

STRATEGY

A S P I

AUKUS and critical minerals

Hedging Beijing's pervasive, clever and coordinated statecraft

Hydrogen

3

Li

Lithium

4

Be

Beryllium

11

Na

Sodium

12

Mg

Magnesium

19

K

Pot

20

Ca

Calcium

21

Sc

Scandium

22

Ti

Titanium

Ben Halton and Kim Beazley

A S P I

AUSTRALIAN
STRATEGIC
POLICY
INSTITUTE

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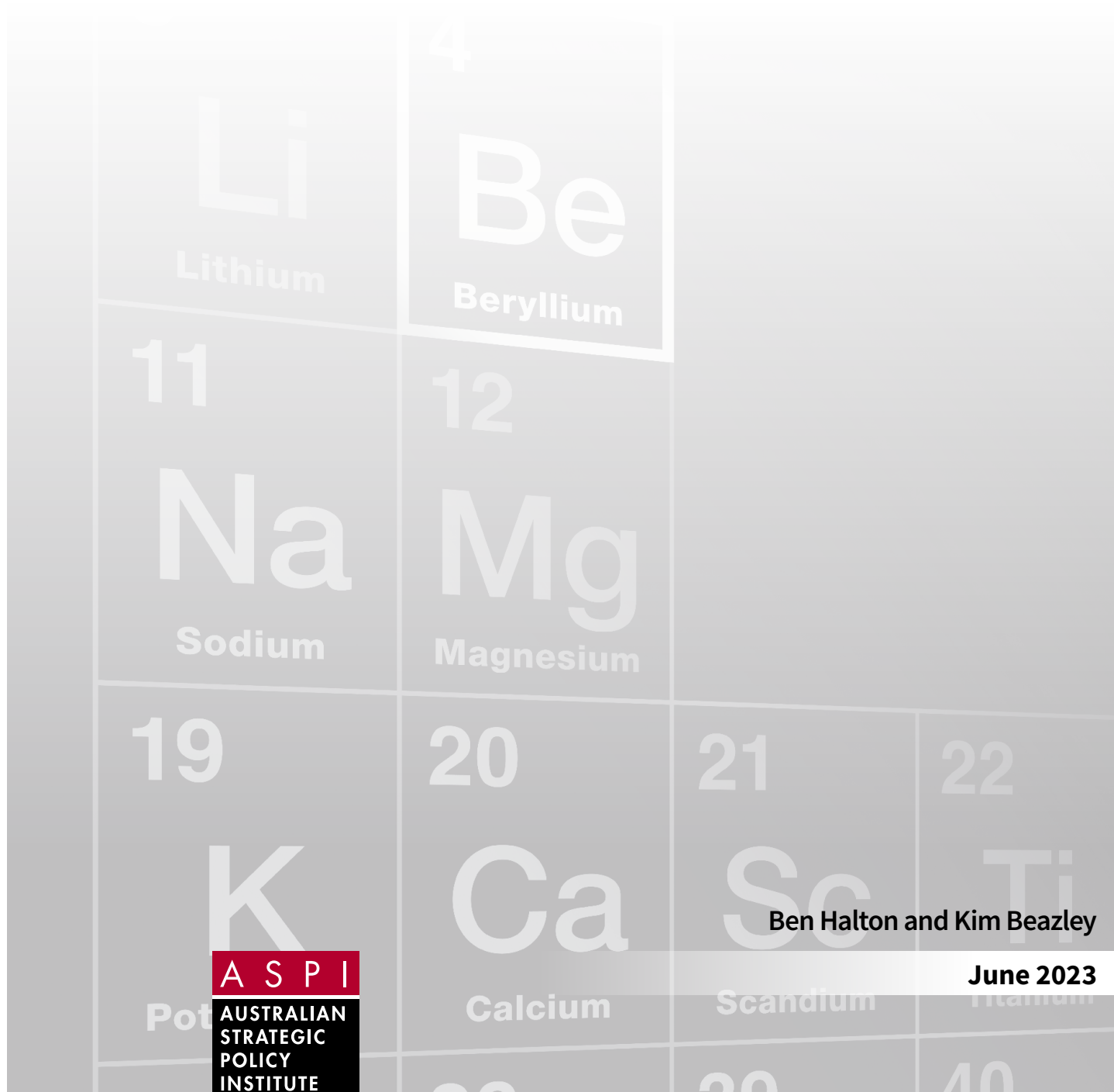
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For the want of a nail the shoe was lost. For the want of a shoe the horse was lost. For the want of a horse the rider was lost. For the want of a rider the battle was lost. For the want of a battle the kingdom was lost - and all for the want of a horseshoe nail.

- Benjamin Franklin

Executive summary

AUKUS is a trilateral security partnership between Australia, the UK and the US. The three partners have many friends with various understandings and priorities. AUKUS, however, presents the opportunity for disciplined focus. The three AUKUS partners know each other well and have a long history of interaction on security matters, including in research and production.

AUKUS has a heavy focus on R&D of military capabilities. A number of departments, including defence, foreign affairs and prime ministerial equivalents are engaged. The science and technology to deliver those capabilities must resolve issues of insecure supply chains. Currently, supply chains for processed critical minerals and their resulting materials aren't specifically included.

Yet all AUKUS capabilities, and the rules-based order that they uphold, depend heavily on critical minerals.¹ China eclipses not only AUKUS for processing those minerals into usable forms, but the rest of the world combined. Without critical minerals, states are open to economic coercion in various technological industries, and defence manufacturing is particularly exposed to unnecessary supply-chain challenges.

This is where Australia comes in. Australia has the essential minerals, which are more readily exploitable because they're located in less densely populated or ecologically sensitive areas. Australia also has the right expertise, including universities offering the appropriate advanced geoscience degrees, as well as advanced infrastructure, world-class resources technology and deep industry connections with Asia and Africa, which are also vital global sources of critical minerals.

The problem that's held us back is in developing the right approach. This issue can only be dealt with strategically, not commercially. We haven't done this since World War II. We didn't need to in the Cold War because the AUKUS nations had negligible dependence on the Soviet Union. Now the international environment is becoming more contested. More states will adopt economic statecraft as a lever in competition. Furthermore, modern weapons systems (as well as vital green technologies) are more dependent on critical minerals than those in service during the Cold War, and current supply chains are beholden to processing in China.

The challenge lies in the need to diversify from China. The many attributes of China's dominance in critical minerals include complex and carefully guarded processing capabilities that make critical minerals usable. That extends to the manufacturing of essential inputs to technologies such as rare-earth permanent magnets, which enable technologies such as leading-edge missile guidance, satellites and aircraft. All of that's backed up by strong investment in top-quality research, so that China's universities and national labs now lead the world in the publication of high-impact research on critical-minerals extraction and processing, highlighting their continued efforts to innovate and achieve technological breakthroughs in the critical-minerals space.²

Problems are compounded by the unprofitability of much of the critical-mineral markets. China's enormous economies of scale, including through the state amalgamation of companies, is remarkable. Beijing has merged 150 private companies into six state-owned enterprises in the rare-earths sector alone.³ While Beijing's subsidies keep prices low, they also maintain its vast influence over market prices, which disrupts the viability of new entrants, upholding China's monopsony.

For instance, only one major rare-earth producer independent of China's supply chain survives to this day: Lynas Rare Earths Ltd, a public company registered in Western Australia (WA). It took 11 years for Lynas to turn a profit and enormous strategic foresight and financial support from the Japanese Government totalling hundreds of millions of dollars. Although efforts to gain independence from Chinese processors appear to be on the verge of success, the sole US mine at Mountain Pass in California still has 100% of its rare-earth mineral production processed in China.

The solution is for AUKUS and its partners to engage Australia as the spearhead of mineral diversification. Australia has a legal presence in US strategic industry arrangements. Secure access to *processed* critical minerals enables the emerging technologies that will 'win' or, better still, deter the next global war. It will also help to ensure the continuity of a global economy free from risks of statecraft. China would benefit, too, from more diverse supply, as its own requirements will grow exponentially over the coming decades.

This paper outlines why Australia offers an unrivalled rallying point to drive secure critical-mineral supply among a wide field of vested nations, using AUKUS but not limited to AUKUS partners, how WA has globally superior reserves and substantial expertise, and why northern Australia more generally has a key role to play. The paper also explains why policy action here must be prioritised by the Australian Government.

The problem and the solution

What's the problem?

Beijing's economic coercion, underwhelming global action, and haphazard domestic policy have highlighted the risk of disruption to global rare-earth and critical-mineral supply chains. China has developed a virtual monopoly over rare earths and significant control of critical-mineral supply chains and is willing to use its position of strength to access those strategically important materials.

Chinese Foreign Ministry spokesperson Zhao Lijian was right when he said: 'No one should use the economy as a political tool or weapon, destabilise the global industrial and supply chains or punch the existing world economic system.' Yet that's precisely what the Chinese Communist Party (CCP) has been doing with rare earths for over a decade.

In 2010, the CCP effectively restricted rare-earth exports to Japan after a Chinese fishing trawler collided with a Japanese coastguard vessel near the disputed Senkaku/Diaoyu Islands. More recently, it threatened to limit rare-earth supplies to US defence contractors, including Lockheed Martin, over US arms sales to Taiwan.

But the problem isn't just about economic coercion: the CCP's domestic policy has had other serious consequences for the global supply of critical minerals. In 2021, the central government began actively monitoring energy consumption across China. Later that year, Shaanxi Province fell victim to the country's 'dual control' when it failed to meet energy-consumption targets. The CCP swiftly shut down high-energy-intensity industries, including aluminium and magnesium production. An international supply crisis ensued, and prices and supply risks soared.

Beijing's coercive actions and domestic policies pose unacceptable economic and resilience risks to rare-earth and critical-mineral supply chains. Diversified supply chains are now needed to mitigate the economic and national-security risks associated with disruption.

Establishing alternative rare-earth supply chains is difficult enough. The CCP's actions, including its information campaigns targeting the West's rare-earth interests, rapidly increase the complexity of the challenge.⁴ The key strategic message here for Australia, Japan, the US and other like-minded countries is that market forces alone aren't going to fix this problem. Sovereign resilience is beyond the reach of any one country.

What's the solution?

It's a positive sign that so many like-minded countries, including Australia, aren't just identifying that there's a problem but are willing to take action. Now is the time for 'minilateralism' to take centre stage. AUKUS, as an existing minilateral partnership, is well situated to tackle critical minerals and rare earths, in concert with other relevant countries.

This paper proposes five priorities, based on AUKUS, to solve this problem:

1. Given that all AUKUS capabilities rely on critical minerals, the AUKUS countries should add critical minerals into AUKUS Pillar 2, and in doing so develop a consistent definition of critical minerals among the partners.
2. Contextualising AUKUS against that definition is necessary to prompt informed action.
3. Australia must refine its 2022 critical-minerals list to better reflect the strategic situation that we face, rather than primarily commercial factors.
4. AUKUS should be the premier minilateral mechanism for creating resilient critical-mineral supply chains for each of the partners, while working closely with friends and allies, consistent with Pillar 2's remit not being an exclusive arrangement.
5. The AUKUS partners must cast aside any reservations about working intimately with one another.

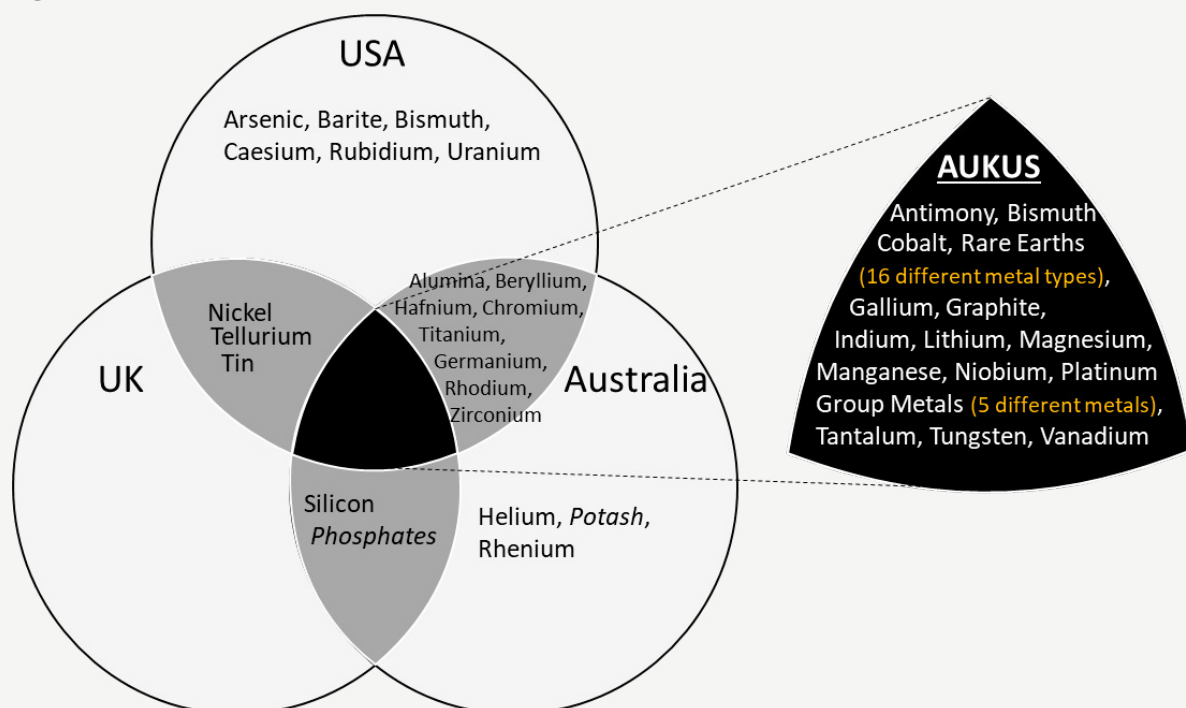
The fundamentals

First, a consistent definition of critical minerals among the AUKUS partners is essential. The US definition under US Executive Order 13817 (2017) is good.⁵ It articulates both the economic and strategic dimensions of critical minerals. Other definitions tend to underplay strategic risk and can be influenced by geological stakeholders with vital technical knowledge but who can sometimes be insufficiently attuned to geopolitics and national security. A workable definition derived from the executive order might be:

Critical minerals are metals, non-metals and minerals essential to economic and national security, the supply chain for which is vulnerable to disruption and serves an essential function in the manufacturing of products, the absence of which would have significant consequences for our economy or our national security.

Figure 1 shows the AUKUS partners' critical-mineral needs, including their overlapping needs.

Figure 1: AUKUS nations' critical-mineral needs



Notes: Australia: Few (if any) minerals seems to be based on Australia's genuine need but rather to exploit export opportunities. Phosphorous (phosphates) and potash (potassium) have been included based on previous Geoscience Australia assessments but aren't officially listed.

AUKUS: Rare earths are listed as 16 rare earths, omitting promethium. This is because, while the US now distinguishes between each of the 17 rare earths, most nations (including the UK and Australia) group those together. Promethium (produced in nuclear laboratories) is unlikely to be critical to the UK. Platinum metals are listed as five, omitting osmium. Many nations, such as Australia, also group the six platinum group metals (it's doubtful that osmium is critical to Australia).

UK: The UK defines iridium, manganese, nickel, phosphates and ruthenium as a subcategory of increasing criticality, so they're included in the diagram in the interests of simplicity.

Second, contextualising AUKUS against that definition is necessary to prompt informed action. AUKUS serves to ‘foster deeper integration of security and defense-related science, technology, industrial bases, and supply chains.’⁶ Critical minerals processed into usable forms are the bedrock of those industrial bases and supply chains.

Using substitute ‘non-critical’ minerals would deliver inferior defence capabilities—with bulkier sizes, smaller ranges, reduced speed, reduced lethality or shorter life spans—or prohibit delivery altogether. For instance, nanotechnology, which requires extraordinarily compact components with extraordinary performance, is dependent upon critical-mineral-based materials. The absence of some minerals may also reduce the option of mass military production to boutique quantities. Many non-military commercial sectors would also be untenable without critical minerals, including the automobile and clean-energy industries.⁷

Case study: Magnesium

US Geological Survey data shows that China accounts for around 90% of world magnesium production.⁸ Magnesium is the lightest of all structural metals. It’s the easiest metal to machine and has essential damping (anti-noise/vibration) qualities. It’s integral to mass industrial production. It’s also key to aluminium and titanium production, which are fundamental to defence capabilities. This includes the undersea domain, where AUKUS currently maintains a big strategic edge. Magnesium is also key to land and air platforms (both civil and defence).

Magnesium production is enormously energy intensive. In 2021, a Chinese energy directive slashed magnesium production by half in Shaanxi Province, which dominates world supply. Record magnesium prices resulted. European industry groups demanded that the European Union appeal to Beijing, issuing a joint statement that the incident ‘threatens thousands of businesses [including major car makers] across Europe, their entire supply chains and the millions of jobs that rely on them’.⁹

China’s state-run tabloid, the *Global Times*, conveyed the message that swift resolution was ‘unrealistic’ and that ‘China’s efforts to tackle these challenges at its own pace are responsible and should be respected.’¹⁰ New diversified production was prompted, including in Canada and Australia. On 1 March 2022, China removed a 15% tax on magnesium production in six provinces in order to drive new operations.¹¹ That seriously undermines the viability of non-Chinese competitors and coincides with Beijing’s world share growing by 6% in a year (up from 84%).

The US Government has no magnesium stockpile¹²—nor, it appears, do Australia or the UK. This places great faith in the free market and the means to rapidly mobilise reliable, complete, supply-chain solutions. It also undermines preparedness for major-power competition.

Mass military production wins wars. Suggestions that mass military production is less pertinent in the nuclear age are debatable: the capacity for mass production is as relevant as ever, as highlighted by Russia’s invasion of Ukraine. The emerging risk of global war aside, the war in Ukraine has at times resembled an emerging war of attrition based not on casualties, but on the ability to resupply the war fighter. Nations such as Russia, Ukraine and even the US are depleting their arsenals to various degrees¹³—remedies include mass industrial production.

*Third, Australia must refine its 2022 critical-minerals list to better reflect the strategic situation we face, rather than primarily commercial factors.*¹⁴ This means more clearly defining our own domestic needs. The US and the UK did that in 2022.¹⁵ Australia’s critical-minerals mandate remains heavily skewed by export partners’ needs.¹⁶ That clouds AUKUS collaboration and hinders definitive action. Even worse, it could undermine national resilience if Australia’s own needs are lost among a wider list of trading opportunities. Such disruption may also prove ruinous to partner supply-chain interdependencies.

Granted, Australia is more of an exporter of critical minerals than a consumer. The nation does, however, seem to depend on critical-mineral inputs that aren’t on its heavily trade-oriented list. For example, Geoscience Australia previously referenced phosphorous (phosphates) and potash as crucial domestic needs (probably for agricultural production in barren soils).

The subsequent omission of those agricultural inputs from Australia's 2019 critical-minerals list (and indeed the current list) appears short-sighted, considering Australia's ongoing dependence on foreign fertiliser supply. Forebodingly, in 2022 the international Fertilizers Price Index¹⁷ reached record highs—at one point greater than 300% higher compared to January 2021—resulting from high energy prices and the cessation of Russian, Belarusian and Chinese fertiliser exports.¹⁸

While it's fair to accept that defining a national list of critical-mineral requirements might always be contestable, and notwithstanding several promising new domestic Australian fertiliser operations now under consideration, the above case suggests an imbalance in which Australian methodology has prioritised mainstream trade benefits over national-security interests in recent years. This is consistent with the recent weighting of language in Australia's minerals policies, from which a promising but ultimately still unconvincing and somewhat confused new taxonomy has emerged.¹⁹

Fourth, AUKUS needs an inner sanctum. That means that partners outside of AUKUS are to be supported and engaged, but AUKUS countries shouldn't let that engagement distract from the centrality of the AUKUS mission. The number of bilateral and multilateral critical-mineral partnerships with other partners is alarming. Australia alone is party to at least seven such partnerships covering 10 partner nations,²⁰ including via the Quadrilateral Security Dialogue,²¹ in addition to the European Commission (another 23 nations among the 27 not already in a partnership with Australia).

Such multilateral effort within the rare-earths sector of critical minerals over many years suggests inevitable failure.²² This is due to competing interests, including geopolitical misalignment, and meeting the demands of such diverse arrangements, which draws focus and resources from governments that have only limited resources to devote to each critical technology area. For prospective companies attending to such deliberations, slow progress and bureaucratic protocol are often not enticing or conducive to tenable business propositions.²³

The common goal of security of supply is not in dispute among AUKUS and its partners. The means to that end are. This is complicated by national legislation and mandates. Then there are inconsistencies in environmental standards and policies (or no policies) on Western industry's use of minerals mined with child labour.²⁴

But nations' views on sovereign risk and securing economic value tend to be polarising. The associated risk of significant delay and failure to deliver tangible action is enormous. Increases in risk are commensurate with the number of friends in the critical-mineral equation. Defining what constitutes even a select number of partner needs is enormously complex (see Appendix 1).

Finally, the AUKUS partners must cast aside any reservations about working intimately with one another. Sensitivities abound in the realm of cutting-edge defence science and technology. Thankfully, Australia, the UK and the US are among history's closest allies. That will make the task easier. Beyond trusted intelligence-sharing networks, Australia has demonstrated more than a century of dependability with the UK and US, which are themselves intimately bound together.

Australia is far from a 'freeloader'. It's indispensable to the supply chains that underpin the trilateral bond and thus the means to secure the inputs for future defence capability. Unlike its key partners, it barely consumes critical minerals. It is, however, a vital producer.

Australia gains *comparably* very little economically in mining critical minerals,²⁵ yet its critical-mineral customers derive almost incalculable economic and strategic benefit.

The collaborative AUKUS A-game must span producing and processing critical minerals into usable forms. This includes metals and alloys, and the subsequent manufacturing of war-winning (or deterring) products such as advanced rare-earth permanent magnets. Such collaboration will help deliver synergies, secure future economies and continue to facilitate the development of defence capability superior to that of potential adversaries.

Key players

There's no shortage of nations that talk a big game on critical minerals. That partly reflects valuable contributions on offer from many nations. However, in truth, few nations are integral to secure critical mineral supply, and false claims saturate the public and government spheres. The resulting 'noise' is exacerbated by corporations and politicians seeking to appeal to misinformed investors or grow their political standing.

The value of existing and prospective critical-mineral operations is proven in nations such as Russia, the Democratic Republic of the Congo (DRC), Brazil, Chile, South Africa, Canada (for some key forms of metals production) and the US, but most other nations are insignificant players. In comparison, China and Australia are on a different level entirely in terms of strategic importance.²⁶

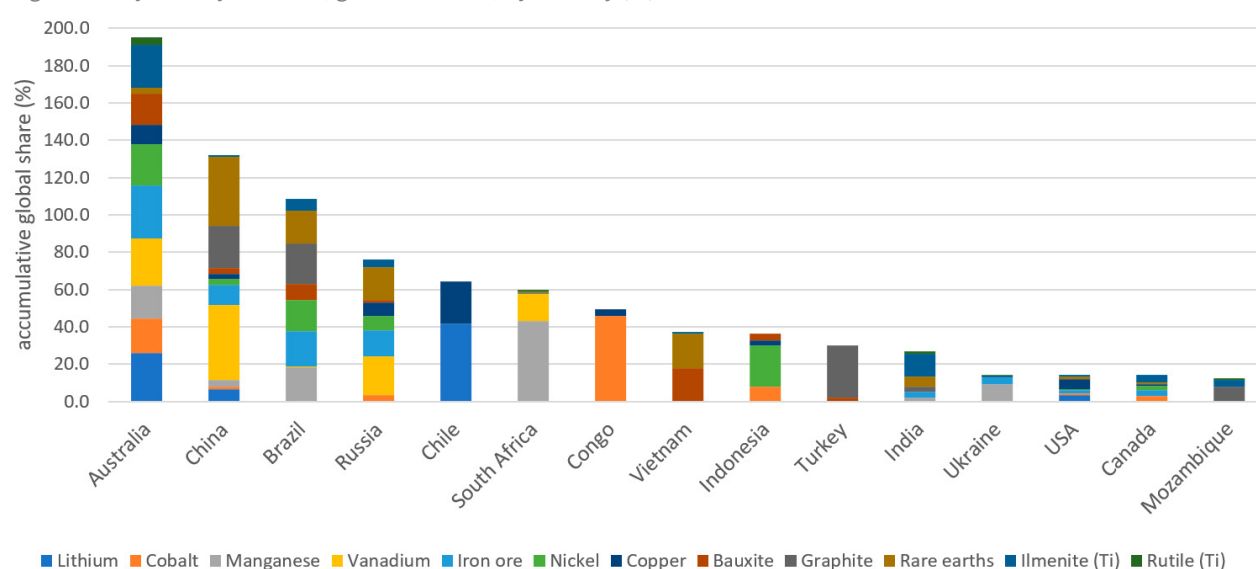
Currently, China dominates critical-mineral supply chains and has production lines that are secure from 'mine to battlefield'.²⁷ Its enormous *economic* reserves²⁸ of minerals such as rare earths and magnesium also support China's dominant position. Australia is the only nation able to challenge it, and often vastly exceed it, based on proven mineral reserves (and with considerable specialist mineral expertise).

Although even modest mineral reserves can go far in meeting more immediate demand, apparent mining 'powerhouses' such as Canada have their resources resting deep below cold, hard-to-access and environmentally fragile areas. Or as a *CBC News* fact check (which applies to most nations) notes:

Basic statistics offer something of a cold shower ... global surveys suggest Canada holds a tiny percentage of mineable worldwide reserves of critical minerals.²⁹

Conversely, based on US Geological Survey data, economically demonstrated *battery-mineral* reserves show that Australia (especially WA) exceeds all other nations—far above second-placed China (Figure 2). The US (13th) and Canada (14th) are the next best positioned partners within the 'inner sanctum' of Western security.³⁰ Battery minerals are essential to more than just electric vehicles, green technology and electrical goods such as mobile phones and laptops. They're essential for defence manufacturing.

Figure 2: Key battery minerals, global reserves, by country (%)



Note: Graph derived from a 2018 assessment by Future Smart Strategies.
Source: Mineral Commodity Summaries, US Geological Survey, 2022.

The US is blessed with enormous mineral and fuel resources, but few critical minerals, and the UK is generally resource poor. It's imperative that AUKUS supply chains are supported by Australian critical minerals and associated scientific and operational expertise.

In 2021, WA alone had non-fuel mineral sales (US\$120 billion) equivalent to the US (US\$80 billion) and Canada (US\$41 billion) combined.³¹ The state's production includes enormous volumes of many critical minerals. WA is sometimes the major alternative to Chinese production, as is the case with aluminium and rare earths; sometimes its production eclipses China's, as with lithium minerals or iron ore (iron ore being a critical mineral for China); sometimes it's a sovereign secure source, as it is for titanium and tantalum—the latter of which is otherwise available only from China or countries prone to geopolitical or economic risk.³²

However, although Australia is seemingly a blessing for AUKUS and the global economy seeking large, ethically mined, environmentally sustainable and secure critical-mineral supplies, the data on reserves and primary production hides the fact that most output is dug up and then sold to China for processing. In that way, Australia and other producing countries reinforce Chinese monopolies rather than helping to diversify supply. In fairness, those producers at present have few markets other than China in which to sell their raw minerals.

Critical minerals are currently unusable without heavy, often nearly total, dependence on Chinese supply chains, principally for processing the minerals into usable forms, and their subsequent components. Rare-earth minerals are exemplars in this regard.

Case study: Rare earths—‘vitamins’ of defence capability

The creation and regeneration of modern defence arsenals isn't possible without access to *processed* rare earths. Rare earths are the 17 elements in the periodic table—the 15 lanthanides plus scandium and yttrium—that possess extraordinary magnetic, luminescent, catalytic and strengthening properties.

Some 3,300 items of US military equipment depend on rare earths, which have few known or potential substitutes.³³ They include almost every weapon being used by combatants in Ukraine as well as every fighter jet, navy vessel and nuclear weapon on Earth. Nor is the commercial production of green energy and electric vehicles possible without them. Rare earths matter immensely.

Rare earths are commonly derived from rocks and mineral sands of which there are few economically viable deposits worldwide. ‘Heavy’ rare earths are commonly defined as a subset of 10 of the 17 metals,³⁴ and economically viable deposits of them are even more scarce. China, Myanmar (where China holds significant influence) and Australia have notable proven heavy rare-earth quantities as well as the other rare earths. China has control over about 94% of the world's (usable) rare-earth production and can readily scale up or down its established production systems.

Global spending on exploration for rare earths far outweighs investments in processing capacity. The key is learning how to diversify world processing capacity away from dependence on China. One Australian mine (the Lynas Mount Weld site, WA) is the only major source of rare earths that's independent of the Chinese supply chain. Other operations are generally laboratory scale, not industrial. Lynas' associated processing capacity to get rare earths into usable forms is replete with potential points of failure, passing as it does through Malaysia on to Japan.

The US has reopened its only mine (Mountain Pass, California) that contains copious quantities of mostly light rare earths. The US exports 100% of the product to China, as it's still yet to develop sufficient expertise and processing capabilities, although it's now looking to redirect its product to Japan.

Rare-earth processing expertise is scarce and extremely complex. Indicative of this is the fact that iron ore has three chemical stages in its processing, gold has 10 and uranium about 100, while rare earths can have up to 1,000 chemical stages (~600 for dysprosium). Promethium is the only rare earth that isn't mined naturally. It's created in nuclear laboratories and was ‘discovered’ (isolated) during the Manhattan Project to create the atomic bomb.

Processing rare earths is expensive, too. Such operations cost in the order of US\$1 billion to establish and have no guarantee of success. That's led successive national governments to ignore strategic risk in preference for a free-market solution—bar Japan in propping up Lynas for many years. Also, some promising grants and loans have included the Australian Government in 2022 offering a low-interest A\$1.2 billion non-recourse loan to Iluka Resources for a processing operation (Eneabba, WA) after enormous behind-the-scenes effort by strategic players.

Statecraft has allegedly washed out the viability of new competitors via market-price manipulation, including premeditated overproduction to dissolve profit margins integral to the viability of new market entrants, as well as restrictions on supply for geopolitical reasons. That geopolitical tension has even played out in the courts. The World Trade Organization finally ruled in 2014 that China's self-imposed quota restrictions on rare-earth exports were untenable (the restrictions appeared to be connected to the 2010 Senkaku/Diaoyu Islands territorial dispute in the East China Sea).

The global industry survived last time by using solutions that are no longer viable. Principally, the industry accessed the Chinese black-market trade in rare earths, which then accounted for more than 40,000 tons (double Lynas's current production). Finite stockpiles helped too. However, the black market has since been all but stamped out, and access has been further constrained by Beijing's appropriation of 150 companies and subsequent merger of them into six state-owned enterprises (and now effectively just two).³⁵

Outside China, the Australian Nuclear Science and Technology Organisation and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) join French-owned company Carester as but a few players with adequate knowledge in the field. Australia's Lynas is also valuable. Both private companies heavily derived that expertise from China before Beijing ordered strict cessation of knowledge transfers several years ago. As Deng Xiaoping is reported to have said in 1992 in regard to strategic opportunity: 'The Middle East has oil, China has rare earths.'³⁶

In Myanmar, rare earths are linked to human-rights abuses, political violence and environmental degradation. There are widespread reports of villagers being beaten to wrestle away lands for heavy rare-earth production supplying some of the world's biggest companies, as well as threats of execution-style killings and the funnelling of money to brutal militias.³⁷ And, as an investigation by The Associated Press suggests, Myanmar police line the streets in the north for cash payments from miners in what's now a (if not the only) key global hub for heavy rare earths to drive green energy.³⁸

The Associated Press further suggests that China Southern (one of only two Chinese state-owned rare-earth miners underpinning Beijing's global dominance) had proudly advertised in a company post that it was 'seizing overseas rare earth resources'. That investigation also alleges that:

[Myanmar police advised one miner] that the rare earths he extracts can only be sold to China, not to the Americans or Japanese, because they are China's strategic resources. He is under no illusions about the damage from acids so strong that they corrode the shovels of his bulldozers and excavators—something he'd never seen before [in previous operations outside of Myanmar].³⁹

Other key mineral producers, such as Brazil, also raise ethical and environmental concerns. Mining operations are often undertaken in fragile ecosystems, on unstable ground or near population-dense communities. Catastrophic accidents are all too common. The Brumadinho tragedy in 2018 alone took more lives than all coalition deaths combined in the 1990–91 Gulf War.⁴⁰

South Africa and the DRC deserve attention as, respectively, the major sources of platinum group metals (especially if Russian production is omitted) and cobalt (Australia is the only sizeable alternative). Many of the minerals held by South Africa and the DRC might not be critical to the AUKUS countries and their core partners, but the platinum group metals may be an exception. For instance, Japan views them as more critical than rare earths.

However, there are sometimes alternatives to meet the demands of AUKUS and its friends. Scientists and major manufacturers are striving to develop substitute materials or technologies that reduce reliance on critical minerals, including to avoid cobalt from conflict-affected areas such as the DRC. Those emerging technologies include synthetic graphite made from the by-products of oil and coal refining, which provides an alternative to the concentrations of natural graphite reserves in China, Brazil and Turkey.

But, undoubtedly, Beijing is the biggest player of all. It's apparent that there's declared and undeclared Chinese-state control within the critical-minerals sector. Ultimately, it all comes under the purview of the CCP, and no one dare break from the ranks or risk severe reprimand.⁴¹ The very foundation of this purposeful state combined with a brilliantly orchestrated, long-term plan centres on a commanding processing monopsony on which much of the world depends.⁴²

The rest of the world is intelligent enough to understand complex processing science, but the West's efforts to counter Beijing's efforts at critical-mineral domination have been almost entirely absent. Processing is a very expensive art backed or owned by the Chinese Government and is heavily regulated by Beijing to restrict foreign ownership and joint ventures in mineral processing.

For those reasons, although they have a part to play, private investors aren't the key to the diversification that AUKUS, and indeed the rest of the world, need.

AUKUS will never realise secure critical-mineral supply without sizeable government investment and strategic intervention from it and potentially other partners. That's because profit is the underlying basis for private-sector investment. Private investors have negligible interest in managing geopolitical risk, bar for wealth creation. The market conditions that China controls throughout much of the sector are also not conducive to new competition being viable or overly appealing to investors, who might seek less niche markets.

Private investment gravitates towards but a few critical minerals and is usually concentrated in vastly lucrative markets such as those for gold, aluminium, copper and iron ore. *Statista* suggests that the worldwide market value of iron-ore mining was US\$375 billion in 2021.⁴³ That's where investors like to speculate. It's also why BHP and Rio Tinto were the world's two biggest iron-ore mining companies in October 2022, based on market capitalisation, ahead of Glencore and Vale.⁴⁴

Private-sector investment in most critical minerals is a vastly different story. For example, the Center for Strategic and International Studies suggests that 'In 2019, the value of worldwide rare earth imports [16 of the 50 US critical minerals] stood at just \$1.15 billion.' That's a crude average import value of just US\$72 million each—a far cry from US\$375 billion. It holds marginal interest for most investors despite the International Energy Agency suggesting that growing markets for products such as wind turbines could dramatically increase rare-earth demand in the coming decades.⁴⁵

But Beijing sees the bigger picture. It knows that critical minerals underpin manufacturing competitiveness and the ability to participate in future industry. It knows that they enable the rapid domination sought under 'Made in China 2025'. On 7 July 2015, the Chinese State Council's opening statement to that doctrine, which spans 10 high-tech industries,⁴⁶ offers a rare overt glimpse of Beijing's mindset:

Manufacturing is the main pillar of the national economy, the foundation of the country, tool of transformation and basis of prosperity ... it has been proven repeatedly by the rise and fall of world powers that without strong manufacturing, there is no national prosperity.⁴⁷

It's worth considering that 'strong manufacturing', in terms of China's economies of scale and the 10 high-tech industries that are the focus of Made in China 2025, requires enormous quantities of critical minerals via a continuous stream of supply drawn globally.

Strategic dimensions

Analysts often assess the importance of critical minerals in purely economic terms, looking at the integral nature of critical minerals to the automotive sector,⁴⁸ for instance—a global manufacturing sector that ranked first in total revenue at more than US\$3,000 billion annually in 2019.⁴⁹ The economic heft of that sector can uphold national security (at least that of major automobile-producing nations and those allied to them), including for the simple fact that solid national wealth empowers sizeable defence purchasing.

However, viewing critical minerals as enablers of lucrative civil sectors may inadvertently obscure other important national-security dimensions. Lithium isn't just for batteries, even though batteries account for 74% of its global end-use market.⁵⁰ It's also essential for armour, airframes, jet engines and nuclear reactors, too. And tin isn't just for roofing; it's also critical for alloys and semiconductors for 'dual-use' (military and civilian) applications. That may help to support the US, the UK, Japan, Canada and South Korea designating tin as a critical mineral, as by their own definitions, they have determined that tin has sufficient supply risks.

In 2022, the RAND Corporation assessed that China's manufacturing accounts for about 25% of total world output. About 50% of it is considered to be dual use.⁵¹ That may be alarming to some, if they factor in the adage that wars are battles of industrial production, especially when considering that the means to scale up production is dependent on resources—most fundamentally, critical minerals. And, of course, heavy manufacturing capacity is in relative decline in the AUKUS countries.⁵²

In terms of critical-mineral diversification, RAND also offers a rather pessimistic assessment about Beijing's orchestrated domination of critical minerals, suggesting that:

- 18 of 37 minerals relevant to defence applications are concentrated in China
- 14 more are concentrated in countries with strong diplomatic and economic ties to China, including Russia, Brazil, and Belt and Road Initiative countries
- only five defence-related minerals are concentrated in the US, Canada and Australia.

Beijing's dominance is by no means unresolvable, and AUKUS can act to diversify supply and mitigate risk. It's highly doubtful that anyone else has the capacity to hedge Beijing sufficiently, given the partners' trust and closely bonded leaderships.⁵³ The key lever here is mineral reserves—which must be supported by independent processing and production chains—and Beijing is outdone (principally) by Australia for that feedstock.

Sourcing minerals from the DRC may be supporting conflict or the use of child labour. Beijing also has nefarious influence in the DRC. For example, in 2021, *Bloomberg* and the *New York Times* reported a massive alleged bribery scandal involving 3 million leaked banking documents linking the Chinese leadership to the (then) DRC President, Joseph Kabila and his family via a US\$55 million personal payment scheme.⁵⁴ And, as David Uren notes:

Chinese interests now own 15 of the 17 cobalt operations in the DRC. The five biggest Chinese mining companies with cobalt and copper interests in the country can draw on lines of credit with Chinese state banks totalling an extraordinary US\$124 billion.⁵⁵

China's influence in the DRC matters. Among other things, DRC cobalt is vital for lithium batteries, automobiles and (fighter) jet engines, and the nation accounts for 70% of global production and 46% of reserves. Quite reassuringly, Australia ranks a very clear second for cobalt reserves, with a healthy 18% share. But, for current production, Russia and Australia (in second and third place) account for only 4.5% and 3.3%, respectively, and Russia is at best an unlikely collaborator.

Activating new cobalt production at scale would almost certainly take a long time. Factoring in flow-on disruption to products such as lithium batteries, electronic goods, automobiles and jet engines, disruption of cobalt production would be potentially catastrophic for global industry. Substitutes are few and inferior.⁵⁶

The RAND assessment, conversely, might provide false assurance in one of its charts showing that some 90% of lithium minerals outside China are concentrated in Australia.⁵⁷ That would overlook the fact that China is the world power in lithium hydroxide production—a crucial form of processing to get lithium into usable forms. And, even if Australia has three major lithium hydroxide operations well in the works and a fourth apparently under consideration, that doesn't offer a full supply chain, there are arguably conflicts of interest within those operations,⁵⁸ and they pale against China's dominance.

Stock-market news service *Stockhead* speaks to that dominance:

While North America could see lithium chemical production increase four-fold from current supply to 70,000 tonnes LCE (lithium carbonate equivalent) by 2025 if all capacity announcements come to market successfully, it still pales in comparison to China, which is forecast to have production of 847,000 t LCE by 2025 if facilities from all producers are considered.⁵⁹

It's a lack of mineral processing, its associated industrial and scientific complexity, sizeable lead times and the necessarily large investments that too often exacerbate strategic risk surrounding critical minerals. That's especially the case for rare-earth production, in which a project typically needs at least 10 years and over \$1 billion to get up and running, and there's no guarantee of success—capital markets are cautious because of past misadventures, as this paper will explore.⁶⁰

For instance, in the case of the Lynas Mount Weld rare-earth operation, before making its remarkable breakthrough in still being the world's only industrial-scale producer of rare earths independently of Chinese processing supply chains, it took 11 years to turn a profit. The operation was once on the brink of bankruptcy before maturing into a robust company. We should also note that, where rare earths are concerned, they aren't typical mining operations, but essentially costly and complex chemical-processing operations.⁶¹

That factor, coupled with a series of era-defining economic upheavals since the 1980s, including the Black Monday crash in 1987, the 2007–08 global financial crisis and the Covid-19 pandemic, might help to explain why Western governments have tended to ignore strategic risk in order to avoid financial anxiety and expending enormous political capital. After all, expensive and risky investments amid austerity don't typically appeal to treasury advisers or the voting public.

Beijing, on the other hand, has sought to remain proactive and to grow its increasing advantage. This has seen China undoubtedly become the most unrelenting player in the critical-minerals sphere.⁶² Its effort to secure critical minerals seemingly has no financial limitations where it's related to upholding and expanding the CCP's near monopolies of critical minerals and, as per the DRC incident, virtually unlimited lines of credit.⁶³

Some might rightly argue that Washington and others are currently re-embracing industrial policy through a more strategic lens, but few would suggest that those positive moves yet amount to the longstanding, unwavering and active statecraft that Beijing has increasingly undertaken since at least the mid-1980s.⁶⁴

Beijing's *modus operandi* seems best described as 'Secure oneself and lever others.' That's consistent with widely observed practices as outlined in this paper, and what some see as a dual strategy of 'strategic shortage minerals', centred on its own need, much like AUKUS and partner nations, and 'strategic advantage minerals' for which it's claimed that Beijing seeks geopolitical influence over others.⁶⁵ The latter may be fair game in a contested world, but that does bear implications.

A more overt hint at the 'strategic advantage' that Beijing's policy might afford was offered in May 2019, when media reported images of President Xi striding through a vital rare-earth permanent magnet factory, peculiarly with one of China's chief trade negotiators, during the height of the Sino-US trade war. That was widely portrayed in the global media as a thinly veiled threat, given the US's (and the rest of the world's) dependence on Beijing's state-owned enterprises for these critical inputs to consumer products valued in the order of US\$6 trillion annually.⁶⁶

In controlling 94% of the world's usable rare earths,⁶⁷ China has delivered robust processing capacities that include specialist manufacturing on which others depend. In other strategic settings, such as military conflict or having the means to maintain the technological edge to deter the next global war, the 'strategic advantage' that Beijing is cultivating takes on heightened importance.

The uncompetitive nature of the sector outside China seems largely embodied in Chinese statecraft. That includes the means to control prices and exclude new entrants. As noted by Dr Jeffrey Wilson:

Establishing a viable non-Chinese supply chain will take years and require major government support, international co-operation and collaboration from industrial giants ... The Chinese state-owned producers can do the Saudi oil trick: they turn on the taps, flood the market, the price of dysprosium crashes, the new entrant is washed out, and then they've re-established their monopoly.⁶⁸

James Kennedy, writing for *National Defense Magazine*, suggested in 2019 that:

Out of more than 400 rare earth start-ups publicly listed in 2012, less than five reached production. Of those, only two reached significant volumes. Of those two, one became bankrupt [allegedly because of Chinese market-price manipulation] and resurrected with Chinese financing, and the other lost its operating permit for a short period.⁶⁹

While some, like Professor Dudley Kingsnorth, question the true number of failed start-ups in 2012, he noted that US\$10–12 billion was lost from a combination of the New York, Australian and Canadian stock exchanges from failed rare-earth ventures around that period, which were linked to China's cessation of rare-earth exports over the Senkaku/Diaoyu Islands incident that had global industry concerned.⁷⁰

Professor Kingsnorth also noted that this supply disruption was significantly alleviated back then by quickly depleting stockpiles and by industry access to China's then enormous black market. Those channels are now almost entirely closed by Beijing because of environmental devastation and wasteful collection of finite resources by provincial communities undertaking crude mining practices.⁷¹

These cases illustrate the difficulty of creating viable rare-earth (and other critical-mineral) operations on solely commercial grounds, free from government support. It seems that China has understood that since at least 1985, when it enacted a 13% VAT rebate for initiatives to grow its rare-earths sector.

Only a year earlier, in 1984, US Geological Survey data showed that China accounted for zero production of global rare-earth oxide production.⁷² Then, in 1990, the Chinese Government declared rare earths a protected and strategic mineral, barring foreign investment and restricting foreign participation in joint processing ventures.⁷³ Subsequently, around the time that it introduced production-limitation quotas in the early 1990s,⁷⁴ Beijing commenced merging 150 rare earth companies into the six state-owned enterprises (effectively only two state-controlled megacompanies now). In 2022, Beijing's control of 94% of world supply (given dependence on it for processing feedstock)⁷⁵ supports some US\$6 trillion in global manufacturing that would otherwise be unsustainable or highly inferior.⁷⁶

Beijing is further empowering itself to control magnesium supply flows and spot prices. History suggests that this is liable to crowd out any 'green shoots' from new entrants. That could include significant challenges for two otherwise promising prospects in Australia and Canada that emerged out of the 2021 European supply crisis (see the 'Magnesium' case study page 10).

Beijing could again freely build upon its monopsony buying power to dominate processing to make usable rare earths and magnesium, as well as related products. Worse still, if it chose to act as it did against Japan for 59 days in 2010, it could hold swathes of global manufacturing, and even national economies, to ransom.

Appendix 2 examines supply-chain challenges in more detail.

AUKUS: Know the ‘lay of the lands’

Each AUKUS partner offers much towards a complete critical-mineral supply-chain solution. Albeit in different ways, the national capacities of the AUKUS nations appear to be superbly complementary. What’s important right now is for AUKUS to bring it all together. Knowing the ‘lay of the lands’ is a sound starting point.

Australia: the bedrock of secure, quickly obtainable and longer term reserves

Even though Beijing has spent the past 30 years entrenching itself in critical-mineral interests globally—including via enormous financial backing and strategic intervention in Brazil, South Africa, the DRC, Chile, Estonia, Turkey and Kazakhstan,⁷⁷ among others—its own mineral reserves are clearly inferior to Australia’s.

For example, according to US Geological Survey data on proven battery-mineral reserves, Australia vastly surpasses second-placed China. This is largely on the back of WA’s holdings of such critical minerals, which form the crude ‘shopping lists’ from which defence capability derives, not just electric cars, green technology and consumer goods.

In 2020–21, WA’s non-fuel mineral sales (US\$120 billion) were equivalent to the total production of the US (US\$80 billion) and Canada (US\$41 billion) combined.⁷⁸ Furthermore, a general review of US Geological Survey 2022 mineral commodity summaries suggests that every other Five Eyes nation,⁷⁹ Quad partner and NATO country combined are unable to match Australia’s reserves.

Australia’s strict application of the Joint Ore Reserve Committee (JORC) system,⁸⁰ which is integral to disciplined assessment in verifying the truthfulness of new mineral-discovery claims, also means that Australia tends to under-record its reserves relative to other countries. Estimates by the US Geological Survey, which is arguably the most credible geological survey globally, boost and often double Australia’s own-determined reserves. But, despite Australia’s apparent understating, beyond current discovery, Geoscience Australia still rates 44 of the 50 US critical minerals as high (30) or moderate (14) for geological potential in Australia.⁸¹

Australia is yet to explore 80% of the continent for critical minerals.⁸² Even in the nation’s critical-mineral heartland, there’s relatively little focus on critical-mineral exploration:⁸³ in WA, 75% of exploration is focused on iron ore (~50%) and gold (~25%),⁸⁴ while that state alone produced 53% of world lithium mineral supply in 2021. That value accounted for less than 0.7% of WA’s major export commodities,⁸⁵ yet the world industry it enables is vastly more lucrative.⁸⁶ This is driving the nation’s aspirations to harness the value chain more.⁸⁷ Although that’s still motivated almost exclusively by a desire to expand the economy, it’s vital for national security, too.

Similarly, WA is home to Iluka’s enormous Eneabba rare-earth stockpiles, which are ready for a processing solution, supported by a \$1.2 billion non-recourse loan from the Australian Government.⁸⁸

WA’s other critical minerals could meet the entire critical-mineral needs of some nations. Consumers can rely on WA supply in a way they can’t with some other providers.

WA has superior technology and infrastructure featuring the world's busiest port by tonnage, the largest fleet of autonomous vehicles globally, and world-class remote operational centres. It has superior operational and technical staff. That includes many of the best minds globally, including from places such as the Massachusetts Institute of Technology and the US National Aeronautics and Space Administration, China's now 'forbidden' world-leading processing sector, and the South African mining diaspora.

In addition, homegrown Australian talent is being reinforced by the intergenerational transfer of knowledge. And, as the training ground to nurture long-term continuity, WA's concentration of various mineral-science institutes and mining-related universities appears to outstrip that of any other jurisdiction, perhaps outside of China.

While the Colorado School of Mines pips WA for the world's most superior undergraduate degrees, the Western Australian School of Mines' postgraduate programs are superior. According to any given global university rankings for mineral engineering degrees, those two titans commonly maintain a sizeable lead on the third-, fourth- and fifth-place universities, which are all Australian institutions currently, and Canada's McGill University (ranked in sixth place).⁸⁹

Indicative of WA's lucrative mining opportunities, graduate remuneration for the state's Curtin University MBA program (which has many resource-sector specialisations) has been known to exceed the entirety of the Ivy League, including Harvard MBAs.⁹⁰ WA's premier university, the University of Western Australia, also offers extensive leading scientific expertise in mineral engineering that's uncommon elsewhere. Australia's scientific institute, the CSIRO, heads its minerals unit in WA, too.

As annoying as the state's mining ego may be to some, WA's self-belief is backed by results. This is what AUKUS needs to diversify away from Beijing's mineral domination—although the road to a secure supply-chain solution will be long. That's why Australia, and more specifically WA, must be the indisputable focal point for a major new AUKUS-led critical-mineral 'megastructure'.

Australia is ground zero for AUKUS because the alliance is based on supply-chain security that enables war-winning capabilities. And, as noted in the opening remarks of the joint leaders' statement on AUKUS, it's premised on even closer bilateral ties, better information and technology sharing, and fostering 'deeper integration of security and defense-related science, technology, industrial bases, and supply chains'.⁹¹

While technological know-how and sufficient funding are essential to AUKUS, Australia's possession of critical-mineral reserves constitutes the most fundamental enabler of inputs to sustain the large-scale production of war-winning capabilities for the foreseeable future (and technology underpinning the world economy, given its burgeoning thirst for mineral supplies).

Most critical minerals are commercially viable in WA, which has abundant reserves of minerals that are scarce internationally. Australian technical and mining expertise also has deep connections with the Indo-Pacific and headquarters many key African critical-mineral operations—a key point of diversification to China's African mining frontier.

Australia offers an indispensable contribution to AUKUS, and may even see various G7 countries vulnerable, if not untenable, without its resource contributions should China stem flows to meet its own needs or for any other reason, or if Beijing were to adopt the French model of selling only the wine (manufactured goods) and not the grapes (processed minerals).

It's almost inconceivable for AUKUS to realise a secure, long-term and diversified critical-mineral supply chain without Australia spearheading the solution.

The UK: science and finance

The UK doesn’t possess many critical minerals. Notwithstanding its relatively modest capacities, such as its Cornwall lithium carbonate operation, the UK’s contribution to AUKUS supply chains is its technological and corporate strength. More broadly, UK intelligence capacities are probably second to none in some geographies. That could be tremendously helpful for monitoring nefarious activity in the critical-minerals sphere.

Based on the reported market capitalisation of global mining companies in October 2022, the UK and Australia co-own the world’s two biggest mining companies (BHP and Rio Tinto)—while the third and sixth biggest (Glencore and Anglo American, the latter of which is listed in the UK) are headquartered in Britain. Although those companies only partly operate in the critical-minerals domain, some possess world-leading niche dual-use technologies—including for specialist autonomous systems and remote operations—that could equally be applied to defence capability.

The UK also seems re-energised to meet the critical-mineral supply risk. That’s shown by the resolution in 2022 of the delayed UK list of critical minerals.⁹² Furthermore, recent UK Government statements, including the UK’s 2023 *Critical minerals refresh* and *Integrated review refresh*,⁹³ focused on maintaining a valid grasp of security, defence, development and foreign policy, suggest prioritisation and comprehension of the strategic dimensions of critical minerals in the current and emerging age. Such work is perhaps only outdone by Beijing as the current master of the art,⁹⁴ for now at least.

The US: the strategic ‘quarterback’

2022 marked a significant step-up in the Biden administration’s efforts on critical minerals, including rare earths. President Biden began in February 2022 with a virtual forum on securing critical minerals for a future made in America. He linked his previous year’s executive order on domestic supply chains to his efforts at that meeting:

... what I found out was that if I was going to follow through on my commitment to say we were going to make it in America, build it in America, and have all of it built in America, we need a supply chain—that was reliable. And including in critical minerals like lithium, graphite, rare earth materials, which are badly needed for so many American products we were in so desperate need of. These minerals power phones and computers, household appliances, electric vehicles and so much more ... we expect demand for them to increase 400–600% over the next several decades.⁹⁵

Unfortunately, he then bracketed Australia and Chile with China in outlining the US’s near 100% dependence on imports—a situation he was determined to change.

The US Department of Defense announced that the Biden administration was ‘investing \$35 million in MP Materials, currently America’s only rare earth mining and processing operation, to help create a full domestic supply chain for the magnets that power electric motors, wind turbines, and so much more.’⁹⁶ The focus on magnets was brilliant; the quantum was a fair start.

At the forum, MP Materials announced a US\$700 million investment in the magnet supply chain.⁹⁷ MP Materials CEO Jim Litinsky stated that the government’s US\$35 million would complement the company’s investment. Litinsky was proud that his effort to reopen the Mountain Pass rare-earth mine five years previously had now resulted in the employment of 400 people. Further, General Motors would be the foundational customer for a magnet facility that MP Materials is building to produce every aspect of the supply chain in the US. This an exceptionally wise move, given that magnets are most crucial.

The rest of the conversation at the forum focused heavily on lithium. That included Governor Newsom of California’s far-fetched vision of seeing Imperial Valley in his state become ‘the Saudi Arabia of lithium’. Some missteps aside, the US has persisted with its focus on critical minerals.

The issue of supply chains more broadly was the subject of a virtual ministerial conference convened by the US on 19–20 July 2022. Australia was among the 18 participating nations plus the European Union.⁹⁸ Led by the State Department, the Minerals Security Partnership—an effort to build robust critical-mineral supply chains—was among the American efforts identified. The body would ‘help to ensure electric vehicle battery plants, automakers and other US manufacturers have the inputs they need to keep production open and American workers on the job.’ The US Department of Commerce has also launched the Industry Trade Advisory Committee on Critical Minerals.⁹⁹ It leads engagement with allies, including Australia.

There’s US outreach to Australia and the UK well beyond the AUKUS partnership, and a substantial number of other countries are engaged. The US focus in all of this, apart from American jobs, is heavily oriented towards green technologies, in keeping with the Biden administration’s focus on responding to climate change. That includes the Inflation Reduction Act of 2022 affording tax credits for new and used electric vehicles sourcing an increasing percentage of battery minerals from the US or free trade agreement nations, such as Australia.

Dependence on China is clearly in focus. Yet there’s little emphasis on the fact that China has, since December 2021, had a law allowing Beijing to ban exports of strategic materials and advanced technology to specific foreign companies that may present threats to national security and interests.¹⁰⁰ For instance, exporters can be required to name the end user of Chinese critical-mineral exports and the final application thereof, which could readily apply to rare-earth-based weapons. That’s pretty much every weapon in the US arsenal, bar a trusty blade or pair of boots, especially if we factor in the machinery needed to make military equipment.

Clearly, the law is aimed at the US, but so far it apparently hasn’t been activated. The US continues to restrict sales of goods such as semiconductors and high technology to Chinese industry. One wonders when the Chinese will act. In October 2022, Joe Hockey, former Australian Ambassador to the US, remarked:

In terms of critical minerals, my concern is—and there has started to be a few reports in the US suggesting this—is that after the [US] midterm elections, and with a re-empowered [Chinese President] Xi Jinping, as of next year China will start to turn down the tap on the supply of critical minerals to the US and other places ... Now if they even start to adjust that tap, the US is going to go nuts.¹⁰¹

Bipartisan support seems to be gravitating towards the enormous effort required to address that risk. On 7 December 2022, US senators Mitt Romney and Dan Sullivan introduced the Critical Mineral Independence Bill into Congress. Passage of the Bill would see a vital, if ambitious, commitment to achieve critical-mineral supply-chain independence for the Department of Defense by 2027. Senator Romney asserted:

We put our national security and economic vitality at risk when we rely on countries like China for critical minerals ... rapid, strategic investments by the US and its allies in the mining and processing of critical minerals are needed to meet the security challenges we face today.¹⁰²

Although it’s readily apparent that the proposed US\$1 billion in funding for critical minerals under the National Defense Authorization Act is a fraction of what’s required from each of several allied partners, given the worldwide effort required, we’re at least seeing positive action informed by the comprehension of risk.

This action is taking place against the backdrop of Chinese policy and legislative levers established from the ground up. Measures range from CCP minders restricting access at critical-mineral production sites—this even includes Australian industry reporting the mandated closing of airplane blinds to restrict eye-level observation of rare-earth operations on flights approaching processing sites—to the Chinese national-security-oriented legislation mentioned above.

The ability of China to distort the market, discouraging production elsewhere, is broadly recognised. Lynas has also been subject to frequent efforts to shut it down. Thankfully, Tokyo has moved to ensure that it remains in the market. Normal commercial considerations can’t apply if the security of supply of critical minerals is to be achieved.

Lynas's support to Blueline in Texas to establish the means to process several crucial magnet-related heavy rare earths is also very positive, notwithstanding many apparent problems. Among other things, this is a feedstock enabling the production of electric engines, wind turbines and intercontinental ballistic missiles. And, despite Mountain Pass in California now approaching the fourth year of delay in adding a rare-earth processing solution to its operation, it seems likely that it will soon succeed. It's also on the verge of redirecting its minerals supplies away from China to a Japanese processor.

Though this activity doesn't feature in any of the R&D areas covered by AUKUS, Australia has a firm understanding of the significance of critical minerals for defence production. The US is also aware both of Australia's mining expertise and the broad presence in Australia of most critical minerals.

However, for those purposes, Australia's rare earths are most important, especially if we include partner nations' needs (and possibly tantalum, as well as weapons-grade magnesium and titanium alloy powders suited to additive manufacturing). If AUKUS is to succeed, and for the West's supply chains to become resilient, this endeavour must be prioritised. The involvement of the US is vital.

Recommendations

Fundamentals

AUKUS should quantify needs for each individual critical mineral. AUKUS must factor in fair assessments of current and future demand, allow for a 20% contingency in determining volume,¹⁰³ and secure offtake agreements to empower industry to meet those needs. The AUKUS countries might take the following actions:

- Conduct a rolling three-yearly reassessment of current and future critical-mineral demand.
- Align the cycles upon which AUKUS countries determine their individual critical-minerals lists.
- Prioritise projects with low sovereign risk, both politically and geographically (avoiding geopolitical flashpoints).
- Prioritise projects that are proven technically and economically wherever security risk allows it. Most projects needed to meet required volumes won't be proven, so there's a need to take calculated risks.
- Gain and maintain an accurate full picture of total allied mineral-processing failure points.¹⁰⁴
- Agree on co-investments with allied partners to scale up mineral projects. Each might need to fund project milestones totalling in the order of US\$5 billion spread over 5–10 years.¹⁰⁵
- Ensure that all AUKUS-backed mining operations are vertically integrated with secure processing and separation plants that make minerals usable in order to break the Chinese processing monopsony.
- Devise a succession management plan for scarce, often ageing, processing specialists.
- Work towards having multiple mid-supply-chain operations to afford redundancy, spread between Australia and North America (where near resources) and other benign security locations.
- Ready a contingency plan for alternative supply and retaliatory action if China cuts supply for malicious reasons.¹⁰⁶
- Maintain a watching brief on the critical-mineral calculus during Russia's war in Ukraine.¹⁰⁷
- Investigate the circumstances of foreign investors pushing companies to accept only 100% offtake agreements (financial backing in exchange for mineral-supply assurances).
- Map levels of foreign ownership and offtake agreements in AUKUS nations' mineral operations.

Bureaucratic

AUKUS should drive a logical evolution of bureaucratic arrangements to harness its strengths. That entails better fusing respective geoscience, fiscal and strategic agency functions. Trilateral AUKUS dialogues might also be further enhanced, along with ministerial-level bilateral meetings in intervening periods. To do this, AUKUS bureaucratic measures might include the following:

- Agree on a consistent definition of 'critical minerals' akin to US Executive Order 13817 (2017).
- Make critical minerals a standing agenda item for all AUKUS meetings.
- Make critical minerals a standing agenda item for all AUKMIN and AUSMIN meetings and other equivalents (co-opt local representatives from the other AUKUS nation to observe).

- Ensure that critical-mineral lists are exhaustive in articulating minerals based on critical domestic production, delineated with those solely for allies or trade opportunities.¹⁰⁸
- Conduct an independent assessment of the adequacy of government stockpiles and possibilities for sharing among AUKUS based on different comparative advantages.¹⁰⁹
- Train senior geoscience leaders in executive-level strategic studies programs.¹¹⁰
- Train national-security and treasury leaders on critical-mineral industries and economics.¹¹¹
- Agree on trilateral efforts to prioritise mineral-processing infrastructure over new mining.¹¹²
- Routinise critical minerals on national-security agendas.
- Place a senior Geoscience Australia representative in Australia's Office of National Intelligence, and consider equivalent arrangements for the AUKUS partners.
- Better resource critical minerals as national intelligence-collection priorities, commensurate with strategic risk.¹¹³
- Strengthen Australia's Critical Minerals Facilitation Office and AUKUS equivalents.
- Allocate national-security agencies as AUKUS mineral leads, with mineral facilitators' active input.
- Drive greater government-business collaboration on critical-mineral production.¹¹⁴
- Make provision to avoid critical minerals being blocked at ports for larger volume cargo.¹¹⁵

Industrial

AUKUS nations should agree on a framework for defence companies to disclose critical-minerals reserves and demand based on current production and mid- and high-intensity conflict scenarios.¹¹⁶ Disclosure should be via secure reporting means and be more detailed for larger enterprises. Data might fairly be compartmentalised to individual AUKUS nations but with a de-identified industry quantum shared centrally. The framework could include requiring that defence industry companies take the following actions:

- Declare any intention or limitation for ensuring the company's secure mineral supply.
- Stipulate a requirement for subcontractors to the companies to provide relevant information wherever it would enhance such company advice.
- Outline the impact on companies' stockpiles or their open market mineral orders for any defence or non-defence production proposed or current, as part of tender processes.
- Disclose any sourcing of minerals, components or other supplies for defence equipment from China, Russia, Iran or North Korea. This could encompass offering companies a transitional amnesty until 2030, including for legislation likely to have been contravened (for example, for rare-earth permanent magnets under the US 'McCain' Act).¹¹⁷
- Consider voluntary participation in AUKUS-coordinated co-investments to pool critical-mineral offtake agreements, or instead to purchase or create new mineral supply chains.
- Leverage national-security grounds to afford priority access for defence companies (or those of national-security significance, including economic significance) investing in mineral operations.¹¹⁸
- Consider the feasibility of strategic sourcing partnerships with the non-defence sector.

It's not inconceivable that, in the future, the disclosure of critical-mineral reserves and consumption forecasts will need to extend to all significant critical-mineral consumers, potentially for several years, for the purpose of rationing. That will depend on the extent to which new supply, including through adequate processing operations, can meet the expected enormous increase in global demand for critical minerals.

Scientific

AUKUS should build upon current collaborative endeavours and create a magnet taskforce comprising magnetic-mineral scientists, defence technologists, end users and security specialists, with the sole purpose of creating the world's most advanced permanent magnet; that is, a compact magnet with the highest possible magnetic strength retained under high heat and pressure. Both the future economy and the outcome of the next major war might depend on the effectiveness of this taskforce.

- Beyond superior missile technology, such magnets are vital to electric vehicles and green technology driving the competitiveness of major industry, including the sustainability of the automobile sector (historically a key to defence industry mobilisation).
- More than 90% of magnets come from China. There are only four major world producers, and Hitachi's (Japan) production is reportedly at risk of Chinese intellectual property takeover, which would produce an increasingly less diversified global economy. Patents might be challenged (noting that many are excessive and have been overturned recently). Reports suggest that strategic competitors are ignoring patents to their technological advantage.

AUKUS should establish a new strategic partnership on critical minerals with national universities and scientific organisations to enhance other current action. That might include a central research unit¹¹⁹ for critical-mineral advancement aiming to perform the following tasks:

- Redesign or reduce the use of critical-mineral-intensive technologies.¹²⁰
- Hone and integrate critical-mineral-substitution information systems.¹²¹
- Assess untapped by-product sources of critical minerals in AUKUS ores.¹²²
- Determine cost-neutral or profitable models for recycling critical minerals.¹²³
- Advance critical-mineral processing solutions, especially those under competitor monopoly.¹²⁴
- Advance strategic thought in step with evolving geopolitical and industrial dynamics.

Conclusion

AUKUS must form the supreme central command of allied effort to diversify critical-minerals supply beyond China's globe-spanning control and influence. Tangible, ongoing and suitably funded action is needed. AUKUS friends and allies must form a harmonising chorus, too, principally to co-fund projects for supply assurance and possibly contribute towards the science of processing minerals, and the subsequent production of metals and alloys as inputs to vital components.

Although severely lacking in its own accessible critical-minerals reserves, Canada has an elevated role to play among allies and partners in the years ahead via its solid technical know-how (or ownership) in some of the key areas, as well as its secure geography. South Africa and the DRC, their associations with Moscow and Beijing aside, are also important to the strategic calculus of critical minerals as, respectively, the only major global source of platinum group metals (especially if Russia is omitted) and as the cobalt-mining titan.

However, notwithstanding an honourable mention for the US Mountain Pass operation, which should soon overcome its technical challenges or perhaps partner with Japanese industry to process rare earths entirely independently of Chinese expertise, any credible case suggesting that AUKUS or its partners can realise security of supply without a vast new mega-infrastructure in Australia is simply inconceivable.

Australia is unmatched globally in many areas. On balance, Australia's variety of minerals, proven reserves, hundreds of billions of dollars of investment in complementary sectors, deliberately understated geological prospects under the JORC standard,¹²⁵ desolate terrain with commonly less ecological fragility, supporting infrastructure, resources technology, scientific mining expertise, and secure sovereignty, on balance, are far beyond the value of any other nation outside of China.

The path forward is clear. It's time for AUKUS to act. It's time to allay immediate strategic risk. It's time to secure the liberal-democratic order for the next 75 years. Failure to do so would be unforgivable.

Appendix 1: Selection of partners' critical-mineral needs

AUS-CA lists appear to require timely reworking*

	US	UK	Australia	Japan	Canada	EU	S Korea
Aluminium(Alumina			Recently added				
Antimony)							
Arsenic							
Barite							
Beryllium							
Bismuth							
Boron							
Cadmium							
Carbon							
Cerium							
Cesium							
Chromium							
Cobalt							
Copper							
Dysprosium							
Erbium							
Europium							
Fluorspar							
Gadolinium							
Gallium							
Germanium							
Graphite							
Gold							
Hafnium							
Helium							
Holmium							
Indium							
Iridium		#					
Lanthanum							
Lead							
Lithium							
Lutetium							
Magnesium							
Manganese							
Molybdenum							
Neodymium							
Nickel		#					
Niodium							
Osmium							
Palladium							
Phosphates		#	O				
Platinum							
Potassium			O				
Praseodymium							
Promethium							
Rhenium							
Rhodium							
Rubidium							
Ruthenium		#					
Samarium							
Scandium							
Selenium							
Silicon			Recently added				
Silver							
Strontium							
Tantalum							
Tellurium							
Terbium							
Thallium							
Thulium							
Tin							
Titanium							
Tungsten							
Uranium							
Vanadium							
Ytterbium							
Yttrium							
Zinc							
Zirconium							
Borates							
Coking coal							
Natural rubber							

= a required critical mineral (not including rare earths or platinum group metals marked with purple or grey).
 = one of the 16 Rare Earth (RE) varieties, which some operations might mine from the one source but with enormous variation among individual quantities of each RE type, and different processing requirements.
 = the 17th type of RE, only produced in nuclear laboratories not mined. Note: nations group the 17 RE's as one but all may not be critical to them. Only the US appears to conduct a definitive assessment of each type.
 = one of six platinum group metals also grouped by nations haphazardly (bar US who identifies osmium as not critical). Bar for the US, unclear if each nation needs only certain types of the six platinum metals.
 = AUS and CA focus heavily on export opportunities. Questionable confidence that their own true needs are adequately assessed (or suitably prioritised) despite the importance of trade's role to economic security.
O = Added to Aus 2019 list as appears a genuine domestic need based on previous Geoscience Australia assessment and geopolitical developments around the nation's fertiliser supply in 2022 stemming from Ukraine.
= one of four items the UK deems 'increasingly critical' (not necessarily entirely critical for them yet) but included in table of 'critical' minerals for clarity when drawing comparison.
 NB: some minor liberties taken for consistency E.g. For some nations 'phosphate rock' and 'phosphorous' simplified as 'phosphates'; 'silicon metal' as 'silicon'; 'bauxite' as 'aluminium' for S. Korea as it is its common ore.

Appendix 2: Supply-chain challenges

Those in the commercial sector might struggle to grasp a fuller strategic picture enriched by military considerations. Conversely, those in the strategic faculty may struggle to comprehend what a prolonged supply cut would mean amid modest rare-earth stockpiling and resulting broken manufacturing supply chains globally.

Where modest stockpiling is concerned: It's well known that the US national strategic stockpile has between 2 and 10 years of supply for military uses (varied by mineral, albeit with key gaps apparent).¹²⁶ If supply is cut, the global technology and energy sectors risk severe disruption or collapse, and no stockpile could ever cover that level of wider industrial demand.

It's also pointless keeping fighter jets in the air if there's no economy to sustain them, let alone build new ones. Beyond efforts such as the US having a stockpile spanning 37 minerals valued at about US\$1 billion,¹²⁷ it's far better if all AUKUS partners and friends can deliver secure on-demand supply lines in allied geographies, with redundancies. It's also unclear how much of that stockpile would be accessible without dependence on vulnerable or non-existent supply chains and manufacturing.

Where manufacturing supply chains are concerned: The F-35 and the necessity of its inclusion of Chinese rare-earth permanent magnets (REPMs) is one case in point. Concerns about Chinese REPMs contaminating the F-35 were raised back in 2012 by Northrop Grumman and Honeywell.¹²⁸

A *Defense News* media report in 2022 suggested that this dependency on Beijing remains.¹²⁹ That report may be inaccurate or less of a concern, given the US-based REPM capacity via Neo Magnequench, at least if the magnet compositions and manufacturing are fit for F-35s and all other forms of defence capability. It is, however, fair to say that the current supply chain, with its apparent dependence on a processing plant in Estonia,¹³⁰ some 20 miles down a highway from the Russian border, isn't ideal amid the war in Ukraine.

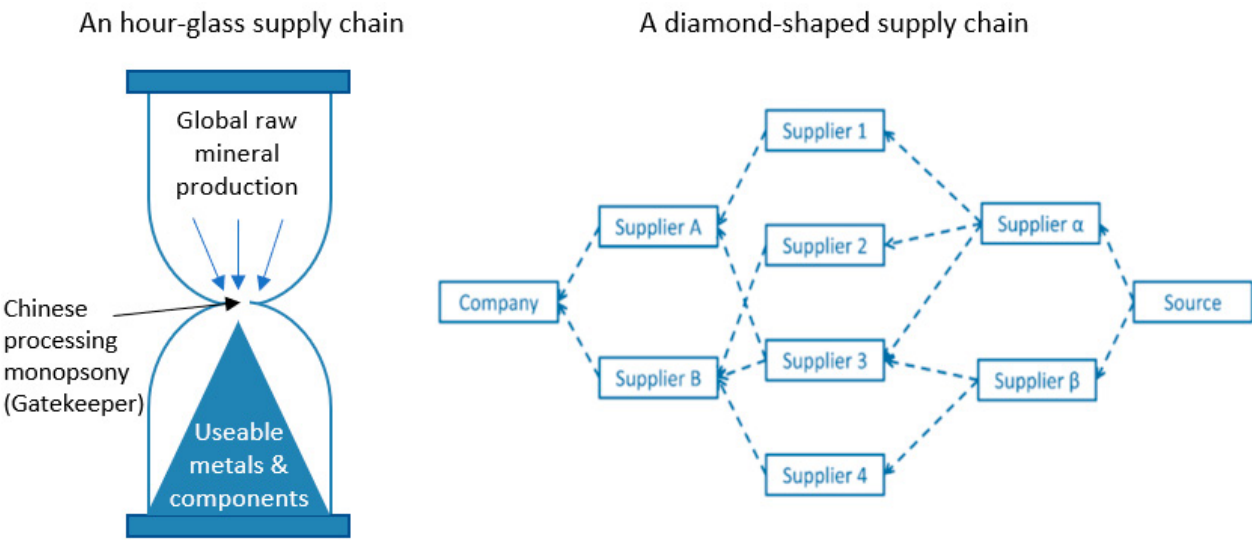
Supply chains need to be explored more holistically. After all, it matters not that semiconductor supplies flow freely again if there's no magnesium to produce the very same cars, or nickel, cobalt, rare earths or other critical minerals for that matter. The calculus is made even more challenging by the opacity and complexity of supply chains, as acknowledged by the likes of the US and Australia.¹³¹

That opacity includes both 'hourglass' supply chains in which Beijing pinches the middle, and what some refer to as 'diamond' supply chains (see Figure 3). The latter gives the sense of assurance via multiple suppliers but might hide one crucial point of failure masked by several layers of suppliers sourcing from the same (potentially 'unfriendly') point of origin.¹³²

Furthermore, unrelated to the F-35 incident above, speaking on condition of anonymity, one source commissioned to review an AUKUS nation's defence industry revealed concealment of dependence on components from strategic competitors. Industry didn't disclose those facts to government as it 'wasn't asked'.

The world enters a new age of innumerable supply-chain risks, including via an escalation of military posturing in Europe and around the South China Sea. Without secure critical-mineral supply chains, beyond just mineral reserves and mine production, the very fabric of world manufacturing and associated economies are at risk. War-winning (or -detering) military capabilities that aren't relegated to using inferior substitutes are also highly vulnerable. Government intervention rallied by AUKUS is vital.

Figure 3: Illustrative critical-mineral supply-chain vulnerabilities



Source: Diamond chain: Gene Slowinski, Darin Latimer, Stewart Mehlman, ‘Research-on-research: Dealing with shortages of critical materials’, *Research Technology Management*, 2013, 56(5), [online](#).

Notes

- 1 The Brookings Institution notes that ‘China currently controls most global critical minerals refining.’ While that report is primarily in the context of critical minerals for energy purposes, the same minerals are integral to defence production. While the RAND Corporation suggests that 18 of the 37 minerals critical to defence capability are concentrated in China, based on current mineral processing and other operations enabling usable mineral forms necessary for manufacturing goods. Other concerning imbalances in global mineral-supply diversification include rare earths and magnesium (which is vital for mass military production). Where rare earths are concerned, China has firm control over at least 94% of world supply, and some 3,300 items of US military equipment, from nuclear missiles and combat systems to what reasonably appears to be all air, land, sea, space and cyber platforms, are dependent on rare earths (see ‘Case study: Rare earths—‘vitamins’ of defence capability’ in this paper), further noting that 16 of the 17 different rare-earth elements account for one-third of the US’s list of 50 critical minerals. Magnesium production, as a key enabler of mass military production, is 90% controlled by China (see the ‘Magnesium’ case study in this paper). R Castillo, C Purdy, *China’s role in supplying critical minerals for the global energy transition*, Brookings Institution, July 2022, [online](#). See also C Weinbaum, C O’Connell, SW Popper et al., *Assessing systemic strengths and vulnerabilities of China’s defense industrial base*, RB-A930-1, RAND Corporation, Santa Monica, 2022, 13 December 2022, [online](#). The figure of 94% is based on the US Geological Survey’s 2022 ‘Mineral commodity summary: Rare earths’, which states that global rare-earth production was 280,000 tons in 2021. A Lynas shareholder report for FY2021 notes that Lynas’s total rare-earth ore production was 15,761 tons. Lynas is the only industrial-scale producer independent of the Chinese processing chain (although some of that production is understood to be processed in China, too).
- 2 ‘How AUKUS is performing against China in critical minerals extraction and processing’, *Critical Technology Tracker*, ASPI, Canberra, 2023, [online](#).
- 3 Various industry media reports further corroborated by Professor Dudley Kingsnorth advising that the once 150 strong privately owned companies have essentially been replaced by only two major Chinese state-owned enterprises, with a third state-owned enterprise providing minor production of rare earths. The other three are essentially mothballed.
- 4 Albert Zhang, ‘The CCP’s information campaign targeting rare earths and Australian company Lynas’, *The Strategist*, 29 June 2022, [online](#).
- 5 Donald J Trump, Executive Order 13817, ‘A federal strategy to ensure secure and reliable supplies of critical minerals’, 20 December 2017, [online](#).
- 6 ‘Joint leaders’ statement on AUKUS’, The White House, 15 September 2021, [online](#).
- 7 Moreover, the supply of many critical minerals integral to military manufacturing appears destined to be further destabilised by burgeoning demand from the green-energy and automobile sectors. Some, like President Joe Biden, believe that demand for many of those minerals may grow by 400%–600% over the next several decades. ‘Remarks by President Biden at a virtual event on securing critical minerals for a future made in America’, The White House, 22 February 2022, [online](#). It’s also worth noting that mineral production and processing lead times commonly require a decade or more, which affords little agility in responding to crises without concerted, longer term remediation occurring.
- 8 ‘Mineral commodity summaries: Magnesium’, US Geological Survey (USGS), 2023. Based on China’s annual share of world primary smelter production of 900,000 tonnes of magnesium out of a total of 1,000,000 tonnes in 2022.
- 9 Various global publications, including L Kijewski, H Cokelaere, ‘Supply chains scramble threatens to spoil German Christmas’, *Politico*, 10 November 2021, [online](#).
- 10 ‘GT Voice: Magnesium shortage highlights need for global coordination’, *Global Times*, 25 October 2021, [online](#).
- 11 ‘Mineral commodity summary: Magnesium’, USGS, 2022, 2.
- 12 ‘Mineral commodity summary: Magnesium’, USGS, 2023.
- 13 For instance, the Center for Strategic and International Studies suggests that some 7,000 US Javelin advanced anti-tank weapon systems have been sent to Ukraine as at April 2022, or about one-third of the US arsenal, which will take years to replenish. M Cancian, *Will the United States run out of Javelins before Russia runs out of tanks?*, Center for Strategic and International Studies, 12 April 2022, [online](#).
- 14 Department of Industry, Science, Energy and Resources, ‘2022 Critical Minerals Strategy’, Australian Government, 16 March 2022, [online](#).
- 15 ‘Resilience for the future: the United Kingdom’s Critical Minerals Strategy’, UK Government, 22 July 2022, [online](#); ‘US Geological Survey releases 2022 list of critical minerals’, media release, USGS, 22 February 2022, [online](#).
- 16 This is reflected in Geoscience Australia’s longstanding definition of critical minerals, which changed recently from: ‘Metals and non-metals that are considered vital for the economic well-being of the world’s major and emerging economies.’ That definition had determined a long ‘global’ list and might have inadvertently cultivated a mindset that’s grown strategic risk. Geoscience Australia’s critical-minerals definition produced in 2022 suggests that a more balanced approach is emerging, driven by a definition centred on ‘modern technologies, economies or national security’ and ‘supply chains’. However, its wider policy advises that ‘The Australian Government considers 26 [technically

- 47] resource commodities to be critical minerals. These have been *selected by assessing Australia's geological endowment and potential with global technology needs.*' While it's important to weigh this consideration, the approach may deprioritise our own needs to uphold societal continuity if not offering a direct economic benefit. Geoscience Australia, 'Critical minerals at Geoscience Australia', Australian Government, 10 May 2023, [online](#). It's 'technically 46' if we adopt the US's more dependable methodology to specify particular rare earths and platinum group metals, given their different mine concentrations and applications ranging from fluorescent lighting to space travel.
- 17 World Bank data referenced in the Fertilizers Price Index: figures compared between January 2021 (index 83) and April 2022 (index 255), representing a 307% increase. Available from *YCharts*, [online](#).
- 18 In 2022, according to three different senior executive-level WA farming representatives with many years of experience, fertiliser shortages were expected to have reduced agricultural production by some 10% by volume in WA (and possibly in other geographies, too). However, they also noted that this wouldn't be noticed amid record harvests driven by optimal seasonal rains and record food prices, disguising the impact of ceasing planting in less nutrient-rich farming fields or rationing fertiliser supplies due to supply shortages and cost increases.
- 19 See endnote 9.
- 20 Either bilaterally or multilaterally and often via duplicative partnerships, including among Japan, the US, India, Canada, the UK, Korea, France, Germany, Finland and Sweden, plus the European Commission (in order of pseudo ratification). While such memorandums of understanding aren't legally binding, especially when established in great numbers, they tend to cultivate layers of diplomatic agendas that often compromise timely, optimised action.
- 21 The 'Quad', comprising India, Japan, the US and Australia.
- 22 As advised by Professor Dudley Kingsnorth (interview, 12 December 2022): 'Although billions of dollars have been invested in Australian rare-earth projects over 30 years, today there's no processing beyond the production of a mineral concentrate to be processed overseas. The situation will be partially rectified in 2023 but only through to the production of a mixed rare-earth carbonate; which is inadequate.' The next step of rare-earth separation is the real game-changer in terms of value-add and the ability to support a larger market. Mineral engineer and investment broker Dylan Kelly, of Ord Minnett, notes about a 15-fold increase in value-add for the difficult art of separation. Furthermore, despite many multilateral meetings to promote the concept of developing critical-mineral supply chains, there's only one 'new' project that's funded through to the production of separated rare earths (Iluka's Eneabba project).
- 23 Interview, 12 December 2022.
- 24 For example, the International Labour Organization's 'C138—Minimum Age Convention, 1973 (No. 138)' ([online](#)) has been ratified by countries such as the UK and Japan, but not Australia nor the US. 'Principle 5 (Labour)' of the United Nations Global Compact ([online](#)) speaks to inconsistencies among national efforts to combat child labour, in its reference to the ILO Convention no. 182, which 'requires Governments to give priority to eliminating the worst forms of child labour undertaken by all children under the age of 18 years'. It's also widely known among those in the resources sector that there's wide variation in advocacy both for and against implementing mineral-tracing systems that could identify the source of mineral supplies to confirm whether they're from environmentally or ethically questionable suppliers.
- 25 It's widely recognised that mining might commonly only capture some 3% of the potential value chain, while 97% of economic value is captured from the point of processing minerals to the manufacturing of end products, such as lithium batteries (that is, 'downstream').
- 26 This is consistent with USGS data on economically proven reserves globally (Figure 2 helps to illustrate this), alongside the current and emerging mineral demands of this fourth industrial age, and for defence capability, especially should mass-production requirements emerge in contest with civil-sector demand.
- 27 For example, Chinese vertical integration—taking direct ownership (or control) of various stages of production without dependence on a pastiche of other actors—is perhaps best illustrated by the JL MAG Rare-Earth factory in Ganzhou. JL MAG is a remarkable 'one-stop shop' for taking rare-earth minerals and processing them into end products, such as rare-earth permanent magnets, at the one site. In comparison, the rest of the world has its supply chains scattered globally among a very few capable stakeholders of varying degrees of dependability and geopolitical alignment. Further, noting only one broadly equivalent non-Chinese solution globally, that spans at least Australia, Malaysia (reportedly known to be undermined by Chinese-Malay parliamentary lobbyists, according to various industry leaders) and Japan. That arrangement is littered with single points of failure that don't stack up to any typical standard sought by the national-security fraternity. While mineral-dependent semiconductors and jet engines are among the apparently few exceptions for which Beijing can't deliver 'mine to battlefield' production, that's primarily due to a lack of scientific expertise in those enormously complex sciences.
- 28 Taken to mean proven and commercially viable mineral reserves. For instance, the largest magnesium resources are held in seawater and brines, yet mining mostly occurs from magnesium-bearing minerals. For rare earths, for example, the Massachusetts Institute of Technology notes that 'While most of these elements are not actually rare in terms of the general amount of these elements in the earth's crust, they are rarely found in sufficient abundance in a single location for their mining to be economically viable'. 'Rare earth elements', *Mission 2016: The future of strategic natural resources*, Massachusetts Institute of Technology, no date, [online](#).
- 29 A Panetta, 'Canada, a critical-minerals superpower? Let's pause for a reality check', *CBC News*, 26 November 2021, [online](#).
- 30 This is perhaps unfair to Turkey (10th) as a member of NATO, and also to India (11th) as a valued Quad member that seems to be slowly rethinking its long-held position of strategic autonomy. Nevertheless, security relationships with both remain tenuous, including because of their associations with Russia as an increasingly concerning autocracy under Putin. Further, where India is concerned, predictable voting or abstention in favour of Russia in international forums is an inconsistent trait that's significant for traditional Western security partners. Turkey also behaves haphazardly on paramount security matters. That includes the widely reported attempts by Erdogan to procure Russian S400 surface-to-air weapons systems that would have severely compromised nations flying the F-35, which is a primary pillar of national defence for 10 countries and is integral to the defence of the liberal-democratic order globally.
- 31 Data for 2021. Sources: USGS, [online](#); Government of Canada, [online](#); WA Department of Mines and Petroleum, [online](#). Conversion rates: A\$1 = 67 US cents; C\$1 = 75 US cents.

- 32 Producers of tantalum include a list of African producers with histories of frequent conflict. Russia must be viewed as an unreliable supplier based on its aggression towards other states and its hostility to AUKUS. Bolivia has only minuscule production of 7 tons. Australia also has more than double the proven reserves (94,000 tons) of second-place Brazil (40,000 tons)—almost all of it in WA.
- 33 Professor Daniel Packey, Curtin University, Perth, WA, 2018. Based on a 2010 figure of 3,264 items of military equipment assessed in studies led by the US Merchant Marine. This figure is probably outdated but, short of a more contemporary calculation, the magnitude might reasonably be expected to be of the same broad order.
- 34 Heavy rare earths are defined by their higher atomic weights. They're more scarce than light rare earths, although not necessarily in higher demand, bar a few exceptions, such as dysprosium and terbium, and potentially yttrium, subject to considerations such as the volume of F-35 production in a particular year. Heavy rare earths also tend to be less commonly substitutable by less critical minerals, which would compromise metal and other material properties.
- 35 Various industry media reports further corroborated by Professor Dudley Kingsnorth, advising that the once 150 strong privately owned companies have essentially been replaced by only two major state-owned companies, plus a third state-owned rare-earth operation with minor production. The other three are essentially mothballed.
- 36 S Hanke, *China rattles its rare-earth-minerals saber, again*, Cato Institute, 25 February 2021.
- 37 Among the various reports is the *Radio Free Asia* news service covering issues of environmental degradation, corruption and control, including that overseen by the local warlord in charge of the Myanmar rare-earth mining territory (Kachin Special Region 1) as the 'central broker of Myanmar's rare earths', also citing Global Witness' 'Myanmar's poisoned mountains' report; 'China-led rare earth mining in Myanmar fuels rights abuses, pollution: report', *Radio Free Asia*, 9 August 2022, [online](#).
- 38 D Kang, V Milko, L Hinnant, "'The sacrifice zone': Myanmar bears cost of green energy', *The Associated Press*, 10 August 2022.
- 39 Kang et al., "'The sacrifice zone': Myanmar bears cost of green energy'.
- 40 ABC Australia reports that the total coalition deaths from the 1990–91 Gulf War were fewer than 200 people; Mark Corcoran, 'Australia in Iraq: a brief history of Australia's involvement from 1991–2014', *ABC News*, 17 September 2019, [online](#). The *Australian Financial Review* reported that the Brumadinho mine disaster of 25 January 2019 saw 231 killed and 40 still missing; Bryan Harris, Andres Schipani, Neil Hume, 'Fallout from dam disaster piles up against Vale', *Australian Financial Review*, 27 May 2019, [online](#).
- 41 More generally, free thought and action are highly constrained within China as a self-proclaimed 'people's democratic dictatorship' (as the Constitution of the People's Republic of China puts it) with a monopoly on power and no direct national elections. Increasingly, this is evidenced by contemporary measures such as the CCP's pervasive social credit system, the momentary disappearance and reprimand of billionaire and former richest Chinese person Jack Ma, who questioned the business conditions set by the CCP, and legislation such as the National Intelligence Law, which stipulates that 'any organization or citizen shall support, assist and cooperate with State intelligence work'. Such 'intelligence work' is both interpreted liberally and known to saturate the social sphere both domestically and internationally. As noted by US intelligence veteran Nicholas Eftimiades in *Chinese intelligence operations*, China's reach readily extends globally. He asserts that 'the Ministry of State Security will continue to penetrate and exploit the political, academic, industrial and technological institutions of Western nations.' That includes via an eight-stage process to effect coercion aimed at students, other diasporas and travellers who risk severe punishment and that of their domestically residing family members in the event of noncompliance. This assertion is backed by one CEO with decades of experience in different roles in Australia's critical-minerals sector, who believes that there have been two types of Chinese representatives on their boards: those vulnerable to be leveraged as Chinese agents of influence, and those already with strict allegiance to, and acting strategically in the interest of, the CCP. Clive Hamilton's *Silent invasion: China's influence in Australia* also suggests a comprehensive Chinese statecraft with distant reach. While not explicitly singling out China, the then head of the Australian Security Intelligence Organisation (Australia's FBI equivalent) suggested during Senate Estimates that acts of foreign interference were 'occurring at an unprecedented scale' in Australia. Further, that 'Foreign actors from a range of countries are seeking to access privileged and/or classified information on Australia's ... mineral resources and our innovations in science and technology.' Senate Committee Hansard, Australian Parliament, 31 January 2018, 18.
- 42 Some, like Dr Wilson (then head of economics and research at the Perth USAsia Centre), have noted that this processing monopsony is very real and far-reaching. It's vital to the vertical integration that's sought by many nations and indeed China's supply assurances. In a worse case, the monopsony also empowers the means of economic coercion to leverage others and can be used to influence market conditions to render non-Chinese mineral producers and product manufacturers unviable.
- 43 M Garside, 'Market value of iron ore mining worldwide from 2011 to 2021', *Statista*, 6 December 2021, [online](#).
- 44 BHP and Rio Tinto are notably ahead of all others. Based on a *Mining.com* assessment drawn from Mining Intelligence, Morningstar, Google Finance, stock-exchange data and company reports. Cross currency rates at 3 October 2022.
- 45 *The role of critical minerals in clean energy transitions*, World Energy Outlook special report, International Energy Agency, revised version, March 2022, 66.
- 46 The Council on Foreign Relations notes that electric cars and other new-energy vehicles, next-generation information technology and telecommunications, and advanced robotics and artificial intelligence are chief among the 10 high-tech industries. The council also notes forced-transfer agreements to harvest intellectual property from foreign companies. James McBride, Andrew Chatzky, 'Is "Made in China 2025" a threat to global trade?', *CFR*, 13 May 2019, [online](#).
- 47 Various reports, including by *Reuters*, refer to a range of Chinese measures to downplay 'Made in China 2025' in response to international backlash, and the cessation of all state-media commentary on the policy since 5 June 2018; Michael Martina, Kevin Yao, Yawen Chen, 'Exclusive: Facing US blowback, Beijing softens "Made in China 2025" message', *Reuters*, 25 June 2018, [online](#). The original quotation by the State Council featured here is no longer accessible. A similar translation of the 2015 'Made in China 2025' publication is available from the Center for Security and Emerging Technology at Georgetown University, 8 March 2022, [online](#).
- 48 Analyses tend to focus on electric vehicles, which are both a burgeoning subsector and vastly more critical-mineral-intensive than cars with internal-combustion engines. For example, the International Energy Agency (IEA) suggests that electric-vehicle demand will need

to surge towards 2050, including due to announced combustion-engine bans planned for the 2030s and net-zero pledges towards 2050; *Technology and innovation pathways for zero-carbon-ready buildings by 2030*, IEA, September 2022, [online](#). Further, the agency suggests that, unlike conventional vehicles, which commonly require critical minerals in the order of 33 kilograms of nickel and copper, electric vehicles require more than 200 kilograms of some 10 critical minerals; 'Minerals used in electric cars compared to conventional cars', IEA, 26 October 2022, [online](#).

- 49 The focus on this sector is perhaps no surprise, given that the next biggest is consumer electronics, itself worth some US\$1,500 billion and equally, perhaps even more, dependent on critical minerals to satisfy consumer demand. Figures from a former Stratfor and US Department of State analyst in P Zeihan, *The end of the world is just beginning: mapping the collapse of globalization*, HarperCollins, 2022, 385.
- 50 'Mineral commodity summary: Lithium', USGS, 2022, 2.
- 51 Weinbaum et al., *Assessing systemic strengths and vulnerabilities of China's defense industrial base*.
- 52 For example, engineering via automaker production lines has historically been the bedrock of national mobilisation in times of war. The last three automakers in Australia closed within the past decade—Ford (2016), Toyota (2017) and General Motors (aka Holden, 2017). Meanwhile, *Statista* suggests that the number of cars made in the UK has been in steady decline since 2017, and a once long list of UK-owned automakers have been bought out, bar Morgan Motors, which makes as few as 200 novelty cars in a year (Toyota makes 200 cars in 10 minutes).
- 53 Context is important here. Australia's total population is merely 70% of Tokyo City's, and its economy is just 9.4% of China's (nominal terms, 2022). This is indicative of Australia's insufficient state power, including investment potential and strategic capital to lever its enormous mineral endowment at scale. That involves delivering complete supply-chain solutions ('vertical integration') independently of monopoly holders. The strategic might of the US is a different story: it's more than sufficient—ideally with the UK bringing up the rear, along with AUKUS partners in seeking secure critical-mineral supply chains. To date, this ultimately amounts to scattergun measures short of anticipated future demand.
- 54 William Clowes, Michael J Kavanagh, 'Biggest African bank leak shows Kabila allies looted Congo funds', *Bloomberg*, 19 November 2021, [online](#); Eric Lipton, Dionne Searcey, 'How the US lost ground to China in the contest for clean energy', *New York Times*, 21 November 2021, [online](#).
- 55 David Uren, 'How China wrestled control of the Congo's critical minerals', *The Strategist*, 6 December 2021, [online](#).
- 56 This paragraph's data and summation regarding inferior and few substitutes is drawn from 'Mineral commodity summaries: Cobalt', USGS, 2022.
- 57 Weinbaum et al., *Assessing systemic strengths and vulnerabilities of China's defense industrial base*, 5.
- 58 Includes majority Chinese ownership among key operations. While such backing is good for the creation of new operations, it undermines the essential diversification that the global minerals sector requires.
- 59 Bevis Yeo, 'Eye on lithium: Australia keen for critical minerals investment from "allies"', *Stockhead*, 25 November 2022, [online](#).
- 60 Dylan Kelly, mining equity analyst, Ord Minnett.
- 61 They also need to manage radioactive substances such as uranium and thorium that are among the rare-earth minerals. This fact is unnecessarily alarming to those unaware of benign and easily managed doses, although they warrant radiation signage. We note that Lynas claims that rare-earth processing workers at its Malaysia node have annual exposure of about one-quarter of Malaysia's accepted safe amount.
- 62 The 13 OPEC countries control about 40% of crude oil production; China alone eclipses that control for at least half of the critical minerals, including 94% of rare-earths production (16 of the 17 minerals). A RAND study notes Chinese concentrations in 18 of the 37 defence critical minerals based on active production. Based on '2022 Mineral commodity summary: Rare earths', USGS, 2022, stating 280,000 tons of global rare-earth production in 2021. The Lynas shareholder report for FY2021 notes that its total rare rare-earths production was 15,761 tonnes—making Lynas the only industrial-scale producer independent of Chinese processing chains (some is understood to be processed in China, too). China's position of power is further illustrated in 'How is AUKUS performing against China in critical minerals extraction and processing', *Critical Technology Tracker*, ASPI, Canberra, 2023, [online](#).
- 63 Australian rare-earth operators also suggest that 'open chequebook' business is sometimes barely curtailed by foreign investment review boards. And, where it's curtailed by the boards, risks them being non-viable without Chinese capital.
- 64 For example, Beijing's 13% VAT rebate for rare earths in 1985, which was instrumental in China commencing its rise to global domination in that sector the following year. Similarly, its rapid response via tax breaks in 2021 for its magnesium sector either inadvertently or intentionally staved off Western attempts to gain a more substantial slice of global magnesium production. For example, China's global share of magnesium production rose from 84% to 90% in the face of new Western start-ups that history suggests won't survive against more favourable Chinese industry conditions.
- 65 Mary Hui, 'What are critical minerals?', *Quartz Journal*, 14 September 2021. Hui notes this distinction made by academics and experts at a strategic minerals conference held by the Chinese Academy of Engineering, based on a summary published by *China Natural Resources News*, under supervision of the Chinese Natural Resources Ministry.
- 66 The scale of fourth industrial revolution technology such as computers and smart devices, as well as enormous military expansion since 2014 (especially by China), might reasonably bring this annual figure to US\$6,000 billion today.
- 67 Based on 'Mineral commodity summary: Rare earths', USGS, 2022, which states that global rare-earth production in 2021 was 280,000 tons. The Lynas shareholder report for FY 2021 notes that Lynas's total rare-earths production was 15,761 tonnes.
- 68 Interview with Dr Jeffrey Wilson, (then) Director of Research, Perth USAsia Centre, August 2020. Direct statements from Jamie Smyth, 'The battle to wean the world off China's rare earths', *Australian Financial Review*, 15 September 2020, [online](#).
- 69 James Kennedy, 'China solidifies dominance in rare earth processing (updated)', *National Defense*, 21 March 2021, [online](#).

- 70 The dispute over islands in the East China Sea, which commenced in 2010, eventually led to a World Trade Organization ruling against China's cessation of exports in 2014, upon appeal by several affected countries.
- 71 Although well after the dispute commencing in 2010, in 2017 this trade was still estimated at about 35,000 tons (noting that total world production in 2017 was 130,000 tons), or roughly double that of Lynas's production today. The Chinese black-market trade is believed to be in the order of about 5,000–10,000 tons annually today, according to Professor Kingsnorth.
- 72 JHL Voncken, 'The rare earth elements—a special group of metals', in *The rare earth elements: an introduction*, Springer, 2016, 1–13. The author cites USGS time-series data from 2015.
- 73 T Pui-Kwan, *China's rare-earths industry*, USGS, 2011, [online](#).
- 74 Pui-Kwan, *China's rare-earths industry*.
- 75 Based on 'Mineral commodity summary: Rare earths', USGS, 2022 which states that global rare-earth production in 2021 was 280,000 tons. The Lynas shareholder report for FY2021 notes that Lynas's rare-earths production was 15,761 tonnes.
- 76 The initial figure estimating rare-earth industry enabling production of ~US\$4,000 billion was provided by mathematician Professor KG van den Boogart at the SME Critical Minerals Conference in Denver in August 2014. The enormous expansion of rare-earth-related original equipment manufacture, including green energy products such as wind turbines and electric vehicles, and the scale of fourth industrial revolution technology such as computers and smart devices, as well as enormous military expansion since 2014 (especially by China) might reasonably see this figure rise to \$6,000 billion today.
- 77 The RAND Corporation notes a combination of economic and diplomatic efforts in these countries in Weinbaum et al., *Assessing systemic strengths and vulnerabilities of China's defense industrial base*, 52–53.
- 78 Sources: USGS, [online](#); Government of Canada, [online](#); WA Department of Mines and Petroleum, [online](#). Conversion rates: A\$1 = 67 US cents; C\$1 = 75 US cents. While some may assert that this is mostly iron ore by value, that wouldn't factor WA's enormous economically proven reserves and current lithium and rare-earth production, or that, conversely, enormous value is derived from North American construction sand and gravel.
- 79 A trusted inner circle of national-security stakeholders comprising the US, UK, Australia, Canada, and New Zealand.
- 80 'A mandatory system for the classification of minerals exploration results, mineral resources and ore reserves according to the levels of confidence in geological knowledge and technical and economic considerations in public reports'; 'What is the JORC Code?', JORC, 2023, [online](#).
- 81 High: cobalt, gallium, germanium, hafnium, lithium, magnesium, niobium, rare earths (16 types), scandium, silicon, tantalum, titanium, tungsten, vanadium, zirconium. Moderate: high-purity alumina, antimony, beryllium, bismuth, chromium, graphite, indium, platinum group metals (6 types), rhenium. Geoscience Australia, 'Critical minerals at Geoscience Australia, Australian Government, 2023, [online](#).
- 82 'Projects and exploration', *Australian Minerals*, Australian Government, 2023, [online](#).
- 83 Although the value of further exploration is doubtful for the time being. The use of existing mines and creating new processing supply chains serving diversification are the key.
- 84 Department of Mines and Petroleum exploration data, referenced in proceedings of the Critical Minerals Roundtable, Government House, Western Australia, 4 May 2022.
- 85 'WA Economic Profile reporting data for the 2021 calendar year', WA Department of Jobs, Tourism, Science and Innovation, July 2022.
- 86 For example, the US Department of Energy notes that most electric, hybrid and plug-in hybrid cars, as well as portable consumer electronics such as mobile phones and laptop computers, depend on lithium batteries.
- 87 According to the former head of Australia's Critical Minerals Facilitation Office, Jessica Robinson, aspirations include to 'move up the value chain to processing, separation, refining and niche manufacturing capabilities.' 'Rare earths and critical minerals provide significant opportunities for Australia', *Resourceful*, CSIRO, issue 22, no date, [online](#).
- 88 This generous arrangement in both the amount and conditions that favour the borrower also precludes the need to stitch offtake agreements together to fund the initiative or to seek one very generous offer from China for the entirety of the supply. That would probably have served to undermine global mineral diversity in feeding the established Chinese processing behemoth with this vast share of feedstock, undermining the ability of other parties outside China to establish themselves as viable operations.
- 89 For instance, see 'QS world university rankings by subject 2022: mineral & mining engineering', *QS Top Universities*, [online](#). Note that Curtin University is listed in reference to its WA School of Mines.
- 90 For example, around the 2012 mining boom period when Curtin MBA graduate pay ranked first, and Harvard second.
- 91 'Joint leaders statement on AUKUS', The White House, 15 September 2021, [online](#).
- 92 'UK Critical Minerals Strategy', UK Government, 22 July 2022, [online](#).
- 93 *Critical minerals refresh: Delivering resilience in a changing global environment*, UK Government, 13 March 2023, [online](#). See also *Integrated review refresh 2023: responding to a more contested and volatile world*, UK Government, March 2023, [online](#).
- 94 China appears to be the only nation to have successfully fused technical and strategic mineral expertise.
- 95 'Remarks by President Biden at a virtual event on securing critical minerals for a future made in America', The White House, 22 February 2022, [online](#).
- 96 'Remarks by President Biden at a virtual event on securing critical minerals for a future made in America'. Incidentally, high-performance rare-earth permanent magnets are possibly the most integral technological input for delivering-cutting edge defence capability to win or deter the next war, or at least matching the likes of nanotechnology, quantum computing and artificial intelligence.
- 97 'Remarks by President Biden at a virtual event on securing critical minerals for a future made in America'.
- 98 Department of State, '2022 supply chain ministerial', US Government, no date, [online](#).

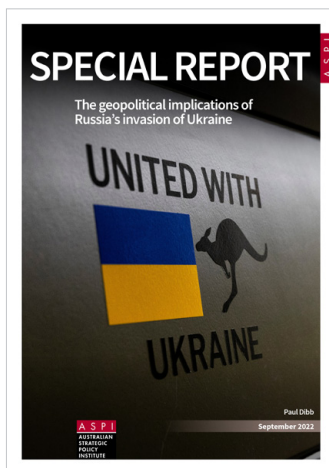
- 99 Industry Trade Advisory Center, 'ITAC 5 overview', International Trade Administration, Department of Commerce, US Government, no date, [online](#). The ITAC 5 charter pertaining to critical minerals was filed on 24 February 2022.
- 100 State Council Information Office, 'Full text: China's export controls', PRC Government, 29 December 2021, [online](#). Note that, while these export controls address threats to Chinese national security and interests, the term used by China in the official English translation is 'safeguarding'.
- 101 Damon Kitney, 'US will "go nuts" on China: Hockey', *The Australian*, 24 October 2022, [online](#).
- 102 Mitt Romney, 'Romney, Sullivan introduce bill to secure US critical mineral independence from China', news release, 12 July 2022, [online](#).
- 103 Beyond offsetting the risk of underestimating demand, any surplus could help to meet any future surge requirements and be a vital supplement for allied partners beyond any co-investment with AUKUS.
- 104 Including total dependencies and single points of failure across the supply-chain spectrum. Information should be held and handled with the highest security (notwithstanding that shortfalls are easy to ascertain, including due to the scarcity of non-Chinese infrastructure). Estimate based on common belief that above \$1 billion is needed for building a single rare-earth processing operation, without any guarantee of success. Although only a handful of new rare-earth processing operations would be required if this is done correctly, other operations are needed to cover a range of other critical minerals, including titanium and magnesium.
- 105 Inform national treasuries of the evidence (consistent with the advice of President Biden, original equipment manufacturers, the World Energy Forum, the IEA and leading consulting firms) that the world is on the precipice of booming if not exponential demand for critical minerals. Nations with secure supply can participate in the most lucrative current and near-future industries, including electrified automobiles and green energy, without supply risks that may potentially render many national industries unviable.
- 106 Fergus Hunter et al. suggest that China's coercive tactics are increasing and offer possible solutions to mitigate the challenge; Fergus Hunter, Daria Impiombato, Yvonne Liu, Adam Triggs, Albert Zhang, Urmika Deb, *Countering China's coercive diplomacy: prioritising economic security, sovereignty and the rules-based order*, ASPI, Canberra, 22 February 2023, [Online](#).
- 107 Shifts in the critical-mineral strategic calculus can be rapid, and distraction may compound mineral deficits. The Silmet rare-metal plant in Estonia, 20 miles from the Russian border, is strategically vital and risks compromise amid the Ukraine War.
- 108 Primarily intended for Australia. Ideally, also encourage Canada to do the same, and, as a trusted Five-Eyes partner, ask New Zealand to redress its ongoing delays in identifying its own critical-mineral vulnerabilities.
- 109 Consider minerals for which the USGS advises that the government has no or modest stockpiles, including magnesium and titanium, which are vital to rapid mass military production and resource-intensive platforms.
- 110 Interagency placements alone would prove insufficient for connecting strategic risks and opportunities.
- 111 Interagency placements alone would prove insufficient for connecting strategic risks and opportunities.
- 112 Push for several common-user processing facilities. New supply will otherwise remain heavily dependent on the Chinese mid-supply-chain processing monopoly.
- 113 The US's Defense Authorization Act of 2021 asked for the identification of intelligence and other information requirements to address foreign defence industrial bases' strength and weaknesses. RAND Corporation studies assert that this should be applied to assessing China's critical-mineral inputs.
- 114 Governments tend to engage through national capitals. Act on a coordinated AUKUS plan while encouraging the sentiment that best results may come from direct industry interactions, especially in WA, further noting that the resources and government sectors aren't always in perfect alignment. Chinese companies and those with allegiances to CCP officials have had great success in securing control of vital assets in direct engagement with WA industry.
- 115 One WA-based company (a deprioritised small-volume exporter) wishes to sail from Fremantle but must truck across the continent to Sydney to then ship low-volume, high-impact critical minerals to the US. For context: the entire annual global rare-earths supply would take up about half of the storage capacity of one supertanker. Split across many trades, critical minerals tend to require comparably very little storage volume.
- 116 This framework could quickly launch as, or simply just amount to, a list of expectations. Companies neglecting fair cooperation without compelling cases might be advised that they risk less-preferred status in tender processes. Grounds for that may include compromising national security, noting that platforms such as submarines, or a handful of fighter jets, may consume the total global annual production of some exotic critical minerals with no or poor substitutes, or otherwise compromising lethality. Yttrium may be one of those minerals. In 2012, according to the US Congressional Research Service in 2015, total world production was 7,000 tonnes, and almost 100% of supply was from China. It's widely asserted that 417 kilograms of yttrium is needed for one F-35, and US Congressional Research Services has shown that total annual global production in 2012 was enough for just 17 jets.
- 117 John S McCain National Defense Authorization Act of 2019, signed into law by the President in August 2018.
- 118 As an aside: the possibility of government commandeering critical minerals for defence or critical infrastructure purposes from 'Forbes 500' type companies would be enormously and unnecessarily disruptive politically, economically, legally and socially.
- 119 Professor Dudley Kingsnorth suggests that China has many hundreds of PhDs related to rare earths. He hypothesises that the rest of the world may have a total of 50. The Colorado School of Mines and the Western Australian School of Mines, as world-leading colleges ranked vastly above all other mineral research universities, might usually have but two metallurgists each, with few others nationally. The UK is understood to be similarly constrained.
- 120 Although not entirely realisable, new solutions in this area may deliver some crucial contingency options. Honda and Daido Electronics are key players in such endeavours for rare earths, and partnership could be explored.
- 121 This approach was deemed a necessity during major strategic competition with the Soviet Union, as reflected in US congressional deliberations in 1985. The issue is more vital now, given China's activity beyond that of the Soviet Union.

- 122 For example, an Australian company has a critical 15% niobium oxide (high-grade) mix sitting idle in the US. Furthermore, Geoscience Australia notes that the production of many critical minerals is strongly dependent upon the production of other major commodities via product (or companion metal) recovery, and many are not yet being extracted. That includes for copper, zinc, lead and nickel mining. The USGS also notes the importance of by-product critical-mineral sources (although they should be viewed as useful supplements and not depended on).
- 123 Studies have occurred over a decade, but no successful commercialised outcome at scale has been apparent so far. Recycled sources seem likely to become increasingly important, and non-profitability will constrain viability.
- 124 This might focus principally on rare earths, given how little processing expertise there is outside Chinese-state control. The Australian Nuclear Science and Technology Organisation, the CSIRO and companies Carester (France) and Lynas (Australia) possess vital but insufficient expertise.
- 125 For example, the USGS is arguably the world's leading geological survey, but Geoscience Australia tends to take a more conservative approach compared to the USGS. For example, the USGS raises Australia's own-assessment of JORC-compliant rare-earth reserves by 25% (and doubles the quantities in other Australian critical-mineral assessments). Mineral reserve claims in nations outside the West are often highly dubious. As an aside: the Australian Department of Industry notes that 'well-established mining regions cover just 20% of Australia. The remaining 80% is largely under-explored.' Geoscience Australia rates Australia's geological potential for further critical minerals high or moderate for a wide range of critical minerals:
 High: cobalt, gallium, germanium, hafnium, lithium, magnesium, niobium, rare earths (16 types), scandium, silicon, tantalum, titanium, tungsten, vanadium, zirconium.
 Moderate: high-purity alumina, antimony, beryllium, bismuth, chromium, graphite, indium, platinum group metals (6 types) and rhenium.
 'Moderate' might tend to equate to 'high' or 'very high' in other non-Australian assessment settings. According to the WA Department of Mines, Industry Regulation and Safety, despite WA's wealth of critical minerals, 75% of exploration in WA is focused on iron ore or gold, and there's a marginal focus on critical minerals with vastly lower economic value but vastly higher strategic value.
- 126 Dr Jeffrey Wilson. For instance, according to USGS critical mineral summaries (2022), the US has no stockpiles of magnesium—a key enabler of rapid mass military industrial production.
- 127 Based on a 2017 figure of US\$1.152 billion. Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Strategic and Critical Materials Operations, Department of Defense, US Government, report to Congress, January 2017, 7–8.
- 128 G Pitron, *The rare metals war*, Scribe Publishing, 2020, 154–155. Pitron also outlines investigations suggesting that China acquired the necessary industrial secrets for its current precision guided missiles via the acquisition of the US military's critical rare-earth magnet maker Magnaquench in Indiana in 2006, transplanting strategic functions to Tianjin, 130 kilometres southeast of Beijing.
- 129 Stephen Losey, 'DoD Eyes waiver to resume F-35 deliveries halted over Chinese alloy', *Defense News*, 10 September 2022, [online](#).
- 130 This notable dependence on the plant in Silmet, Estonia, is apparent in the discussion between Ryan Castilloux (managing director at Adamas Intelligence) and Constantine Karayannopolous (CEO at Neo Performance Materials), occurring prior to the war in Ukraine (interview, 19 October 2021). Note that Neo Magnequench is one of Neo Performance Materials' business divisions; 'Who we are', Neo Materials, no date, [online](#).
- 131 Reflected, for example, in the Australian Productivity Commission's interim report, *Vulnerable supply chains*, 2021, and *Building resilient supply chains, revitalising American manufacturing, and fostering broad-based growth: 100 day reviews under Executive Order 14017*, The White House, June 2021.
- 132 G Slowinski, D Latimer, S Mehlman, 'Research-on-research: Dealing with shortages of critical materials', *Research Technology Management*, 2013, 56(5), [online](#).

Acronyms and abbreviations

CCP	Chinese Communist Party
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DRC	Democratic Republic of the Congo
JORC	Joint Ore Reserve Committee
NATO	North Atlantic Treaty Organization
Quad	Quadrilateral Security Dialogue
R&D	research and development
REPM	rare-earth permanent magnet
WA	Western Australia

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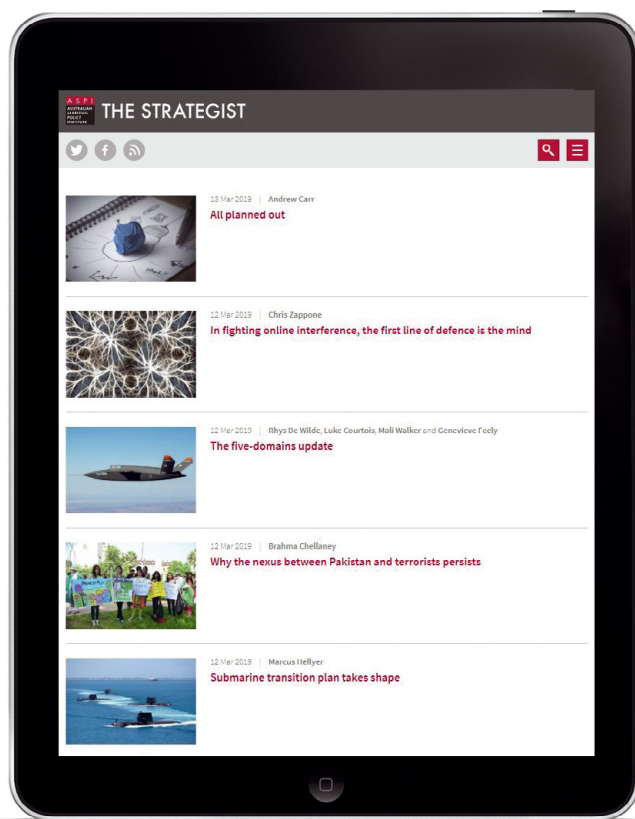


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