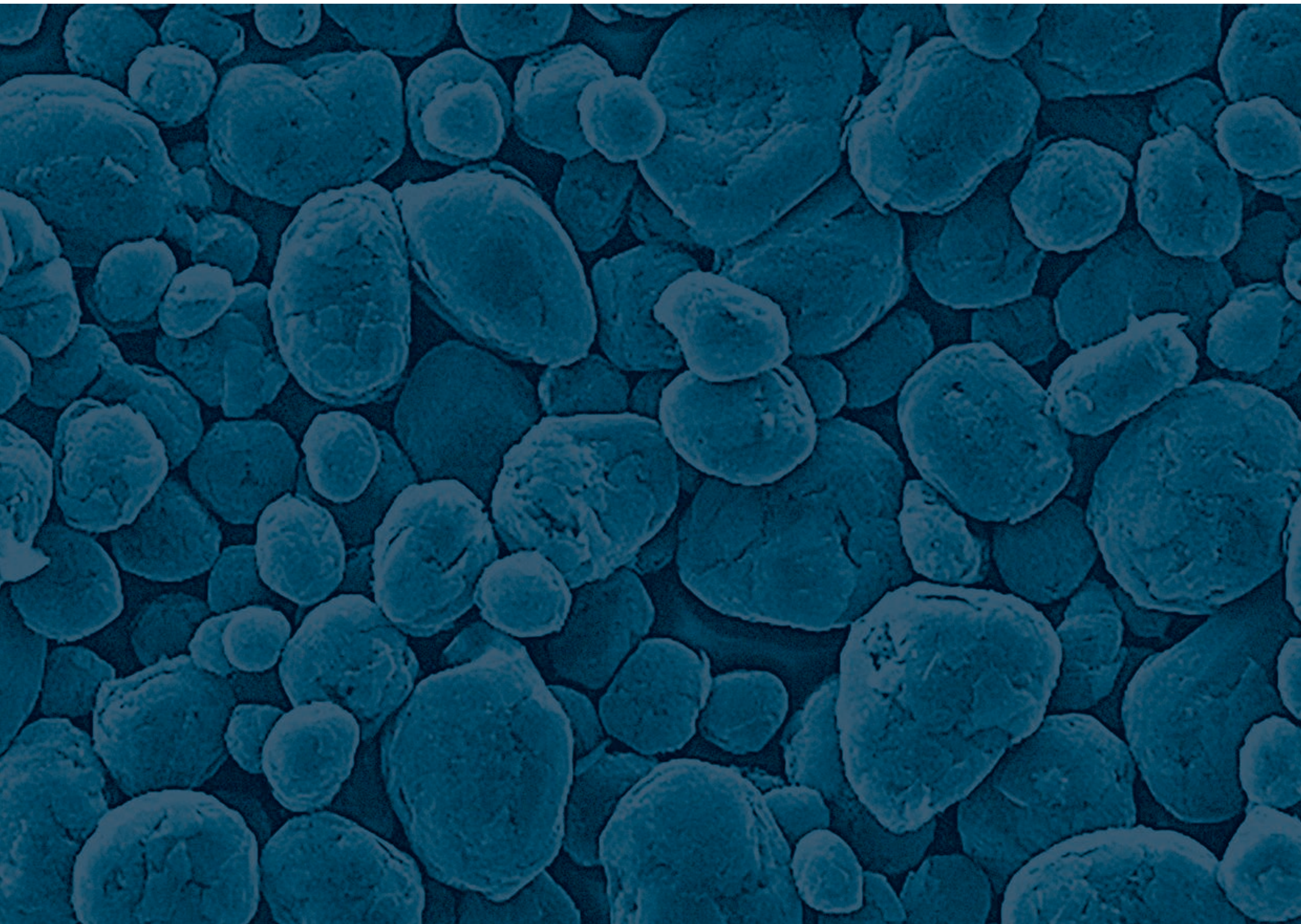
Australia's National
Science Agency

Australian graphite: A path to a global battery market opportunity

2025



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Executive summary

Graphite is a critical material in lithium-ion batteries (LIBs), which are essential for the rapidly expanding electric vehicle (EV) market. Australia holds substantial natural graphite resources, ranking 8th globally for Economic Demonstrated Resources (EDR). However, Australia currently lacks large-scale production capability for battery-grade graphite. This presents a significant opportunity for Australia to develop a robust graphite industry, and establish domestic manufacturing capabilities and become a preferred supplier of graphite in the global market. A new supply chain with high ESG standards would help to diversify the supply and to meet the increasing global demand for battery anode materials to ensure energy security.

Key opportunities for Australia identified in this report include:

- **Resource potential**: Australia has significant natural graphite resources, but currently does not mine nor produce battery-grade graphite at scale. Leveraging these resources whilst discovering new deposits could position Australia as a key player in the global battery anode market.
- **Market dynamics**: China currently dominates 95% of the downstream processing market for anode materials, with this concentration in one country posing a risk to supply chain stability. This also presents an opportunity for Australia to enter the global supply chain, and enhance its processing capabilities.
- **Economic opportunity**: The substantial price differential between graphite concentrate and anode materials highlights the economic potential of downstream processing. Developing domestic processing capabilities could add significant value to Australia's graphite resources.

To capitalise on Australia's graphite resources, actions in the near term could be considered: improve ore characterisation, establish manufacturing capabilities, and integrate renewable energy into anode production. Collaboration with like-minded partners could enhance these efforts, ensuring a robust and stable supply chain, and help mitigate risks in current graphite production and processing concentration.

The development of a graphite industry in Australia could secure a stable supply of critical battery materials, support the growing Energy Storage Systems (ESS) and EV market, and position Australia as a key player in the global battery anode market. This could have significant public value, policy relevance, national interest and enhance economic growth. The potential benefits may include increased energy security, job creation, and technological advancements in battery manufacturing.

1 Why is graphite important?

Graphite, the most stable carbon allotrope, is the primary anode material for lithium-ion batteries (LIBs). Since its establishment in the 1990s, graphite has been utilised in LIBs due to its lightweight, mechanical and chemical stability, high conductivity, compatible voltage with LIB cathodes, and relatively low cost. The battery sector holds the second-largest global market share for graphite, with the highest anticipated growth over the next decade, driven by the increasing demand for electric vehicles (EVs) [1].

Australia, with its substantial natural graphite resources, is well-positioned to meet a significant portion of this demand. According to Geoscience Australia Data, as of December 2023, Australia ranks 8th globally for Economic Demonstrated Resources (EDR) of graphite, comprising 4% of the world's resources. However, Australia currently does not produce battery-grade graphite (or graphite concentrate) at scale for domestic use or export.

Capitalising on Australia's natural resources and the USA's established battery industry could strengthen domestic manufacturing and secure the graphite supply chain for both nations and globally [2,3].

The Australian Government has initiated several programs, including funding CSIRO to support early-stage graphite research activities. Key focus areas are:

- characterisation of Australia's graphite deposits using artificial intelligence (AI) and machine learning
- the integration of renewable energy into processing of natural graphite to battery grade materials, and
- recovering graphite from end-of-life batteries.

A collaborative program with US partners would help to achieve these goals and ensure energy security for both nations.

1.1 Graphite battery value chain

The Supply Chain Readiness Level (SCRL) framework is a structured approach developed by the US Department of Energy's Office of Manufacturing and Energy Supply Chains (MESC) to assess and quantify risks within energy supply chains. Given the complex and dynamic nature of energy supply networks, spanning raw material extraction, processing, manufacturing, and end-of-life management-and ongoing increased demand, SCRL provides a systematic methodology to evaluate supply chain resilience. Developed through the Modelling, Mapping, and Analysis Consortium (MMAC) in collaboration with US national laboratories, SCRL builds on established frameworks like Technology Readiness Levels (TRLs) and Adoption Readiness Levels (ARLs) to assess how reliable and competitive the energy supply chain is, in the context of dynamic technology advancement.

SCRL specifically focuses on energy supply chain vulnerabilities at the segment level. It aims to answer two critical questions related to the reliability of supply in meeting increasing energy demands and the ability of U.S. and allied production to remain competitive in the global market. By leveraging deep analytical capabilities and industry engagement, SCRL identifies key risks [4]. The lithium-ion battery (LIB) supply chain map produced using SCRL is presented in Figure 1.

Graphite is the key focus for the current report. Both synthetic graphite (produced from fossil fuel-based materials) and natural graphite (formed under high temperatures and pressures in the earth's crust) have been used in LIBs.

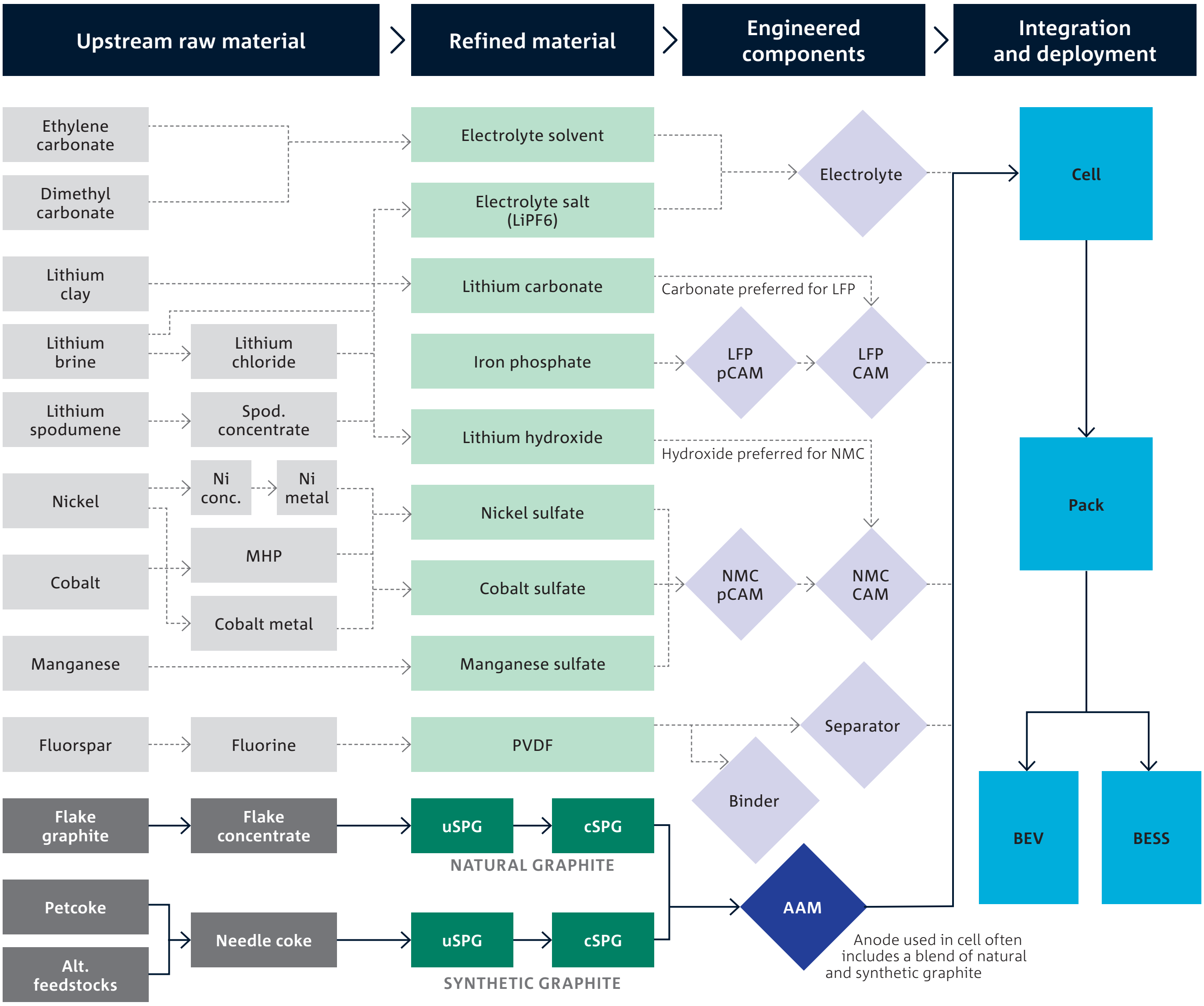

Figure 1. Li-ion battery supply chain map for raw materials to final battery package product [4].

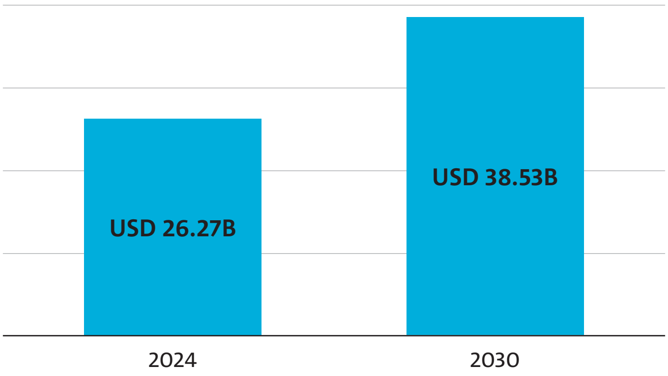

Figure 2. Forecasted global graphite market for all applications, growth at a CAGR of 6.5%, reproduced graph [5].

Synthetic graphite is primarily derived from needle coke, a by-product of oil refining or metallurgical coke making, which undergoes an energy-intensive graphitisation process at temperatures nearing 3000 °C for approximately a month. This costly, energy intensive process has driven major anode producers to vertically integrate their graphitisation facilities in China, where low electricity prices make synthetic graphite more competitive with natural graphite which has dominant market share in China (>70 %). However, regulatory changes and restrictions on coal mine approvals have disrupted this trend, leading to price surges. Although synthetic graphite has been associated with a higher carbon footprint, the growing use of hydroelectric power in China is helping to reduce its environmental impact. Reported data indicate that battery-grade synthetic graphite has a carbon footprint ranging from 4.0 to 9.6 t CO_2eq./t, compared to 5.2 to 24.5 t CO_2eq./t for natural graphite. Despite its higher production costs, synthetic graphite is preferred in many applications due to its superior purity and consistency, which contribute to longer battery cycle life.

Natural graphite, used for battery anodes, is sourced from flake graphite, which requires further processing to meet purity and particle size requirements. This involves (potentially) milling /grinding, spheronisation (particle shaping process), and purification using hydrofluoric acid, alkali-acid treatment, or high-temperature methods, with hydrofluoric acid being the most widely used despite environmental concerns [6]. Natural graphite benefits from geological graphitisation, resulting in lower energy consumption and production costs. In contrast, synthetic graphite, produced from petroleum coke, offers enhanced electrical conductivity, improved compatibility with electrolytes, and more consistent performance due to its controlled manufacturing process. However, its production demands extremely high temperatures, leading to greater energy use and environmental impact. With growing pressure to decarbonise battery supply chains, natural graphite presents a more sustainable and cost-effective solution [7]. This increase is driven by enhanced environmental awareness and regulations that favour natural graphite which offers a lower carbon footprint during production, as well as its lower cost. Its global market size is anticipated to reach USD44.57B by 2023, i.e. CAGR 5.4% between 2024 and 2030 [8].

As shown in Figure 3, graphite accounts for 14–22% of the total cell weight of a Li-ion battery, depending on its type [8].

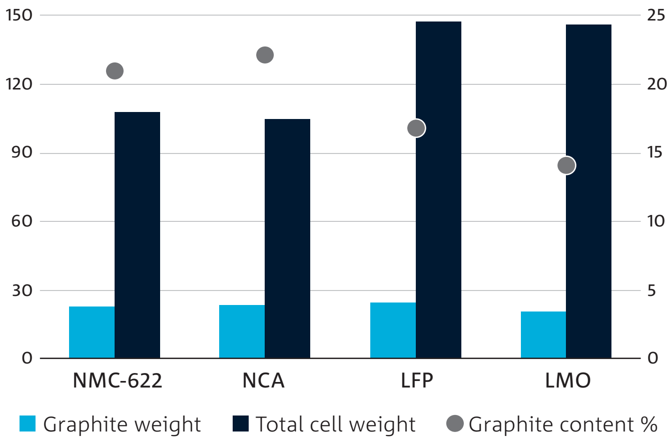

Figure 3. Graphite content ratio in LIBs.

Figure 4 presents a simplified process flow chart detailing the journey of graphite from extraction to its integration into battery components. The process begins with the mining of natural graphite ore, which undergoes several stages of processing, including crushing, grinding, and purification, to produce high-purity graphite. Both natural and synthetic graphite are then shaped into the desired form, often involving coating processes to enhance performance characteristics. The final product is assembled into anodes. This flow chart underscores the complex and multi-step nature of graphite's transformation from raw material to a vital element in advanced energy storage solutions [8]. While several countries participate in this supply chain, China's significant role in all stages is dominant.

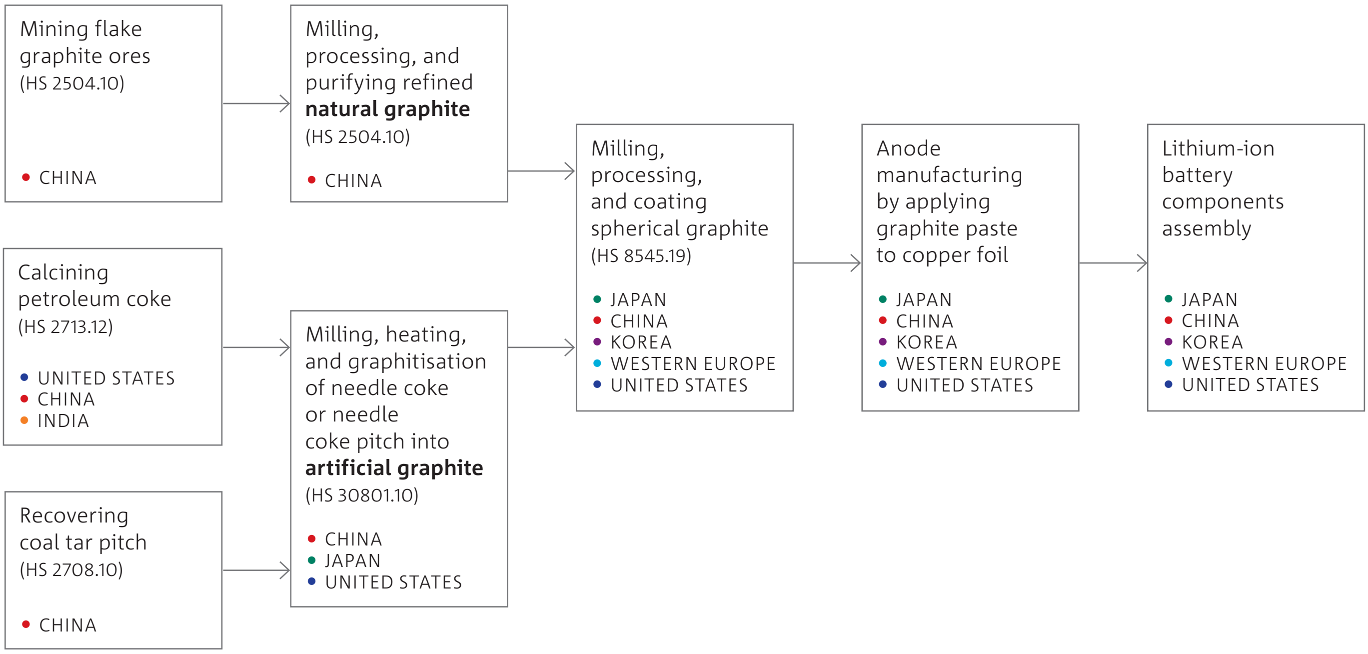

Figure 4. Graphite processing flow chart from extraction to battery assembly and associated countries [8].

1.1.1 Forecasted graphite supply chain for batteries

The Modelling, Mapping, and Analysis Consortium (MMAC), which engages academic experts, industry sector, and research organisations for data collection and study, conducted a detailed analysis of the US lithium-ion (Li-ion) battery supply chain to evaluate its readiness for meeting projected demand by 2030, with a focus on vehicle and stationary storage applications. The study found that over 2,700 GWh of new Li-ion batteries will be required, with significantly higher demand for key materials like graphite, lithium, nickel, and cobalt compared to available domestic supply. While infrastructure investments and US Department of Energy (DOE) initiatives are strengthening the domestic supply chain, lack of processing and refining capabilities, and skilled workforce remain critical challenges. Graphite anode, which is essential for the leading battery chemistries (i.e., NMC and LFP), and is also needed for silicon-based anodes, is projected to make up almost 95% of the US battery market [9].

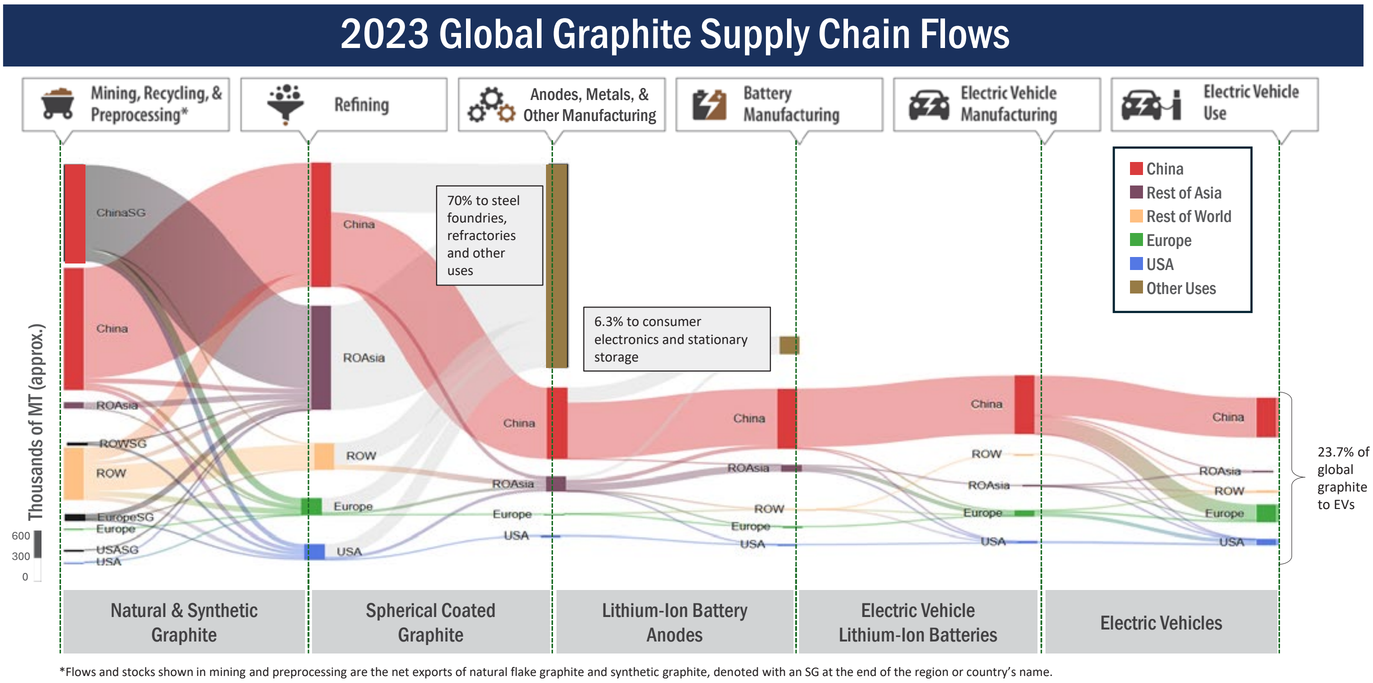

Figure 5. Sankey diagram for graphite. Source: V. Putsche, M. Mann, J. Pattany, National Renewable Energy Laboratory Analysis, 2024.

Despite moderate improvements in supply chain readiness by 2030, the availability of graphite remains a key concern. The MMAC analysis highlights that China is expected to strengthen its dominance in graphite production, particularly for natural graphite, which could enhance the risk of an unsustainable and less diverse supply chain. While the availability of synthetic graphite may increase, it is unlikely to offset the shortfall in natural graphite, due to China's export controls and increased demand.

Based on the recent DOE report, published in January 2025 [4], graphite sourcing remains a critical risk due to the significant market concentration in China, particularly for graphite processing and anode materials production. US investments are diversifying the production however competition remains intense, with China controlling a substantial share of critical segments of the battery supply chain, including graphite. See Figure 6, in which the NMC battery value chain is shown as an example.

In response to these vulnerabilities, the US has recently implemented new trade measures; in July 2025, a 160% effective tariff was imposed on Chinese AAM (with older tariffs also remaining in place). This aims to disrupt control over more than 90% of global AAM production and open opportunities for alternate supply chains [10].

For Australia, these developments present both a challenge and a strategic opportunity. As a major global supplier of raw materials for energy technologies, Australia is well-positioned to support diversification efforts. Syrah Resources, which operates the Balama mine in Mozambique and a downstream processing facility in Louisiana, US, is an example of an Australian-owned firm is providing an alternate supply chain. As trade tensions reshape global supply chains, Australian producers could look to expand their footprint in the US, Japanese, and Korean markets, particularly if they meet purity and performance standards required by battery manufacturers [11].

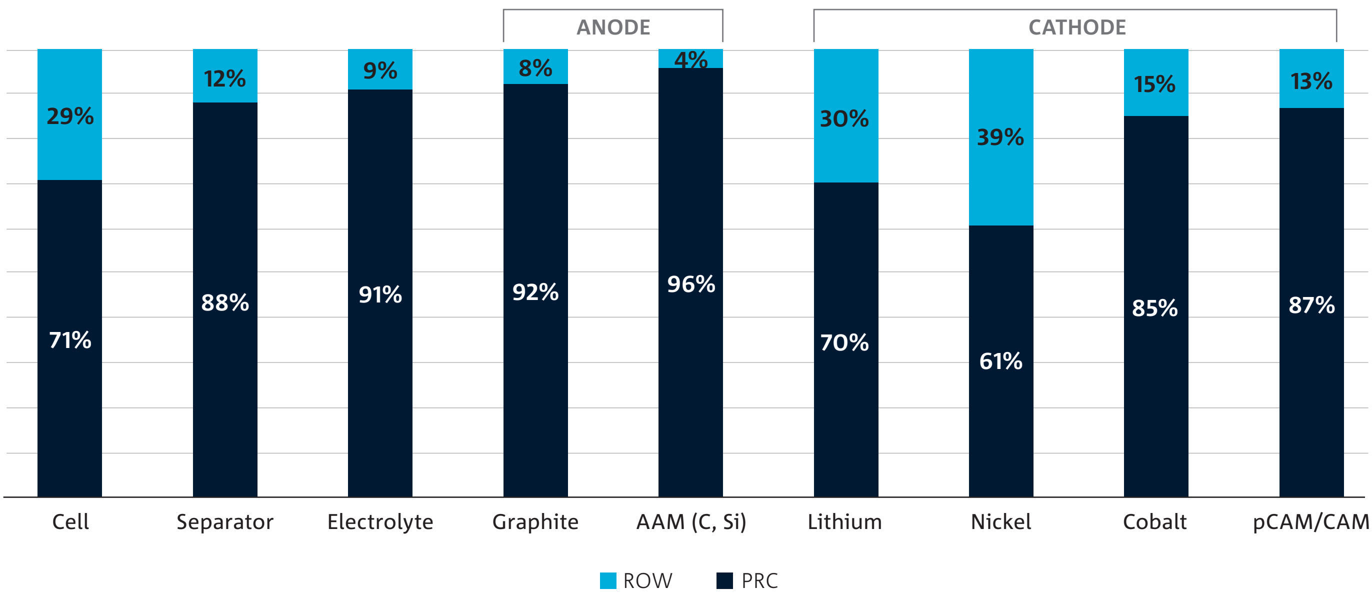

Figure 6. China market share across NMC battery supply chain, % of global production capacity, 2024E [4].

2 Australia’s natural graphite resources

Australia hosts significant geological endowment of natural flake graphite deposits and resources. Natural graphite resources in Australia are predominantly located in South Australia, Western Australia, and Queensland, although a recent discovery in the Northern Territory is expected to add to the resource base. According to Australia’s Identified Mineral Resources 2024 (AIMR) [3], as of 31 December 2023, Australia ranked 8th globally for Economic Demonstrated Resources (EDR), making up a share of 4% of world resources. This equates to a total graphite resource of 26.9 million tonnes (Mt). Of this, Geoscience Australia considers 10.8 Mt as EDR. EDR predominantly comprise Ore Reserves and most Measured and Indicated Mineral Resources that have been reported in accordance with the Joint Ore Reserves Committee (JORC) Code to the Australian Securities Exchange (ASX). It is noted that all the known graphite reserves in Australia have been reported as inclusive of measured and indicated resources. In addition, some reserves and resources have been reported using other reporting codes to foreign stock exchanges and Geoscience Australia may hold confidential data for some commodities.

The table below contains a summary of Australian graphite resources [12], reserves and production in Australia, from Australia’s Identified Mineral Resources 2024 [13].

Table 1. Australian Identified Mineral Resources 2024

INDUSTRY CLASSIFIED RESOURCES	TONNAGE (Mt)
Production	0
Proved ore reserves	1.5
Probable ore reserves	3.9
Measured mineral resources	1.8
Indicated mineral resources	9.0
Inferred mineral resources	10.7
Total mineral resources (inclusive of ore reserves)	**26.9**

It is noted that several graphite maiden resources were announced in 2024 and 2025 and are likely to increase Australia’s share of global resources and world ranking in the coming years. These are expected to be included in future releases of AIMR, which is an annual publication. There is no current Australian production of graphite, with the most recent production from the Uley 1 mine in 2017. However, there are some projects that are advancing towards production including Siviour, Uley 2 and Munglinup, though it is noted that they are in different stages of development.

A map of graphite resources in Australia displaying size ranges of the deposits (deposit size is based on total resources), as of 31 December 2023, is shown below. The data behind this map, including resource size ranges for each of the graphite deposits, can be found as part of the Australia's Identified Mineral Resources 2024 Dataset [13] under the graphite tab. Additional points have been added to the map to include the recently announced resource at Leliyn in the Northern Territory, and graphite occurrences from Western Australia (Minedex), Queensland (MinOcc), and South Australia (SARIG) that do not yet have an announced resource. References and links to national and state databases for graphite mines, deposits and occurrences are listed in Appendix A.1.

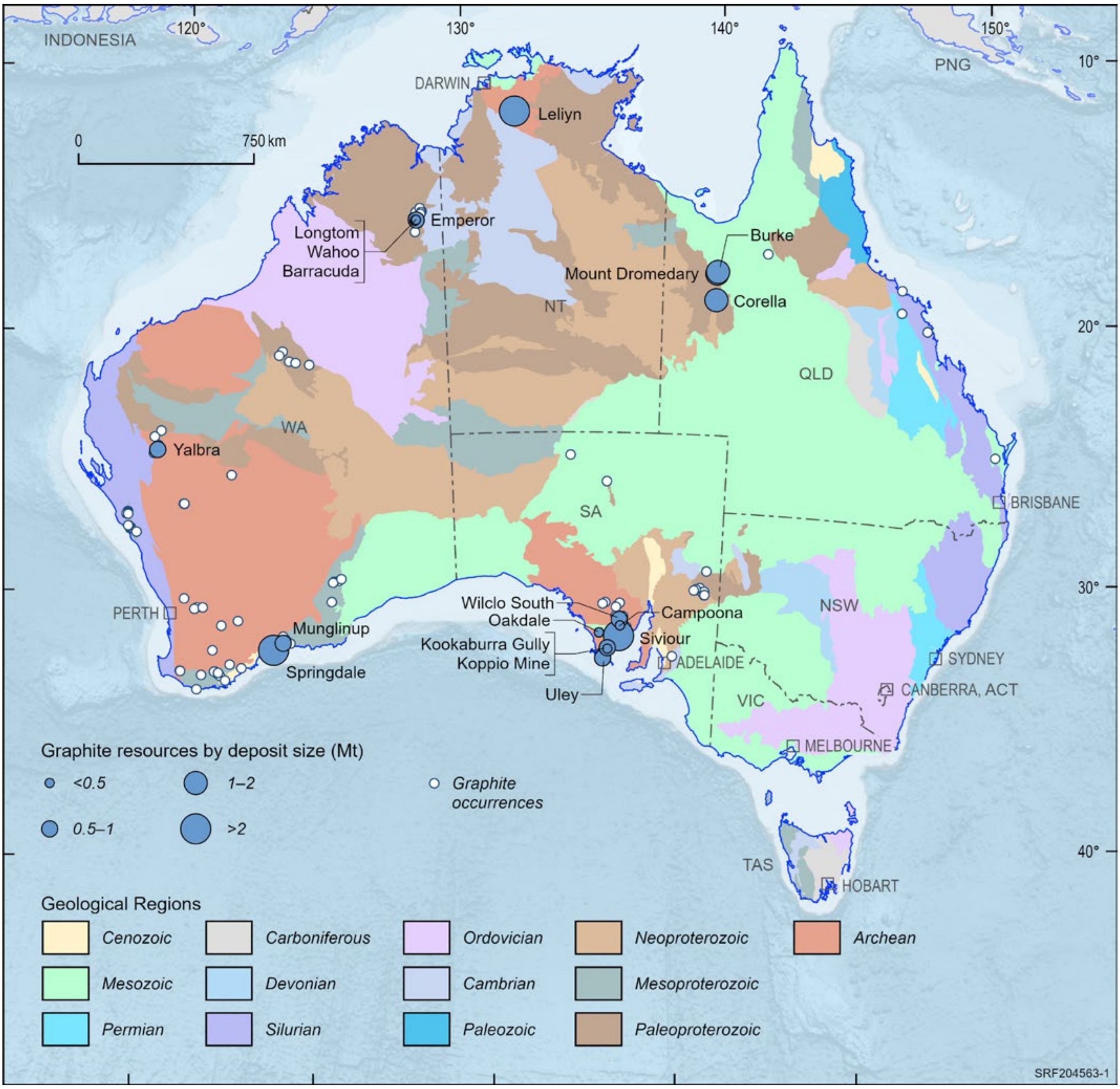

Figure 7. Map of the graphite resources major graphite resources (blue circles) and notable graphite occurrences (small white circles) relative to geological regions of Australia, modified from Australia's Identified Mineral Resources 2024.

2.1 Understanding graphite mineralogy

Characterisation of natural graphite mineralisation assists in understanding of deposit formation, ore variability and potential effects on processing, beneficiation and end-use performance. Furthermore, characterisation of key parameters such as flake size distribution, texture, crystallinity and mineralogical associations can aid development of mining and processing workflows to improve the mine's economic viability [14].

Reflecting variation in the geological settings and conditions at which the graphite formed, economic natural graphite deposits fall into three main categories [15]:

- crystalline flake graphite – used in batteries, refractories and flame retardants
- microcrystalline (amorphous) – used for lubricants, steel recarburiser, pencils
- vein graphite, also known as lump and chip – used in carbon brushes, brake linings.

The three types are distinguished by physical characteristics, such as crystallinity and distribution of the graphite within a deposit, which are related to different geological origins [15]. Natural graphite occurs as the result of either regional or contact metamorphism of sedimentary rocks containing organic carbon material, or, alternatively, by precipitation from CO_2-rich fluids or melts [16,17]. Fluids are derived from metamorphic or metasomatic processes with graphite precipitation associated with changes in fluid chemistry or temperature.

Crystalline flake graphite deposits originate from carbonaceous sedimentary rocks that have undergone high-grade, upper amphibolite to granulite facies metamorphism, associated with temperatures over 500–700 °C and pressures over 5 kbar [18]. Flake graphite is hosted in a wide variety of host formations, including metamorphosed sedimentary rocks, such as quartz-mica schist, marble, feldspathic or micaceous quartzite, paragneiss and iron formations. Within these deposits, flake graphite is present as disseminated, flat or platy crystals and flaky morphology, regardless of size, concentrated in stratabound, tabular or lens-shaped ore bodies. Graphite content in the host rocks commonly sits around 10–15%, although it can vary locally between 2 and 90%. Common impurities include quartz, mica, feldspar, garnet, and calcite, with minor magnetite and pyrite, amongst others, with potential byproducts including Ti, Ge and Ga [19].

For commercial purposes, flake graphite crystal sizes are grouped into the following ranges:

- coarse flake 150–850 µm
- medium flake 100–150 µm
- fine flake 75–100 µm
- powder <75 µm.

In contrast to flake graphite, microcrystalline graphite deposits are associated with sub-greenschist to greenschist facies contact metamorphism. The microcrystalline graphite deposits are predominantly formed through contact or regional metamorphism of anthracitic coal seams [20]. Whilst amorphous to the eye, it has a micro- or cryptocrystalline structure visible under optical and electron microscopes. Microcrystalline graphite has a soft, black friable texture and a crystal size finer than 40 µm. It occurs in massive form and frequently has high levels of impurities.

Graphite that occurs in fractures or veins is characterised by aggregates of microcrystalline to coarse, platy to needle-like graphite crystals, interpreted as hydrothermal in origin. These deposits are commonly structurally controlled, with carbon transported in CO_2- and CH_4-rich fluids derived from magmas that had assimilated organic-rich metasedimentary rocks [18]. The resulting precipitated graphite is characterised by high purity and crystallinity. Veins range in size from 1 cm to 1 m thick and are hosted in igneous rocks and amphibolite to granulite facies metasedimentary rocks, gneiss, schist, quartzite and marble. Locally, the massive aggregates can be associated with commercial contained graphite of 75 to 85%.

Each of the three types of graphite deposits is found within Australia. In South Australia, the 75 graphite occurrences include flake, vein and microcrystalline varieties, including the graphite district of the Eyre Peninsula, which is dominated by flake graphite. Of the 3.6 Mt of contained total graphitic carbon in Western Australia, the majority of occurrences are flake or microcrystalline varieties with minor vein-hosted deposits. The graphite deposits in Queensland and the Northern Territory are predominantly flake variety.

2.2 How do we discover more graphite in Australia?

In general, exploration proceeds by first locating geological characteristics (e.g., geological architecture, metamorphic grade, faults, lithology) that are associated with the mineral system that created the deposit. This exercise is typically guided by field mapping and airborne geophysical surveys. As prospective areas emerge, higher resolution data is required, such as airborne or ground-based electrical geophysical surveys, drilling and surface sampling. In the case of microcrystalline graphite, coal occurrences may be used as an indicator. Graphite flakes may be present in stream sediment sampling. Co-occurrence with vanadium and uranium has been reported [20,21].

The unique petrophysical and chemical properties of graphite ore render it well-suited to geophysics-based exploration techniques, as it is commonly more conductive than its host rock, with corresponding low magnetic susceptibility [22]. Key datasets to support graphite exploration in Australia include a national map of metamorphism, and cost-effective datasets that support the mapping of electrical conductivity such as airborne electromagnetics and magnetic survey. Progress towards completion of these datasets nationally will form part of Geoscience Australia's work program over the next decade as part of the Resourcing Australia's Prosperity initiative [23]. Currently, the AusAEM [24] airborne electromagnetic coverage in Australia covers approximately two-thirds of the continent at a nominal flight line spacing of 20 km and shows depth slices of electrical conductivity down to several hundred meters. This work program also includes Geoscience Australia delivering an integrated assessment of Australia's graphite potential, which is likely to include the use of AI to predictively model its prospectivity nationally.

Regional exploration for graphite targeting commonly employs airborne time-domain electromagnetics and TEMPEST AEM data, whilst prospect-scale target refinement includes higher resolution electrical methods, such as resistivity and induced polarisation. Geophysical workflows can be specifically tailored for graphite exploration, as demonstrated in resource-rich regions such as the Eyre Peninsula of South Australia [25]. This workflow can delineate the orientation of mineralised zones, including the dip and continuation of conductive layers in the subsurface.

The use of artificial intelligence (AI) is likely to increase in the near future. AI methodologies consist of data science, machine learning and optimal decision-making concerning data acquisition. Ensemble machine learning approaches are well established for mineral prospectivity mapping and well demonstrated at a regional scale [26]. At a camp scale, AI has been shown to accelerate resource assessment though sequential optimised drilling campaigns [27] that cut costs possibly up to 10-fold. In sparse data environments, including those with an absence of known deposits, data scientific methods that help geoscientists interpret large volumes of data equally apply to graphite exploration. Field exploration is now more commonly assisted by machine learning methods, accelerating the field campaigns [28]. Other forms of improvement include the advancement of geophysical inversion and inference techniques [29]. Computational challenges could also be addressed using machine learning that reply to forward modelling of EM surveys.

3 Where are the opportunities for Australia from here?

3.1 Downstream processing

The largest growing end-use for graphite concentrate is high-value anode material for batteries. Currently, China dominates downstream processing, producing 95% of the global supply of anode material. This concentration presents risks to the security and stability of the graphite supply chain, and conversely presents an opportunity for scaling up processing in other countries.

Graphite anode materials command significantly higher prices (approximately USD7000/t) compared to graphite concentrate (USD700/t). While the production of one ton of anode material requires roughly two tons of graphite concentrate, the significant price differential between graphite concentrate and anode materials indicates substantial value addition in downstream processing. This presents an economic opportunity for nations to enhance their domestic manufacturing capabilities and reduce reliance on external suppliers.

Economics of processing

Natural graphite

Feasibility studies of graphite mining projects from 2014–2024 indicate an average operating cost of USD550/t for graphite mining, with an average long-term price assumption of USD 1300/t. Initial capital costs for these projects average USD2200 per tonne of capacity. In Southern Australia, Renascor's mining and mineral processing plant has an average OPEX of USD 472/t of concentrate, with an initial CAPEX of USD 145M for 75000tpa capacity [30].

In terms of downstream processing, Renascor's study for the Siviour plant in Southern Australia calculates an operating cost of USD 1782/t for producing purified spherical graphite (PSG) using acid-alkali roasting, with a capital cost of USD 256 million for a 50kt plant. The Siviour PSG Facility process does not include carbon coating.

Typical CAPEX for coated spherical purified graphite (CSPG) production in Western countries is approximately USD 10,000/tonne capacity, with an OPEX of about USD 3000/t (including graphite concentrate). Factoring in a 15% IRR over 10 years, the average production cost is approximately USD 6000/t [31].

Production costs in China are estimated to be closer to USD 4000/t due to lower CAPEX, as evidenced by the feasibility study of Falcon's plant in Morocco which uses Chinese equipment [32].

Vertical integration could help produce high-value material at lower cost. Renascor's feasibility study for its purification plant assumes a graphite concentrate cost of USD405/t, and Syrah's Vidalia plant assumes a cost of sourcing graphite from their Balama mine at USD425/t. By integrating vertically, these plants could leverage significant savings as the market price of graphite concentrate is USD700/t. Moreover, over 50% of natural graphite is lost as fines during spheroidisation. Vertical integration can improve yields by ensuring feedstock consistency, thereby reducing waste and costs [32].

High CAPEX and challenging market conditions present risks for downstream processing. Downstream processing requires substantial capital investment due to technical complexity. On a per tonne of CSPG basis, the costs of downstream processing are much larger than the costs for mining and mineral concentrating. The geological advantages of high-grade Western deposits would make them more cost effective compared with China (on mining costs), however, cost related to graphite processing would likely be more challenging without significant innovation. Moreover, anode material prices have declined (from over USD9,000/t in 2022 to under USD7000/t in 2024), making economic competition difficult. Finally, the decreasing price of synthetic graphite pose a significant threat to the natural graphite market. A surplus of cheap synthetic graphite could reduce the market size for CSPG [32].

Synthetic graphite

Synthetic graphite prices range from USD 3000–7000/t depending on the material quality, end-use application, and production process. The largest drivers of cost for the production of synthetic graphite are petroleum coke feedstocks and consumables like graphite crucibles, electricity used for graphitisation, and high capital costs to construct plants with large furnaces. Techno-economic analysis shows that costs to make high-grade synthetic graphite in China are around USD5500/t which is less than half the costs of developed country producers [31].

The capital investment to produce synthetic anode material is larger than CPSG production- announced projects in the US have a capital intensity of >USD20,000/t [33,34]. While the decision to use natural vs synthetic graphite is highly dynamic and depends on the preferences of the battery manufacturers, there has been a trend towards increasing synthetic graphite usage. Synthetic graphite production can be tailored to meet specific quality requirements, and falling costs in China have driven substitution towards synthetic graphite. While high-grade synthetic graphite is still more expensive than natural, the price difference has reduced to <USD1000/t, although it was ~USD3000/t in 2022. When comparing production costs in developed countries, it is likely that natural graphite production would be relatively cheaper due to lower energy and consumables requirements. Consumers prioritising resilient supply chains may choose to increase the share of natural graphite in anodes for cost reasons [35].

3.2 Why is this important?

With growing demand for batteries in a range of different applications, with over 80 % of that demand anticipated for electric vehicles, there is increasing pressure on the global battery active materials supply chain. The US is forecast to have over 1,200 GWh of battery production capacity by 2030 [36], most of which is targeted to electric vehicles, marking a significant demand driver for graphite production. Graphite makes up between 25–30% of the materials found in a lithium-ion battery, and a diversity of suppliers is required to ensure robust and secure supply chain to meet this need.

Synthetic graphite is preferred in electric vehicle applications due to the high specific capacity, reversibility and uniformity of the material whilst having a large carbon footprint due to the energy and carbon intensity of the processing of this material. Natural graphite has, in some instances, lower specific capacity and energy density, but a significantly lower energy and carbon footprint as graphitisation has occurred in the earth.

Australia has identified substantial resources of natural graphite that could meet some of the global demand, not only as part of a domestic battery production sector, but also as a secure and stable export product. To date, Australia does not produce any battery grade PSG for use domestically or for export.

3.2.1 Possible options for Australia

Efforts to better characterise Australia's graphite deposits would enable a more detailed understanding of the size and key ore parameters and variability of identified reserves. Further, expanding the coverage and resolution of airborne electromagnetic surveys, enhancing vectoring techniques, and deploying the use of tools such as Artificial Intelligence and Machine Learning could be used to identify new graphite deposits, enhancing the success rate of explorers within Australia. Similarly, these tools could be brought to bear on the currently identified resources to determine whether they are properly described for mining. By expanding the number of identified reserves, Australia could help build a sustainable, long-term industry.

Drilling down further, a deeper understanding of the type of ore bodies being identified and whether they are truly suitable for battery applications would be beneficial. A critical downstream step in producing battery-grade graphite is the spheronisation of flake graphite. Smaller flake sizes, < 30 micron, are preferred as this removes the need to mill the particles prior to spheronisation. Milling would require a significant CAPEX investment, energy demand and can lead to a greater dispersity of flake particle sizes and, more concerningly, can reduce the degree of graphitisation and impact the specific capacity of the material [37]. Through pre-mining micro-characterisation and improved resource modelling, the development and mining of deposits with flake sizes in the prescribed range could be prioritised, thereby reducing processing costs and improving the utility, output, and profitability of an ore body. Awareness of the characteristics and variety of graphite deposits in Australia, would also ensures that the nation could maintain agility in a graphite-constrained global scenario.

Research, development and deployment (RD&D) and innovation in processing and manufacturing will be key elements to Australia being able to pursue the opportunities described here. It would not be enough to utilise graphite production or processing technologies developed elsewhere, and it is even questionable if they would be accessible based on recent export controls. Consequently, Australia could consider investment in RD&D activities that would improve the yield and efficiency of mine operations, and in natural graphite processing particularly through spheronisation and final-step purification, which would reduce in waste both from processing methodologies and valorisation of the 'out-of-spec' graphite. These actions would help improve both the competitiveness and economics of graphite industry in Australia.

The use of renewable energy for the processing of natural graphite is another important aspect of the processing problem. Several publications indicate that spheronisation and, carbon coating stages require significant amount of energy. Sweden's electricity system is heavily based on renewable energy, with hydropower contributing approximately 45% of total electricity generation. This abundant and consistent source of low-emission electricity plays a key role in keeping electricity prices low, particularly for industrial users [38,39]. Australia, with its current roll out of renewable energy, could utilise technologies such as solar, wind, battery and thermal storage to drive down the cost of energy for graphite processing and deliver 'emissions free' graphite.

As batteries reach end of life, there is a need to consider effective and efficient methods for the recovery of the materials inside the cells. Typically, there are three ways to recycle a battery: (1) shred the battery and recover the metals via a pyrometallurgical technique; (2) shred the battery and recover the materials using a hydrometallurgy process; (3) deconstruct the battery, put new electrolyte in the cell and re-seal it. Pathway (1) does not recover the graphite as the pyrometallurgical process combusts graphite. Pathway (2) may allow the recovery of graphite, through flotation (the beneficiation processes that is applied to graphite ore to produce a graphite concentrate of approximately >95 % total graphite content). While pathway (3) has been described by a number of researchers, major engineering challenges still exist due to the complexity of how batteries are fabricated, particularly those comprised of cylindrical cells, [40,41].

To support miners who have ambitions to expand beyond mining to processing and manufacturing, establishing common user facilities could be considered to undertake routine activities that do not inhibit the ability of developed IP protection by relevant industries. Common user facilities where equipment and or expertise could be accessed for analytical and / or electrochemical characterisation as described by a suite of defined tests (i.e. minerology, impurity analysis, electrochemical testing) would help support miners in validating their materials, help reduce costs associated with these tests, and help support them through the qualification process with battery cell manufacturers.

3.2.2 How could this be achieved

The National Battery Strategy has established a clear vision for Australia to become a globally competitive producer for battery active materials by 2035, through upgrading raw materials into high-value battery components for global export. Natural Graphite would be a key element to achieving this goal, considering the forecast future demands for this material. The Australian Government has a number of other strategies to support this ambition, including:

- Future Made in Australia
- Critical Minerals Strategy
- Battery Breakthrough Initiative.

In addition, CSIRO has undertaken early-stage graphite research activities with Australian companies and entities with the financial support of the Australian Government.

Partnerships with the US

Australia and the United States are actively strengthening collaboration to advance graphite and broader critical mineral supply chains, with a particular focus on battery technologies and national security. This is driven by a shared desire to diversify global supply chains, and is aligned with bilateral frameworks such as the California–Australia Memorandum of Understanding (MOU) on climate and clean energy (2022). The US Executive Order titled 'Immediate Measures to Increase American Mineral Production' (March 2025) focuses on accelerating domestic production of critical minerals, streamline permitting, and reducing reliance on foreign sources.

Recent collaborative activities between Australian and US entities in this area include:

- A 2-week study tour in Western Australia including Stanford researchers (amongst other global partners, August 2025).
- CSIRO-Stanford Workshop on Exploration, Processing and Learning for ORE Resources using Intelligent Agents (EXPLORE-IA, August 2024).
- Participation in Stanford's STEER (Strategic Technology Evaluation for Energy Resources) workshops to engage with academic and industry participants (2024).
- Contracting with the University of Chicago regarding: Physical Stocks and Flows Framework on sodium-ion battery development (in development).

A strategic researcher exchange program with Stanford University (under development) focused on critical minerals, batteries and grid.

4 Summary

Core conclusions

Australia has a significant opportunity to develop a robust graphite supply chain to help meet the growing demand for battery materials. Actions and strategic collaboration with advanced industry would help to capitalise on this opportunity, supporting a stable and sustainable supply chain. The development of this supply chain would assist to support the EV market and enhance energy security.

The following opportunities are supported by analysis of Australia's graphite resources described in section 2 of this report, market dynamics, and processing capabilities. Advanced characterisation using integrated microanalytical techniques, AI and machine learning, improving processing techniques, and utilising renewable energy would help to enhance the quality and efficiency of battery-grade graphite production. This report highlights the economic potential of downstream processing and the importance of diversifying global supply chains particularly for anode materials.

Areas that could be considered for support

1. **Improved characterisation of graphite deposits**: Early stage microanalytical characterisation of natural graphite occurrences would help understand ore variability and potential effects on processing, beneficiation and end-use performance.
2. **Enhanced greenfield and brownfield graphite exploration**: Employing AI and machine learning would help to better understand and identify new and existing graphite deposits. This would help build a sustainable, long-term graphite industry in Australia.
3. **Enhanced processing**: Focusing on spheronisation and purification techniques would help produce high-quality battery-grade graphite. This could include seeking deposits with flake sizes that reduce processing costs and improve utility.
4. **Vertical integration**: Integrating mining, processing, and manufacturing operations would help reduce costs and improve yields. This would ensure feedstock consistency and reduces waste.
5. **Renewable energy**: Using renewable energy sources would help lower the carbon footprint and production costs of graphite processing. This could help to position Australian graphite to be more competitive in the global market.
6. **Recycling innovations**: Developing efficient recycling methods for end-of-life batteries would help recover valuable materials. This could include exploring hydrometallurgy processes that are amenable to recovering graphite.

Future implications

Without a coordinated approach to graphite production, Australia could miss significant economic opportunities in critical battery materials market share. Proposed options would help to address the stability and security of the supply chain, stimulating the growth of the EV market and broader economic development. Strategic actions to secure a national and sustainable graphite supply chain would position Australia as a key player in the global battery materials market.

By focusing on advanced characterisation, processing improvements, vertical integration, renewable energy utilisation, and efficient recycling methods, Australia could help ensure a stable and sustainable supply chain. Collaboration with countries with advanced battery industry, such as the US, could further enhance these efforts, providing mutual benefits and strengthening the global battery materials market.

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A.1 Australian national and state databases for graphite mines, deposits and occurrences

JURISDICTION	CONTACT	DATABASE NAME	UNIQUE ID	SOURCE	METADATA
Australia	Geoscience Australia	Mineral Resources and Reserves		https://services.ga.gov.au/gis/earthresource/wfs?request=GetFeature&service=WFS&version=1.1.0&typeName=erl:CommodityResourceView&outputFormat=csv	https://portal.ga.gov.au/metadata/6d263a31-5710-4223-8371-69cacc5c287b
Australia	Geoscience Australia	Mineral Occurrences		https://services.ga.gov.au/gis/earthresource/wfs?request=GetFeature&service=WFS&version=1.1.0&typeName=ama:MineralOccurrences&outputFormat=csv	https://portal.ga.gov.au/metadata/99edc585-9adf-4475-98bd-9cc86dea849c
Western Australia	Department of Energy, Mines, Industry Regulation and Safety – Geological Survey and Resource Strategy Division	MINEDEX Database	ANZWA1220000513	https://dasc.dmirs.wa.gov.au	https://warsydprdstadasc.blob.core.windows.net/downloads/Metadata_Statements/XML/MINEDEX_Database_GDA2020.xml?ts=20241212121210
South Australia	Department for Energy and Mining, Customer Services	Graphite mines and mineral deposits	mesac445	https://pid.sarig.sa.gov.au/dataset/mesac445	https://catalog.sarig.sa.gov.au/geonetwork/srv/api/records/5facd4c3-a0ec-4541-a29b-86c20988ffaf/formatters/xml
Northern Territory	Department of Industry, Tourism and Trade, Northern Territory Government	Northern Territory Mineral Occurrences	FA9776DB9DFB9746E040CD9B2144298B	https://strike.nt.gov.au/wss.html	http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=FA9776DB9DFB9746E040CD9B2144298B
Northern Territory	Department of Industry, Tourism and Trade, Northern territory Government	Northern Territory Mines	FA9808BABD9D2375E040CD9B21442B6C	https://strike.nt.gov.au/wss.html	http://www.ntlis.nt.gov.au/metadata/export_data?type=html&metadata_id=FA9808BABD9D2375E040CD9B21442B6C
Queensland	Geological Survey of Queensland, Queensland Government	Mines and mineral resource (MINOCC)	DS000004	https://geoscience.data.qld.gov.au/data/dataset/ds000004	
New South Wales	Geological Survey of New South Wales			https://minview.geoscience.nsw.gov.au/#/?lon=148.5&lat=-32.5&z=7&l=ms0:y:100	https://geonetwork.geoscience.nsw.gov.au/geonetwork/srv/eng/catalog.search#/metadata/0c88c49c871234ba4277f317360c6214b146f564

A.2 Australian miners active in graphite

ASX CODE	COMPANY	DEPOSIT	TOTAL MINERAL RESOURCE	TOTAL RESOURCE GRADE	CONTAINED GRAPHITE	MEASURED RESOURCE	MEASURED RESOURCE GRADE	CONTAINED GRAPHITE	INDICATED RESOURCE	INDICATED RESOURCE GRADE	CONTAINED GRAPHITE	INFERRED RESOURCE	INFERRED RESOURCE GRADE	CONTAINED GRAPHITE	
			TONNES	TGC%	TONNES	TONNES	TGC%	GRAPHITE	TONNES	TGC%	TONNES	TONNES	TGC%	TONNES	ASX SOURCE DATE
KNG	Kingsland Minerals, NT	Leliyn	194,600,000	7.3	14,200,000							194,600,000	7.3	14,200,000	ASX announcement 13 March 2024
RNU	Renascor, SA	Siviour	123,600,000	6.9	8,500,000	16,900,000	8.6	1,400,000	56,200,000	6.7	3,800,000	50,500,000	6.5	3,300,000	ASX announcement 14 Sept 2023
IG6	International Graphite Ltd, WA	Springdale	49,300,000	6.43	3,168,300				11,500,000	7.5	862,500	37,800,000	6.1	2,305,800	ASX announcement 12 Sept 2023
ITM	Itech Minerals Ltd, SA	Campoona	35,150,000	5.99	2,104,000	320,000	12.7	40,000	22,600,000	5.3	1,196,000	12,230,000	7.1	868,000	ASX announcement 1 July 2024
NVX	Novonix Ltd, QLD	Mt Dromedary	14,300,000	13.33	1,905,700	1,000,000	12.9	129,000	8,500,000	13.9	1,181,500	4,800,000	12.4	595,200	ASX announcement 20 Oct 2016
GCM	Green Critical Minerals Ltd, WA	McIntosh	30,100,000	4.4	1,320,000				19,200,000	4.44	850,000	10,900,000	4.33	470,000	ASX announcement 1 July 2024
LEL	Lithium Energy Ltd, QLD	Bourke	9,100,000	14.4	1,310,000				4,500,000	14.7	670,000	4,500,000	14.2	640,000	ASX announcement 5 April 2023
MRC	Mineral Commodities, WA	Munglinup	7,990,000	12.2	973,190				4,490,000	13.1	588,190	3,500,000	11	385,000	ASX announcement 28 Apr 2023
LML	Lincoln Minerals Ltd, SA	Kookaburra Gully	12,840,000	7.57	971,980	1,000,000	11.77	117,700	4,860,000	8.8	427,598	6,980,000	6.11	426,682	ASX announcement 16 April 2024
QGL	Quantum Graphite, SA	Uley	6,900,000	10.98	757,300	800,000	15.6	124,800	4,200,000	10.4	436,800	1,900,000	10.3	195,700	ASX announcement 14 March 2023
BUX	Buxton, WA	Graphite Bull	4,000,000	16.1	644,000							4,000,000	16.1	644,000	ASX announcement 12 October 2022
OAR	Oar Resources, SA	Oakdale	6,320,000	4.7	297,040				2,690,000	4.7	126,430	3,630,000	4.7	170,610	ASX announcement 2 Dec 2015
LEL	Lithium Energy Ltd, QLD	Corella	13,500,000	9.5	1,280,000							13,500,000	9.5	1,280,000	ASX announcement 16 June 2023
	GraphinEx, QLD	Esmerelda	434,500,000	5.8	25,350,000				173,100,000	5.8	10,110,000	261,400,000	5.8	15,240,000	

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