IGF

INTERGOVERNMENTAL FORUM
on Mining, Minerals, Metals and
Sustainable Development

COMMODITY PROFILE

Natural Graphite

6
C
Carbon
12.011

1.0 Geological Considerations

1.1 Material Properties

Very high thermal stability*

Electrical conductivity ~10^5 s/m (in-plane)

Low recyclability

Low density 2.09–2.23 g/cm^3

Soft and easily cleaved along its layered structure

**Note: Graphite does not have a conventional melting point at atmospheric pressure. It sublimes at approximately 3,600°C–3,700°C. Melting occurs only under high-pressure conditions.*

This fact sheet focuses primarily on natural graphite and refers to synthetic graphite only where relevant for comparison, substitution, or market context. Natural graphite is mined from ore deposits, while synthetic graphite is manufactured from carbon-rich feedstocks through high-temperature graphitization. Synthetic graphite can offer higher purity and more consistent performance, whereas natural graphite generally has lower production energy requirements and a distinct mining-based supply chain (Cherakkara et al., 2025; Engels et al., 2022).

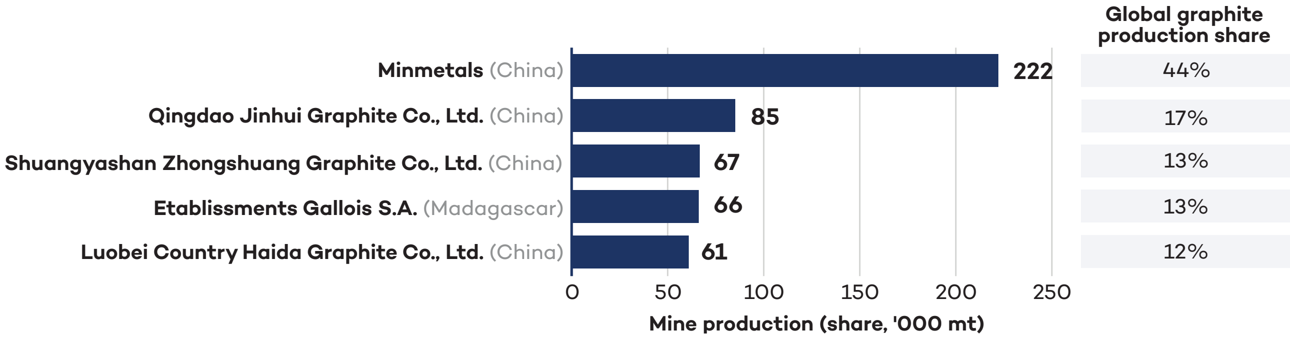
1.2 Major Natural Graphite Producers

Rank	Country	Production	Reserves
		Quantity (metric tonnes, mt, 2024) – (Global share in %)	
1	**China**	1,270,000 (78%)	81,000,000 (28.9%)
2	**Madagascar**	89,000 (5.5%)	27,000,000 (9.7%)
3	**Mozambique**	75,000 (4.6%)	25,000,000 (9%)
4	**Brazil**	68,000 (4.2%)	74,000,000 (26.5%)
5	**India**	27,800 (1.7%)	8,600,000 (3.1%)

Source: U.S. Geological Survey, n.d.-a.

1.3 Top Producing Companies

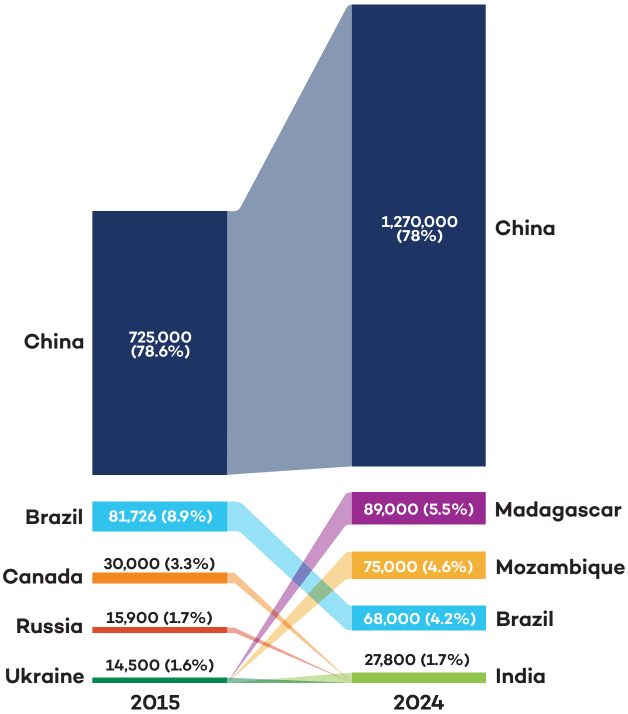
Top five natural graphite-producing companies by global production share ('000 mt, % share, 2024)



Source: Benchmark Mineral Intelligence, 2025 [custom data set; personal communication].

1.4 Top Graphite Producers 2015 vs 2024

Top five natural graphite producers 2015 vs 2024 (mt & global production share)

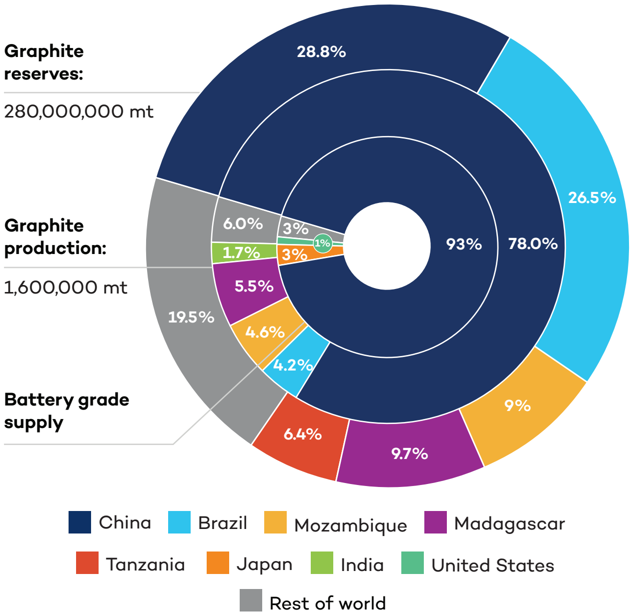


** Excludes U.S. production.*

Sources: Benchmark Mineral Intelligence, 2025 [custom data set; personal communication]; British Geological Survey, 2025; U.S. Geological Survey, n.d.-a, n.d.-b.

1.5 Natural Graphite Market Distribution

Global distribution of the natural graphite market: global reserves, mine production, and refining shares (%)



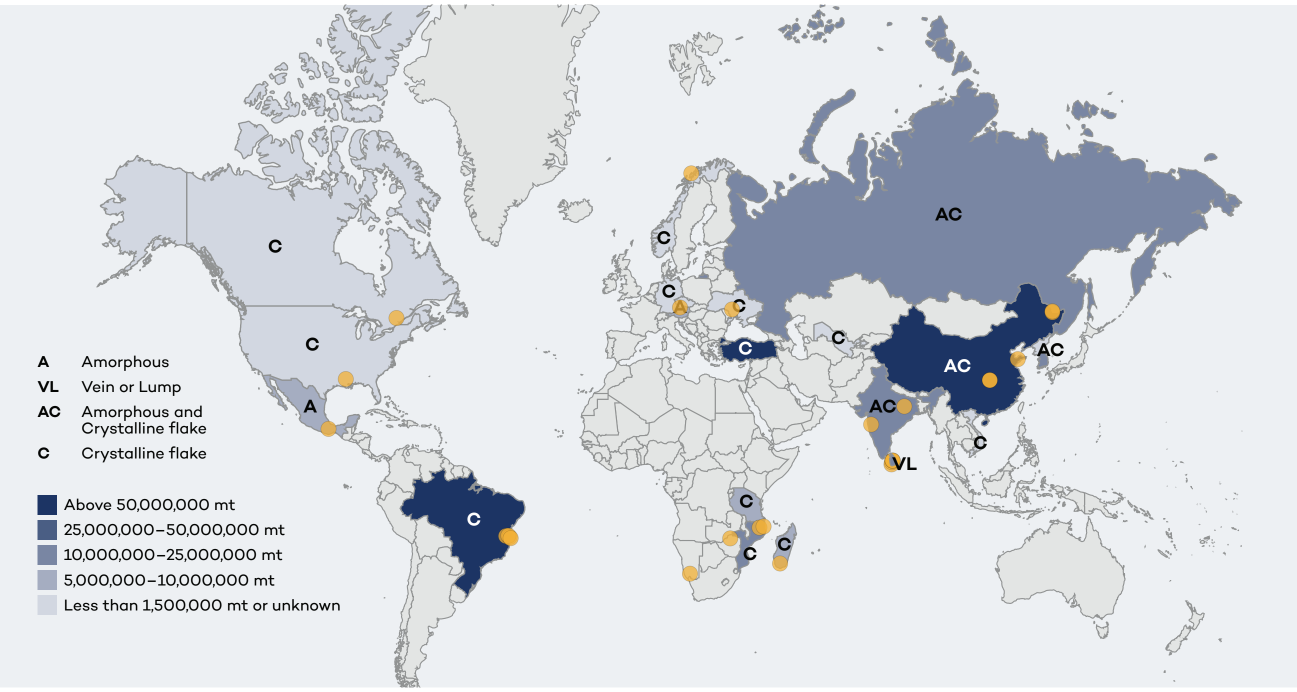
Methodology note: *This figure shows the concentration of global natural graphite reserves (outer), production (middle), and battery-grade supply (inner) capacities. Countries selected in the pie chart above represent the top-producing countries of each category, with the remainder aggregated to "Rest of World." For battery-grade supply, only three are presented, as they occupy 97% of the market. Where data labels are not present, the share is less than 5%.*

Source: International Energy Agency, 2025; Natural Resources Canada, 2025; U.S. Geological Survey, n.d.-a.

In 2023, global natural graphite production reached 1.7 million mt, accounting for roughly one-third of total graphite consumption (estimated at 5.2 million mt). The remaining supply deficit was largely met by synthetic graphite production, primarily in China.

1.6 Reserves, Resources, and Geology

1.6.1 Distribution and Geology of Natural Graphite Deposits Globally



Source: Park et al., 2025; U.S. Geological Survey, n.d.-a.

1.6.2 Natural and synthetic, origin, grades, operations, and main uses

Commodity type	Amorphous	Flake	Lump or chip	Synthetic
Deposit type	Amorphous	Disseminated flake	Vein	N/A
Ore grade % graphitic carbon (% Cg)	50%–90%	5%–30% (locally higher)	40%–90%	N/A
Product grade (% fixed carbon [% FC]*)	60%–90%	75%–97%	90%–99.9%	99.95%
Mine operations (natural graphite) and production route (for synthetic graphite)	Surface or underground, mechanized and hand methods, often found as coal	Open-pit, surface mines	Small, labour intensive, and underground. Ore is hand-sorted.	Produced by thermal graphitization of hydrocarbon materials
Main uses	Refractories, steel, industry, paint, batteries	Refractories, brake linings, lubricants, batteries	Carbon brushes, brake linings, and lubricants	Batteries, carbon brushes, nuclear moderator rods, graphite electrodes

***Methodology note:** *Carbon remaining after moisture, volatile matter, and ash are accounted for, often used in commercial graphite product specifications.*

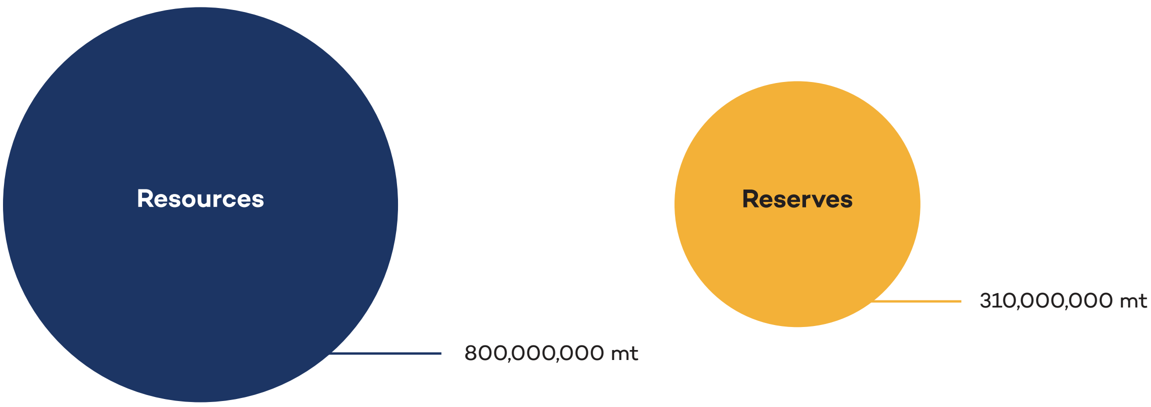
Source: African Development Bank (AfDB) & Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), 2025; U.S. Geological Society, 2017.

The surge in demand for lithium-ion batteries for electric vehicles and electronics has sharply increased demand for high-quality graphite, both natural and synthetic (AfDB & IGF, 2025). There are three main types of natural graphite: flake (crystalline), amorphous (microcrystalline), and vein. Flake graphite is the most prevalent type of natural graphite, primarily used in electric vehicle battery production. Amorphous graphite is primarily utilized in industrial applications. Vein graphite is more expensive due to its rarity and high purity; thus, it is typically reserved for specialized industrial uses. Once processed, natural graphite is primarily used in battery anodes, refractories for steelmaking and foundries (AfDB & IGF, 2025).

Given the chemical requirements of lithium-ion batteries, anode graphite manufacturers increasingly favour synthetic graphite. However, with modern beneficiation and purification techniques, natural graphite can also reach high purity, with its larger crystalline structure providing superior electrical and thermal conductivity, making it particularly attractive for anode applications (U.S. Geological Survey, 2017).

1.6.3 Reserves vs Resources

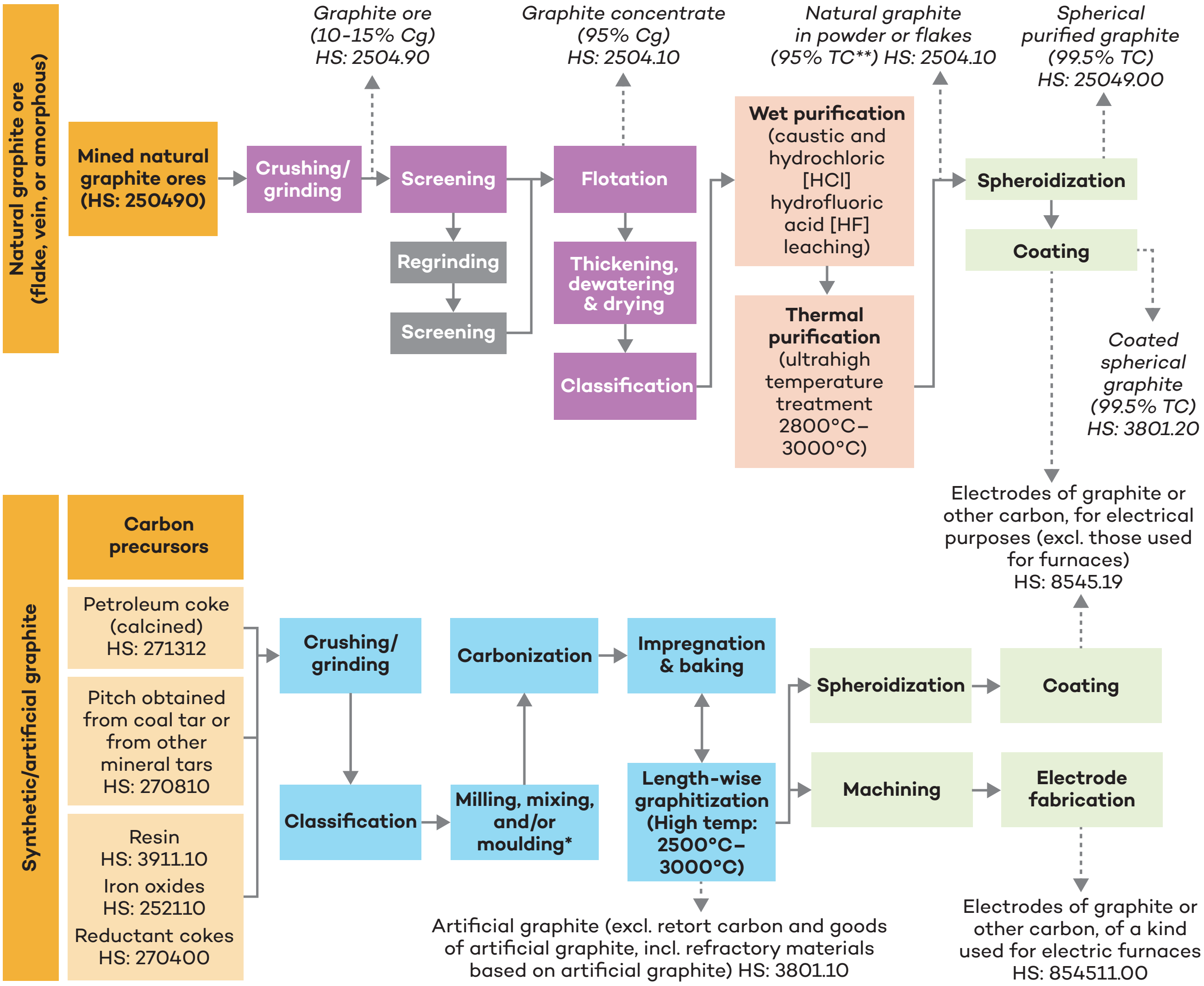
Global graphite reserves versus resources



Source: U.S. Geological Survey, n.d.-a.

1.7 Value Chain Diagram

High-level value chain diagram for natural vs synthetic graphite



Methodology notes:

** For synthetic graphite powder or battery anode material, the route may not involve moulding and machining in the same way.*

*** Total carbon (% TC) is the proportion by mass of all carbon present in the material, measured using an elemental carbon analysis. This differs from graphitic carbon (% Cg), which aims to measure only carbon present as graphite, and from fixed carbon (% FC), which is generally calculated by difference in proximate analysis. %FC=100% (% by mass of the sample)−(%moisture+%ash+%volatile matter). For relatively pure natural graphite, a rough practical assumption is often:%TC≈%FC.*

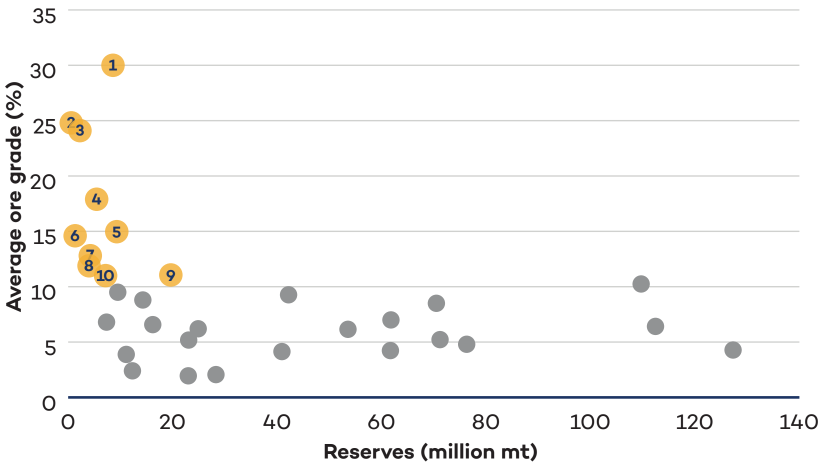
Source: Adham and Francey, 2023; AfDB & IGF, 2025; Gao et al., 2018; Jara et al., 2019; Kulkarni et al., 2022; Notter et al., 2010; United Nations Conference on Trade and Development, 2023.

The figure above presents a simplified overview of the graphite value chain, comparing synthetic and natural graphite beneficiation and processing routes. For natural graphite, mined ores are crushed to remove gangue and reduce ore size. Flotation allows the extraction of hydrophobic graphite particles from gangue to produce graphite concentrate (Adham & Francey, 2023). Following beneficiation, wet purification, such as chemical leaching, is used to separate metallic and silica impurities, with thermal purification used to volatilize any remaining impurities (East Carbon, 2024; Jara et al., 2019). In contrast, synthetic graphite is not mined but manufactured as a by-product of the oil and gas industry (Adham & Francey, 2023). Synthetic graphite can be derived from both coal tar pitch and petroleum coke, both carbon-rich residues of refining processes.

Each type of graphite serves different end uses: synthetic graphite is highly pure and is favoured for applications demanding high-grade consistency and purity, such as electric arc furnace electrodes and in some battery anodes (Adham & Francey, 2023). Despite the higher capital expenditure and emissions footprint of the processing pathway, recent life-cycle assessments note the potential of electrochemical graphitization for lowering environmental impacts compared to conventional methods (Kulkarni et al., 2022).

1.8 Ore Grade vs. Reserves

Relationship between natural graphite ore grade and reserves



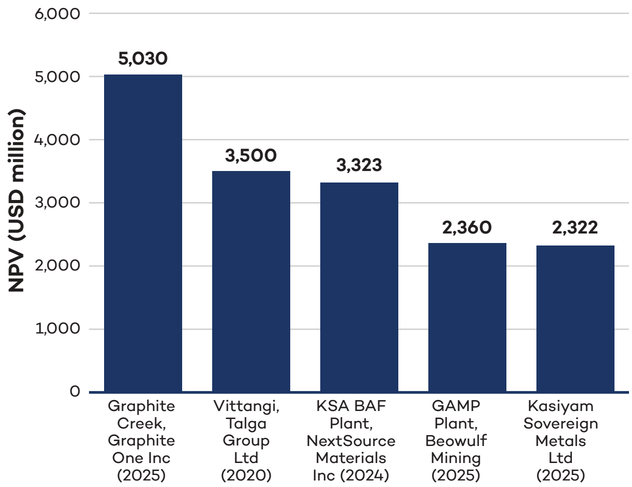
Top 10 producing mines:

1. Sarytogan – Kazakhstan
2. Traelen – Norway
3. Vittangi – Sweden
4. Lindi Jumbo – Tanzania
5. Lac Knife – Canada
6. Koppio–Kookaburra Gully – Australia
7. Munglinup – Australia
8. Uley – Australia
9. Balama Central – Mozambique
10. Beishan – China

Source: S&P Global Market Intelligence, 2026.

1.9 Exploration

Top graphite development projects (2020–2025) by estimated net present value (NPV) (USD million)

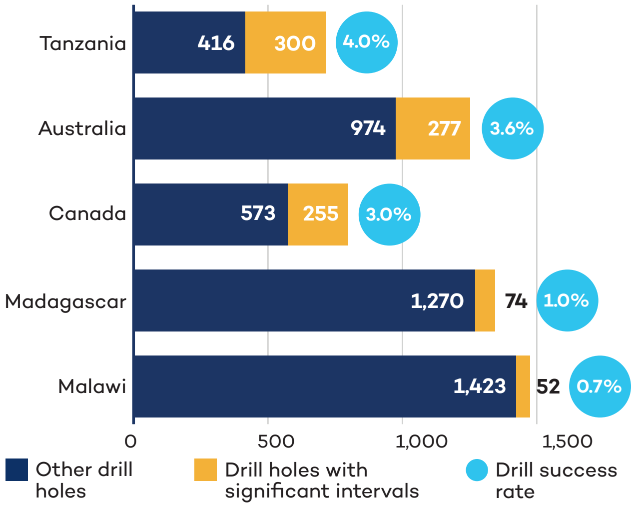


Methodology note: *This bar chart shows top graphite development projects (2020–2025) by estimated NPV in USD million. For NPV, note that if after-tax data is not available, pre-tax is reported, and across values, only the base case value is displayed.*

Source: S&P Global Market Intelligence, 2026.

1.10 Drilling Activity

Top five countries by drill hole success rate 2015–2025 (% share, number of drill holes)



Methodology note: *S&P Global Market Intelligence assesses the significance of drill results by considering both the objective of the drill hole and the quality of the intercepted interval. A result is deemed significant if it has the potential to add to or extend known mineralization or resources at a project, and if it surpasses a value threshold determined by prevailing commodity prices.*

Source: S&P Global Market Intelligence, 2026.

1.11 Future Resources of Graphite

Overview of potential future graphite resources and supply

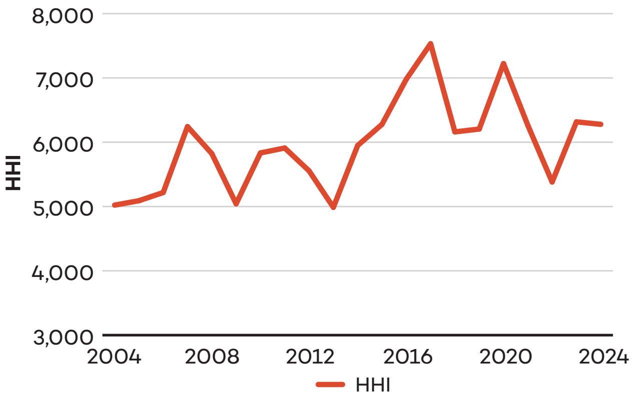
Future and alternative resource of graphite supply	Description
Biographite (biomass-derived graphite)	Graphite produced from biomass, timber, or organic waste through pyrolysis or other carbonization processes.
Synthetic sources	Artificially produced graphite manufactured from petroleum coke or coal tar pitch via high-temperature processes.
New reserves of natural graphite	Newly discovered or untapped deposits of natural graphite mined from subterranean deposits.

Sources: AfDB & IGF, 2025; Carbonscape, n.d.; Carrère et al., 2024; Manjong et al., 2025; U.S. Geological Survey, n.d.-a.

2.0 Economic and Geopolitical Considerations

2.1 Market Concentration

Mined-graphite (natural) market concentration (HHI)



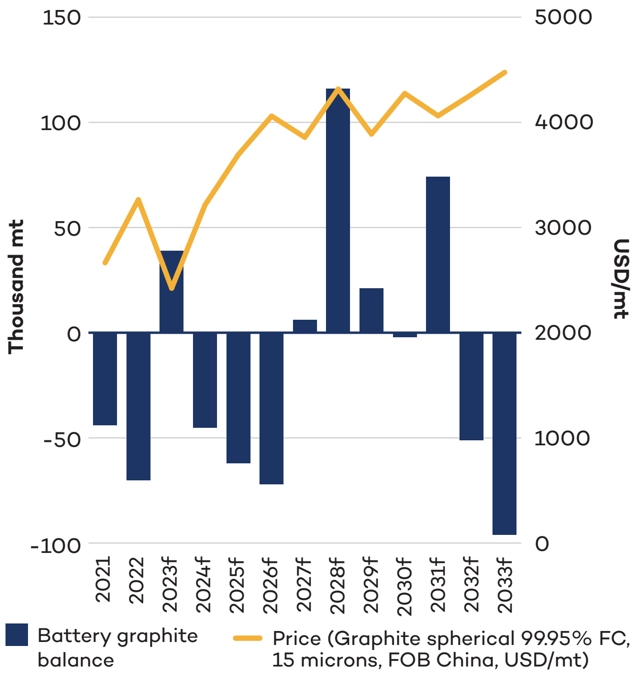
Methodology note: *The HHI is a commonly accepted measure of market concentration in an industry, where a low value (<1,500) indicates a more diversified sector, and high values above 2,500 indicate high market concentration. HHI lines by market concentration are as follows: green for values below 1,500 (low concentration or competitive market); orange for 1,500–2,500 (moderate concentration, some market power); and red for values above 2,500 (high concentration or limited competition and potential monopoly or dominant players).*

Source: U.S. Geological Survey, n.d.-b, 2023.

China mines most of the world's natural graphite. Between 2004 and 2024, China's share of natural graphite mining ranged from 69% in 2004 to 87% in 2017 and was 79% in 2024. The dips in HHI in 2009 and 2013 were likely due to Chinese production cuts. The dips in 2018–2019 and 2022 were largely due to increasing production in Mozambique.

2.2 Battery Market Balance vs Price

Total battery graphite market balance vs. price (2021–2022), forecasted price (2023–2033f)



Methodology note: *Fastmarkets, MB-GRA-0026 - Graphite spherical, 99.95% C, 15 microns, Free on Board (FOB*) in China, USD/mt.*

"f" indicates forecasted market balance and price.

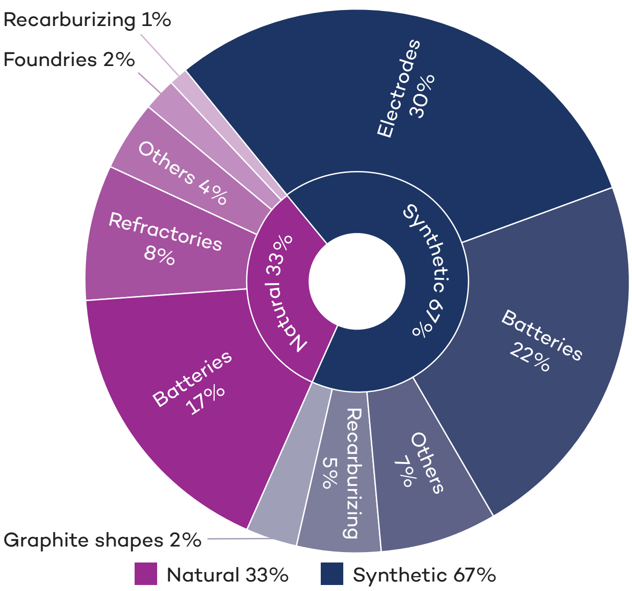
** FOB is the export value of goods at the port of shipment, excluding international freight and insurance costs.*

Source: Fastmarkets, 2023.

2.3 Industrial Considerations

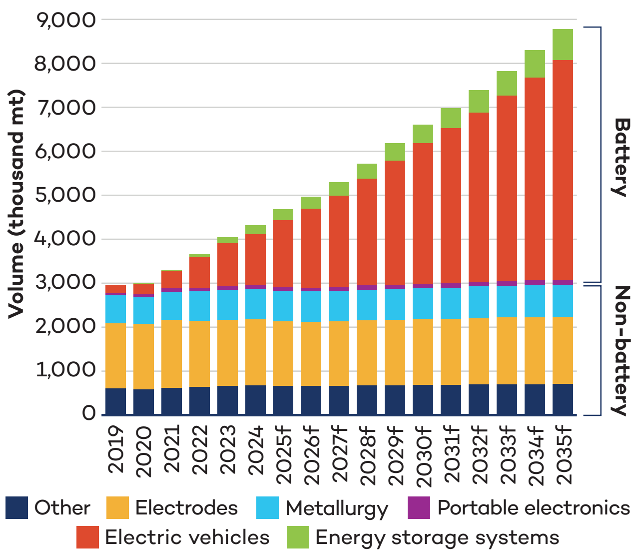
2.3.1 Uses of Natural and Synthetic Graphite by End-Use Product

(i) Major uses of natural and synthetic graphite



Source: Natural Resources Canada, 2025.

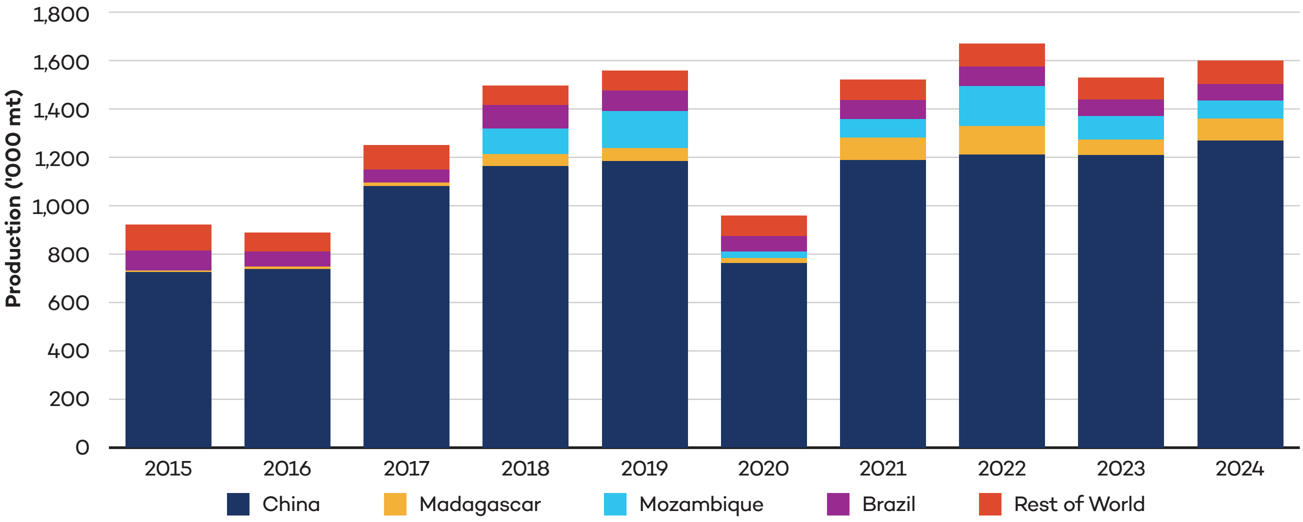
(ii) Consumption by application (2020–2024), and forecast consumption by application (2025f–2034f)



Source: S&P Global Market Intelligence, 2026..

2.3.2 Primary Production

Natural graphite mine production ('000 mt), 2015–2024



Sources: U.S. Geological Survey, n.d.-a, n.d.-b.

China continues to dominate natural graphite production. At the same time, large natural graphite deposits in Madagascar and Mozambique have attracted increased mining investment, driven by rising demand for battery-grade graphite and efforts to diversify supply chains. The graph excludes synthetic graphite, whose production exceeds that of natural graphite. Graphite recycling remains limited, with global recycling rates estimated at only around 1% to 3%.

2.3.3 Substitution Challenges

Graphite substitutability across applications

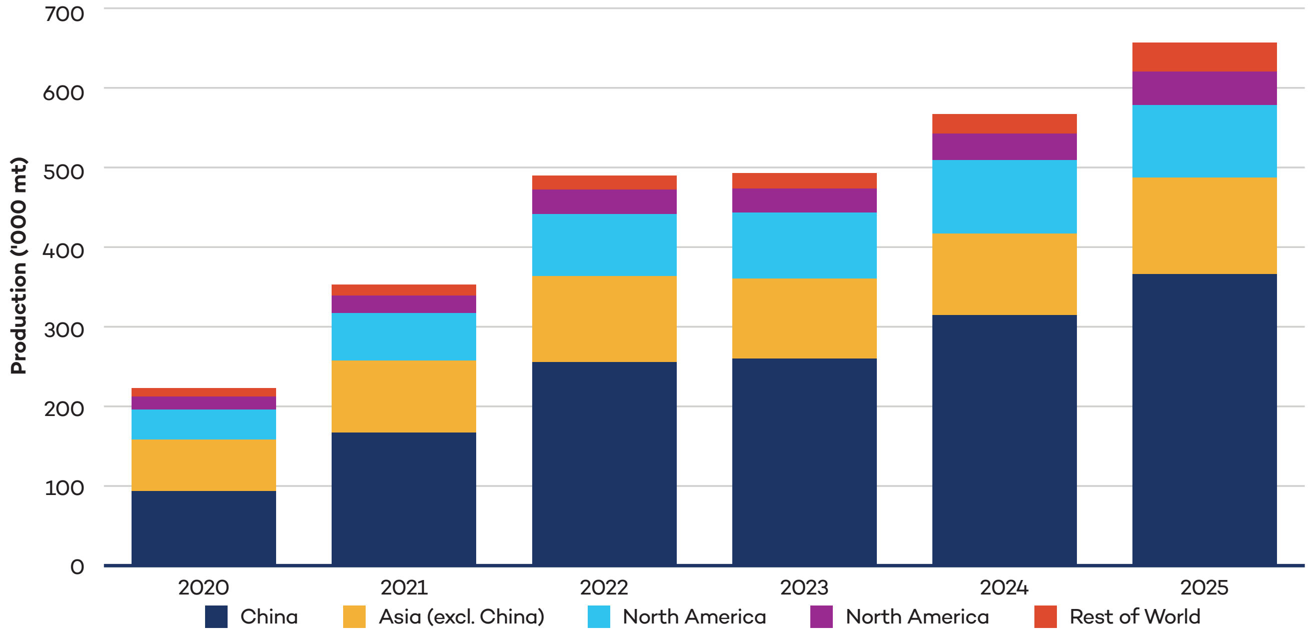
Application	Substitute/alternative	Substitution potential and risks
Batteries	Silicon, lithium, titanium oxide	Silicon-anode technologies can increase energy density, but they remain technically complex and costly. Lithium-titanate and lithium titanium oxide batteries are safer and longer-lasting, but their lower energy density and higher cost limit large-scale deployment (Casey, 2023; Muy et al., 2025).
Refractories	Alumina, silicon carbide	Alumina-based composites offer strong thermal and wear resistance, but their performance can decline under thermal shock, cyclic stress, or severe corrosion. Silicon carbide is hard and thermally stable, but it is costly to manufacture and brittle under impact or tensile stress (Imerys Graphite & Carbon Switzerland Ltd., 2016; Zhang, 2024).
Lubricants	Molybdenum disulfide (MoS_2), Polytetrafluoroethylene (PTFE) (teflon)	MoS_2 provides strong dry lubrication, especially under high loads, but loses effectiveness at very high temperatures in air due to oxidation. PTFE offers very low friction but is limited by softening and thermal degradation at elevated temperatures (Kouzegaran, 2020; MachineMFG, 2025).
Metallurgy & foundry	Graphene, copper, aluminum	Graphene has strong performance potential, but cost, quality control, and scalability remain key barriers. Metallic alternatives can perform well, but some face oxidation or corrosion risks at high temperatures (Owuor et al., 2021; St. Marys Carbon, 2025).
Electric motor brushes and conductive applications	Copper–graphite blends (reduced graphite content)	Good conductivity and strength, but reduced graphite content may increase wear in some conditions (Star Graphite, 2025; St. Marys Carbon, 2025).

Source: Compiled by authors..

2.3 Consumption and Price

2.3.1 Graphite Consumption by Region

Natural graphite consumption for battery manufacturing by region ('000 mt), 2020–2025

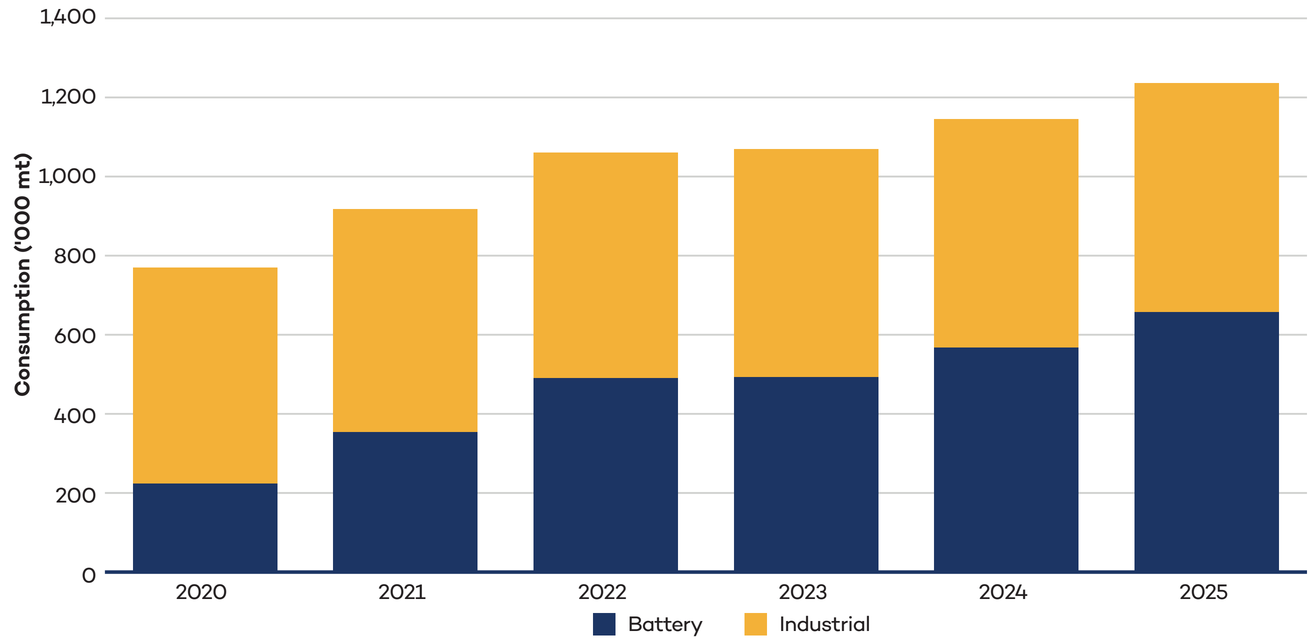


Sources: Benchmark Mineral Intelligence, 2025 [custom data set; personal communication].

Natural graphite consumption in China nearly quadrupled between 2020 and 2025 as China's share increased from 42% in 2020 to 56% in 2024. Although Asia (excluding China) nearly doubled in consumption, its global share dropped from 29% in 2020 to 18% in 2025.

2.3.2 Graphite Consumption by Sector

Graphite consumption in battery vs industrial applications, 2020–2025



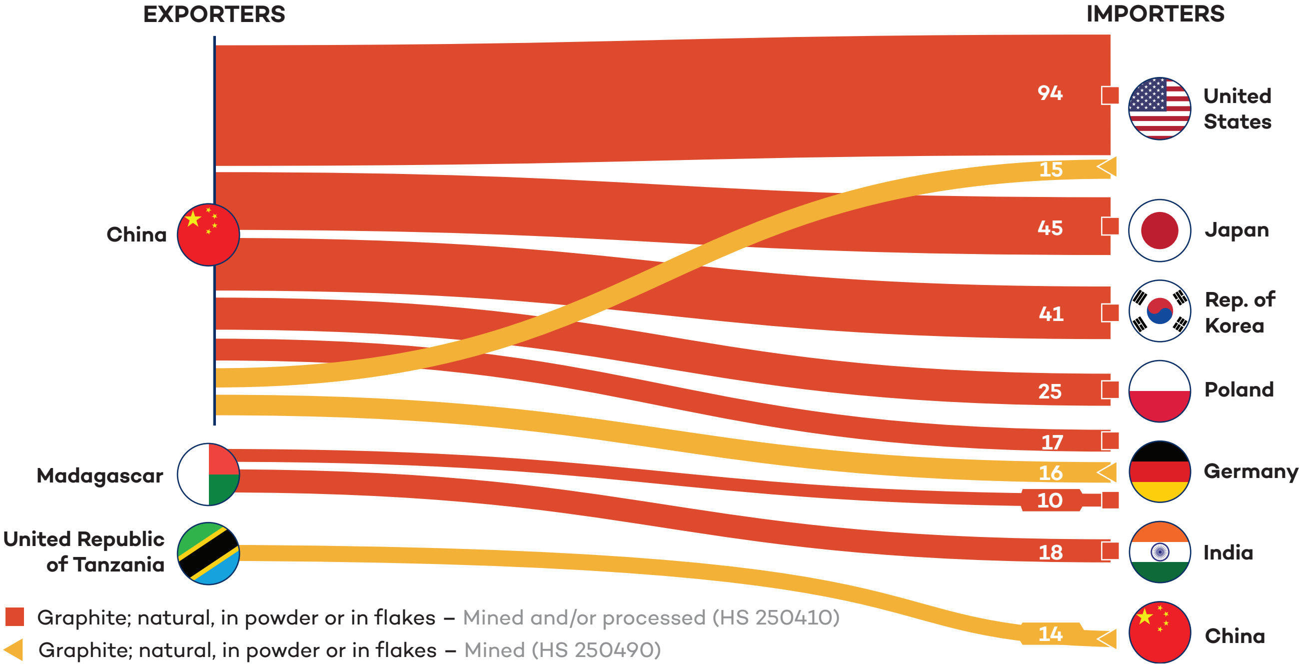
Source: Benchmark Mineral Intelligence, 2025 [custom data set; personal communication].

While natural graphite consumption for batteries has tripled from 2020 through 2025, consumption for industrial applications has remained largely the same. The growth in natural graphite consumption for batteries has predominantly occurred in China.

2.4 Trade

2.4.1 Graphite Trade Overview

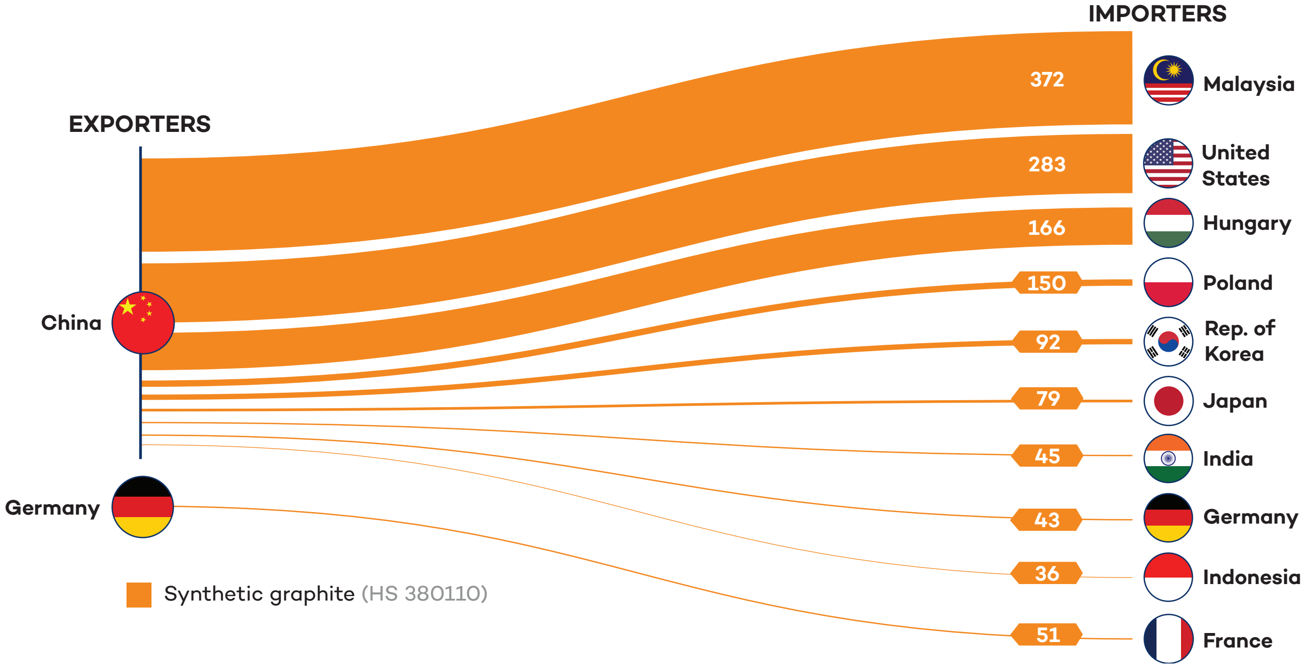
(i) Natural graphite – Top major country-to-country trades by value (USD million), 2024



Source: United Nations Comtrade Database, 2025.

China remains the world's leading exporter of natural graphite, followed by Madagascar, while the United States is the largest importer. U.S. natural graphite demand is concentrated in brake linings, lubricants, refractories, and steelmaking, with battery applications becoming increasingly important.

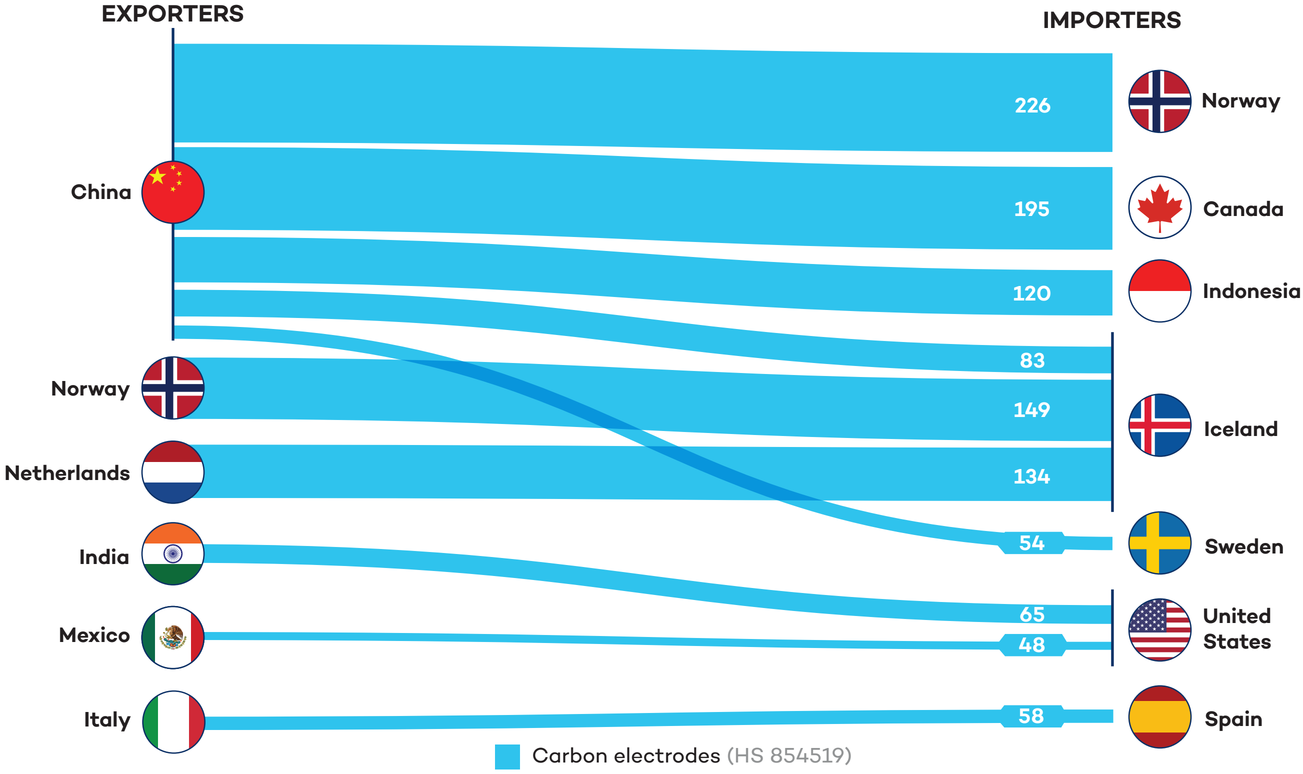
(ii) Synthetic graphite – Top major country-to-country trades by value (USD million), 2024



Source: United Nations Comtrade Database, 2025.

China is the world's leading exporter of synthetic graphite, followed by Germany and Japan. Malaysia is a major importer, with demand likely linked to its growing role in battery and electronics supply chains, including electric vehicle battery anode materials.

(iii) Carbon electrodes – Top major country-to-country trades by value (USD million), 2024

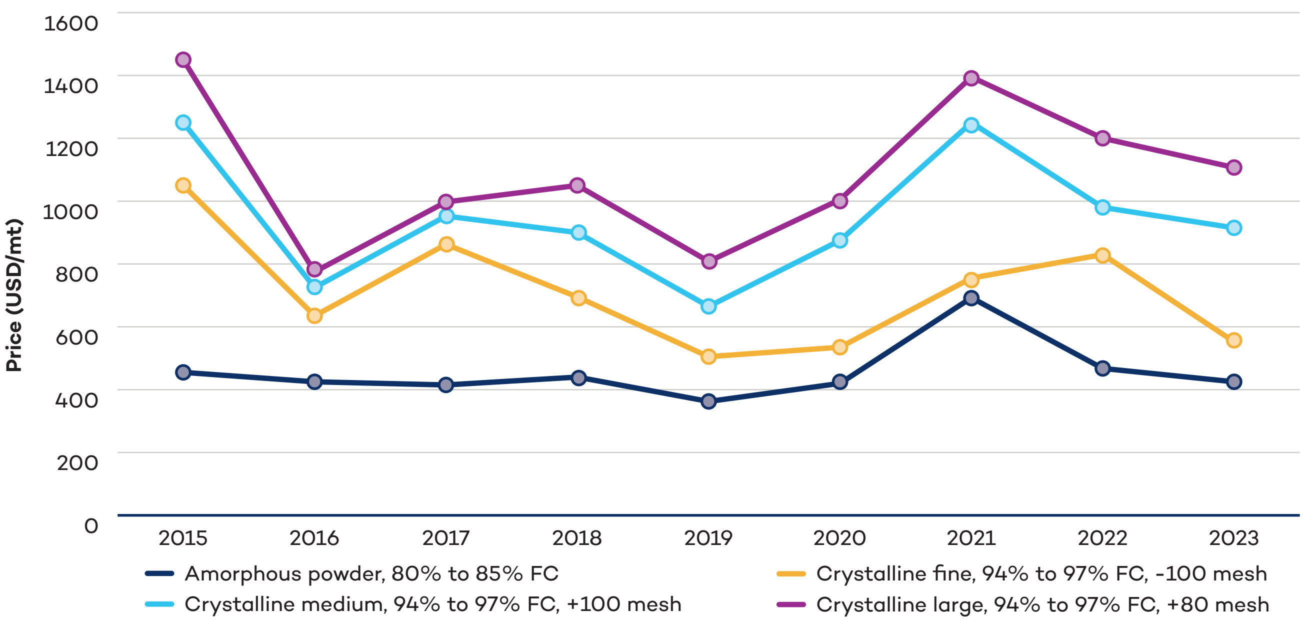


Source: United Nations Comtrade Database, 2025.

2.5 Geopolitical Considerations

2.5.1 Pricing Trends: Natural flake graphite prices

Natural graphite historical pricing, USD/mt



Methodology note: *Prices include cost, insurance, and freight (CIF*) from China to the main European ports.*

**CIF price is the landed import price of goods at the destination port, including the value of the goods, insurance, and international shipping costs, but excluding import duties, local taxes, and inland transport after arrival.*

Source: S&P Global Market Intelligence, 2026; U.S. Geological Survey, n.d.-b.

2.5.2 Strategic Developments Timeline

Timeline of strategic developments affecting graphite value chains, 2015–2025

Notable events and activity

- **2015** – Feasibility study for the Balama mine in Mozambique begins (one of the largest deposits globally).
- **2017** – Syrah Resources begins production in the Balama mine.
- **2021** – Molo mine in Madagascar begins development under NextSource Materials.
- **2022** – Syrah Resources receives a loan of USD 102 million from the U.S. Department of Energy to expand a graphite active anode material facility in the United States.
- **2023** – Tirupati Graphite consolidates its share of the global market by acquiring several projects in Mozambique.
- **2024** – Local protests force shutdown of the Balama mine, underscoring supply chain risks.
- **2025** – African producers, such as Madagascar, Mozambique, and Tanzania, become key players as supply chain concentration risks become apparent.
- **2025** – Global Li-Ion Graphite acquires Montepuez Graphite project adjacent to Balama.

Source: ACCESS Newswire, 2021; Cefai, 2025; Global Li-Ion Graphite Corp, 2025; Mining Technology, 2019, 2025; Reuters, 2023; Sanchez, 2024.

2.5.3 Regulatory Timeline

Timeline of restrictions impacting graphite value chains, 2015–2024

Notable regulatory events and activities related to graphite

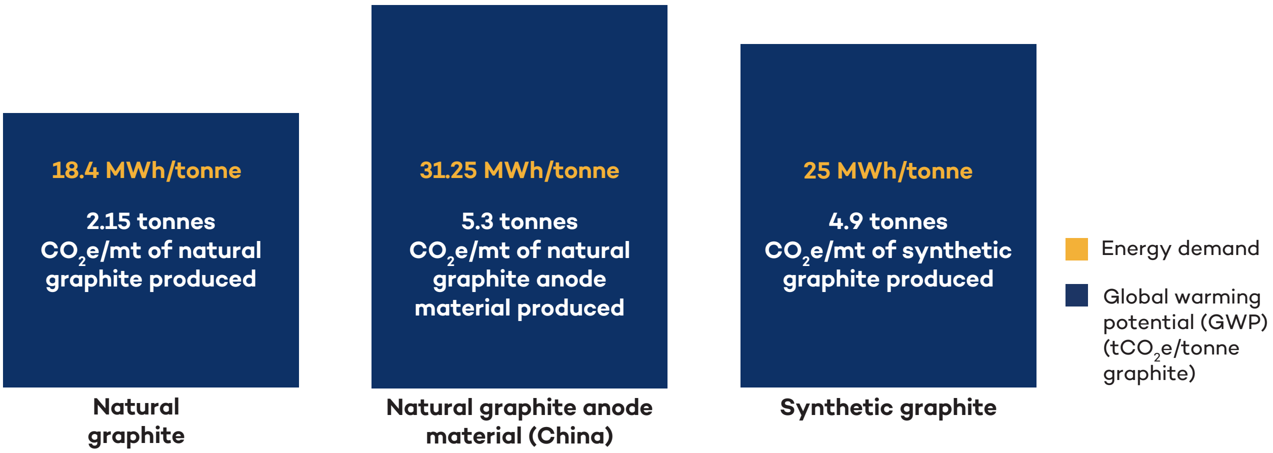
- **2016–2017** – Mozambique updates its mining framework under Mining Law No. 20/2014 (18 August 2014) and its implementing Regulation, Decree No. 31/2015, shaping graphite development projects, notably Balama and Montepuez.
- **2022** – Tanzania codifies state equity participation under the Mining Act (Cap. 123), via the Mining (State Participation) Regulations, 2022 (GN No. 574), mandating a 16% non-dilutable free-carried government interest.
- **2023** – Madagascar overhauls its Mining Code (Law No. 2023-007), raising royalties, strengthening social and community obligations, and adding new provisions on strategic minerals and project development.
- **2024** – The United States imposes a 25% Section 301 tariff on graphite anodes from China, after exclusion expiry.

Source: International Energy Agency, 2024; Mosha & Kapinga, 2022; U.S. Geological Survey, 2023.

3.0 Social and Environmental Considerations

3.1 Emissions Profile

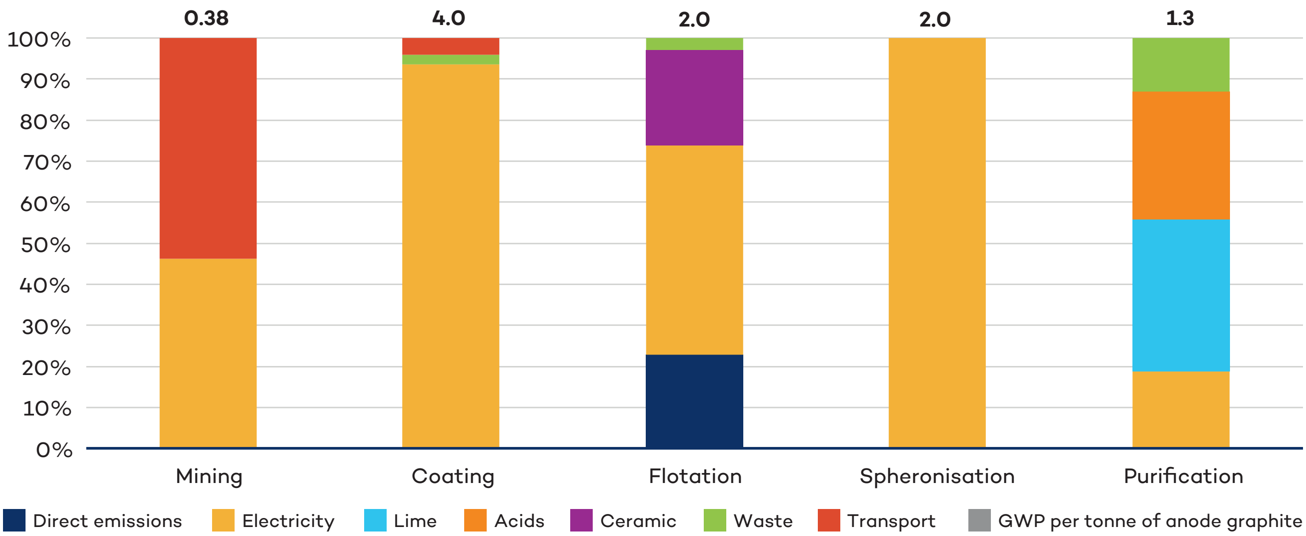
Comparison of energy demand and global warming potential (GWP) of natural vs. synthetic graphite manufacturing



Note: tCO_2e = tonnes of carbon dioxide equivalent.
Source: Notter et al., 2010; Gao et al., 2018; Dai et al., 2019.

3.2 Life-Cycle Impact Assessment for Anode Graphite

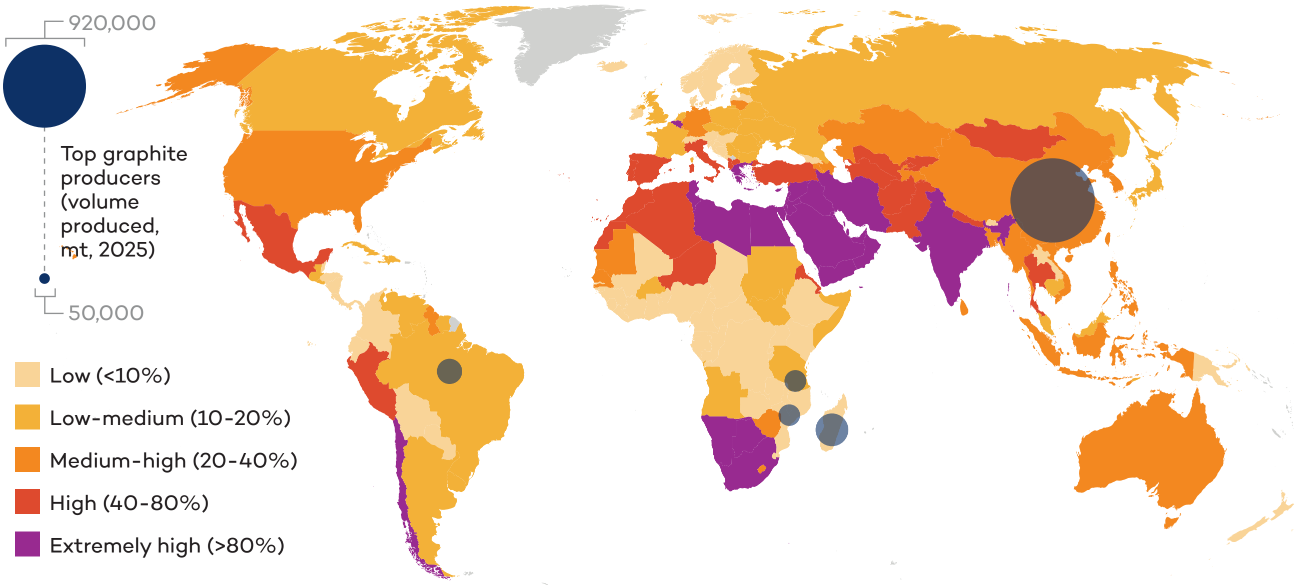
Global warming potential (GWP 100 years) for production steps per tonne of anode graphite



Sources: Engels et al., 2022.

3.3 Water Scarcity Risks

Baseline water scarcity risk in key graphite-producing regions



Methodology note: *Baseline water stress measures the ratio of total water demand (domestic, industrial, irrigation, and livestock uses) to available renewable surface and groundwater supplies. Higher values indicate more competition among users.*

Sources: U.S. Geological Survey, n.d.-a.; World Resources Institute, 2025.

3.4 Overview of Graphite-Related Sustainability Standards and Initiatives

Voluntary sustainability standards, frameworks, and bodies impacting the graphite value chain

European Carbon and Graphite Association (ECGA) Due Diligence Guidance for the Carbon & Graphite Industry:

The ECGA's sector-specific extension of the Organisation for Economic Co-operation and Development's Due Diligence Guidance framework, this guidance provides risk-based due diligence steps: governance, red-flag identification, supplier engagement, third-party audits, remediation, and public reporting tailored for graphite producers

2.0 Extended Minerals Reporting Template (EMRT):

Released in April 2024 by the Responsible Minerals Initiative, the EMRT Version 2.1 expanded its mineral scope to include natural graphite, lithium, nickel and copper, aiming to advance responsible mineral sourcing across a wider range of industries.

China Non-Metallic Minerals Industry Association:

National industry organization composed of production and processing, research, science and technology, and trade-related services for the non-metallic mineral industry, including for graphite.

ECGA:

Leading industry association and platform for EU carbon and graphite producers, representing 100% of EU-based production of graphite products, including electrodes.

Source: China Non-Metallic Minerals Industry Association, 2026; ECGA, 2024, 2026; Responsible Minerals Initiative, 2026.

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