-ordinated with the private sector that has its own risk management strategies.
- **Uphold standards and support actions at the international level** to increase supply security, help diversify production and avoid a race to the bottom. This should include commitments to responsible sourcing, in line with international standards on responsible business conduct.
- **Ensure coordination amongst international organisations** with a mandate covering issues related to the future reliable and responsible supply of critical raw minerals, in particular the OECD, the International Energy Agency, and relevant UN agencies
- **Scale up international co-operation to address export restrictions** through existing trade policy tools at the multilateral, regional or bilateral level and explore new commitments or mechanisms to ensure that domestic-oriented policies of some countries are not detrimental to the fair access of all to critical raw materials.
- **Promote discussions among G7 countries to ensure consistency of measures** aimed at securing the reliable and responsible supply of critical raw materials with other policy objectives, notably in the context of the green and digital transition. This could include approaches to critical raw material procurement that strengthens environmental protection during extraction and along supply chains (e.g. climate smart mining).
- **Avoid trade restrictions and reduce the cost of technical barriers to trade among G7 countries,** which is an important step in ensuring the smooth functioning of value chains relying on critical raw materials.

Annex A.

Table A A.1. The three largest producers of each critical raw material

Material	Country	Share of global production
Bismuth	China	83%
	Vietnam	6%
	Laos	6%
Borates	Turkey	63%
	Kazakhstan	13%
	Chile	11%
Cobalt	DRC	68%
	Russia	5%
	Australia	4%
Germanium	China	66%
	Russia	4%
	United States	2%
Graphite	China	55%
	Mozambique	11%
	Brazil	9%
Lithium	Australia	78%
	Chile	5%
	Brazil	4%
Magnesium	China	82%
	Russia	5%
	Brazil	2%
Nickel	Indonesia	31%
	Philippines	13%
	Russia	11%
Palladium	Russia	43%
	South Africa	33%
	Canada	10%
Platinum	South Africa	71%
	Russia	12%
	Zimbabwe	8%
Phosphates	China	40%
	Morocco	17%
	United States	11%
Rare earth minerals	China	57%
	United States	16%
	Myanmar	12%

Note: Data for 2020. Germanium is a label for the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium. DRC stands for the Democratic Republic of the Congo. G7 members are in bold.
Source: United States Geological Survey

Table A A.2. The three largest exporters of each processed critical material

Material	Country	Share of global exports
Bismuth	China	37%
	European Union	15%
	Hong Kong	14%
Borates	**United States**	62%
	European Union	11%
	Chile	7%
Cobalt	DRC	58%
	European Union	9%
	Canada	5%
Germanium	China	23%
	United States	19%
	European Union	13%
Lithium	Chile	42%
	China	36%
	European Union	8%
Magnesium	China	53%
	European Union	24%
	United States	5%
Nickel	**European Union**	23%
	Russia	16%
	Canada	14%
Palladium	Russia	21%
	European Union	20%
	United Kingdom	17%
Platinum	**European Union**	30%
	United Kingdom	16%
	South Africa	13%
Phosphates	**European Union**	22%
	China	18%
	Morocco	17%
Rare earth minerals	China	28%
	Malaysia	19%
	Japan	17%

Note: Data for 2020. Germanium is a label for the following group of materials: germanium, niobium, vanadium, gallium, indium and hafnium. DRC stands for the Democratic Republic of the Congo. G7 members are in bold.
Source: United States Geological Survey

Table A A.3. The share of global exports subject to export restrictions

Material	Any export restriction	Export prohibition	Export quota	Price measures	Licensing requirement	Domestic market obligation	Restrictions on customs clearance	Other export measures
Bismuth	82.2%	0.0%	0.0%	0.0%	82.2%	0.0%	0.0%	0.0%
Borates	6.5%	0.0%	0.0%	6.5%	4.8%	0.0%	0.0%	0.0%
Cobalt	83.6%	71.3%	0.0%	75.5%	79.0%	0.0%	0.0%	71.2%
Germanium	91.5%	0.0%	0.0%	0.0%	91.5%	0.0%	0.0%	0.0%
Graphite	3.5%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	3.3%
Lithium	5.5%	0.0%	0.0%	1.7%	3.9%	0.0%	0.0%	0.0%
Magnesium	7.7%	0.0%	0.0%	5.8%	1.9%	0.0%	0.0%	0.0%
Nickel	68.0%	30.6%	3.8%	17.7%	68.0%	0.0%	0.0%	2.1%
Palladium	82.4%	0.0%	0.0%	5.7%	82.4%	43.4%	43.4%	43.4%
Platinum	92.2%	0.0%	0.0%	8.3%	92.2%	12.3%	12.3%	12.3%
Phosphates	65.3%	0.0%	0.0%	42.5%	60.3%	0.0%	0.0%	2.9%
Rare earths	59.2%	0.0%	0.0%	0.0%	58.0%	0.0%	0.0%	1.2%
Average	54.0%	8.5%	0.3%	13.6%	52.0%	4.6%	4.6%	11.4%

Note: Data for 2020. Price measures include export tax, export surtax and fiscal tax on exports.
Source: OECD Inventory of Export Restrictions on Industrial Raw Materials