GREENLIGHT OR GASLIGHT?

THE TRANSITION MINERALS DILEMMA FOR AUSTRALIA

JUBILEE AUSTRALIA
RESEARCH CENTRE

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Cover photo: Lithium crusher. Credit: Jason Benz Bennee/Shutterstock

ABOUT JUBILEE AUSTRALIA RESEARCH CENTRE

Jubilee Australia Research Centre is a not-for-profit research centre based in Sydney, Australia. We engage in research and advocacy to promote economic justice for communities in the Asia-Pacific region and accountability for Australian corporations and government agencies operating there. We are an independent and not-for-profit organisation and donations are tax deductible.

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We acknowledge and pay our respects to the Gadigal people of the Eora Nation as the Traditional Custodians of the land on which our office sits. We pay our respects to First Nations peoples of all the lands on which we work, live and play, their culture and Elders past and present. We recognise that this land was and always will be Aboriginal and Torres Strait Islander land, because sovereignty was never ceded.

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GLOSSARY OF TERMS

Critical Minerals	A critical mineral is a mineral element that is essential for the functioning of modern technologies and economies, which includes but is not restricted to those for clean energy technologies. The 'criticality' aspect refers to the risk of supply chains being disrupted.
Electronic Vehicles (EVs)	Electronic vehicles (EVs) are vehicles with a motor partially or completely powered by electricity rather than liquid fuel.
EPBC Act	The Environmental Protection and Biodiversity Conservation (EPBC) Act is a legal framework which provides for the protection and conservation of Australian biodiversity, habitats, resources and environment.
Free, Prior and Informed Consent (FPIC)	Free, Prior and Informed Consent (FPIC) involves the right of Indigenous Peoples to give or withhold consent to projects and developments impacting them or their territories. It is linked to the universal right to self-determination and is recognised in the UNDRIP.
Internal Combustion Engine	An internal combustion engine is the most common form of heat engine in which the ignition and combustion of the fuel occurs within the engine itself.
Li-ion Batteries	A Li-ion or lithium-ion battery is a type of rechargeable battery that is charged and discharged by lithium ions moving between the anode and cathode. Li-ion batteries are commonly used in laptops, mobile phones and EVS.
Mineral Reserves	Mineral reserves are the portion of mineral resources in a company or nation's mineral holdings that are economically mineable or extractable.
Mineral Resources	Mineral resources are a concentration of solid materials in the Earth's crust which have reasonable prospects for economic extraction under current circumstances ie the 'working inventory' of a company's minerals.
Transition Minerals	Transition minerals are the critical minerals required for the transition to a low carbon, renewable energy economy, including but not limited to lithium, nickel, cobalt, manganese, rare earth elements and cooper.
UNDRIP	UNDRIP (The United Nations Declaration on the Rights of Indigenous Peoples) is an international instrument pertaining to the rights of Indigenous Peoples globally and has been adopted by 144 States, including Australia.

EXECUTIVE SUMMARY

RATIONALE FOR THIS REPORT

Just as we will need to stop extracting fossil fuels to burn for electricity generation and for transport, research shows that we will need to source more of the minerals that will be vital to provide the technological components of the new post-carbon age: wind turbines, solar panels, more electricity infrastructure, and, of course, more batteries both for storage and for electric vehicles (EVs). The tendency for many transition minerals to be concentrated in a small number of countries, and the domination of China in the downstream manufacturing end of the supply chain, means that there is anxiety of many in the industrialised West to seek to diversify sources of supply. Australia, rich in transition minerals and a close ally of both the United States, as well as the EU and Japan, is therefore a 'country of interest' when it comes to the new extraction of critical (and transition) minerals.

Unsurprisingly, the mining industry in Australia and elsewhere is already using the narrative about the need for new mining for the energy transition to justify a new boom—and this narrative is supported by policy analysis that projects an enormous increase in demand for new transition minerals in the coming decades. Nevertheless, these demand projections often have built in assumptions based on a 'business as usual' case that is extremely questionable. Moreover, the climate crisis is accompanied by a related problem: a biodiversity crisis, in which our planet is losing a concerning number of plant and animal species every year as we continue to degrade the natural environment. Additionally, the extraction of these minerals often has significant harmful impacts on the communities who live nearby to the deposits—particularly Indigenous communities.

This report therefore examines the reality of Australia's transition mineral reserves, the impacts that extraction could have, and the policy choices that can be taken now to both reduce the demand for these minerals and ensure that any extraction that does take place is both sustainable and respectful of the right of Indigenous communities to consent to any new mine. As Australia is currently reviewing its critical minerals strategy, now is the time to review these policy choices. The primary audience for this report is therefore federal and state government agencies and politicians in Australia who are interested in the issue of transition minerals. However, a number of secondary audiences may also be interested, including researchers, academics and policy specialists in Australia and the region who are also invested in the questions posed here.

CASE STUDIES

The foundation of the report is six individual case studies looking at key transition minerals: **lithium, nickel, cobalt, manganese, rare earth elements (REEs), and copper.** Each of the case studies looks at the application of the mineral to renewable energy, where it is found, a critical assessment of demand projections, and the social and environmental consequences of the mineral's extraction.

Lithium, nickel, manganese and cobalt are all minerals used lithium-ion (Li-ion) batteries, the most common batteries used in electronic vehicles (EVs). The relative proportions of each mineral depends on the type of battery produced, but lithium is of particular importance because it is the only indispensable element in Li-ion batteries. The push for new sources of these four elements is therefore strongly connected to the EV sector which will soon be the main downstream destination for most of these minerals.

Nickel is also used in the strengthening of steel, which means that it is also used in wind, solar photovoltaic, hydro, geothermal, energy storage, and nuclear, i.e., all renewable energy technologies. **Rare Earth Elements (REEs)** aare primarily used in the creation of permanent magnets, which are part of many of the generators used in renewable technologies. This is mainly the case for wind turbines, but permanent magnets are also used in the motors of electric vehicles. **Copper** is present in almost all renewable technologies, reflecting its similarly varied usage as a base component in a range of conventional technology. Copper is used in the electrodes of Li-ion batteries, in the internal combustion systems of EVs and in the wiring and cabling of wind turbines. However, the most dominant renewable usage is in the heat exchangers, wires, and cables of solar photo-voltaic (PV) systems.

Albany Wind Farm, one of the largest wind farms in Australia. The renewable energy transition is underway, which means more wind and solar farms, and more electric vehicles. *Credit: Shutterstock*

Large amounts of these transition minerals are found in **Australia**. Australia is presently the largest global exporter of lithium. It is also the third largest global producer of cobalt and one of the only producers of REEs outside China. Australia also produces significant amounts of manganese, nickel and copper. There are many plans to open more mines of these six transition minerals across the continent, despite the fact that extraction has a large and damaging ecological footprint and is associated with adverse social impacts, both in Australia and globally.

ANALYSIS

Transition minerals are considered a subset of 'critical minerals', a concept that has a history in US policy discussions going back to the first half of the twentieth century. In Australia, the Morisson government started to initiate a critical minerals policy in 2019, but a review underway by the Albanese government presages some significant revisions to this policy. While maintaining an emphasis on the 'diversification of supply chains' and managing the geopolitical complications this poses for US/China relations, the new government is looking for Australia to move up the supply chain into manufacturing. Australia, at this point, appears to have bought into the arguments being pushed by the mining industry to open up new mines for transition minerals based on very rosy demand projections.

In exploring alternatives, we must first ask: **what are the policy assumptions that these demand projections are based on, and can we reduce extraction through alternative sources of supply that do not require new mines?**

Policy choices around recycling, decisions about the amount of EV vehicles on the road, the size and type of those vehicles, the types of Li-ion batteries used, and the potential of non-extractive sources of supply, are all ways that will help reduce demand for many of the transition minerals that Australia possesses. These considerations must be part of a broader discussion about how we can reorient our transport policy, energy policy, housing and construction policy, and urban design in a way that will ensure that the new energy transition will be more sustainable than the previous one.

Even if these policy changes are instituted, some new extraction will undoubtedly occur, but it must be done responsibly. The case studies in this report document the social and environmental impacts of extraction, the details of which differ in both small and large ways for each of the six minerals discussed. However, one generalisation that can be made about the mining of all six minerals is that the type of approach and the technologies used are particularly consequential when it comes to social and environmental impacts. Although any extraction will likely cause environmental damage, mining in a way that is more socially and environmentally responsible can in some cases be possible. However, sustainable extraction is costly in terms of time and money, and mining companies and their shareholders are often reluctant to pay those extra costs. Downstream suppliers and end-point consumers have also been, thus far, reluctant to insist upon them.

Australia has long way to go before it has the environmental and human rights regime that would enable responsible sourcing. The second question that we must therefore ask is: **how can we ensure that the extraction that does take place does so in a way that does not do further and unnecessary harm to Australia's ecosystems and to our communities, in particular our First Nations communities?**

Although the broader Asia-Pacific region does not contain the diversity of deposits in transition minerals as the Australian continent, it does contain significant amounts of nickel and copper, as well as some cobalt. These minerals are often found in or near critical ecosystems, particularly rainforests. The resulting pollution is more likely to affect people given the higher population densities near mineral deposits, and the environmental and social protections in these jurisdictions tend to be even weaker than in Australia. Discussions about global strategies to reduce demand and implement a global regime for sustainable sourcing of transition minerals will therefore be necessary at the regional and global level to prevent the rush to mineral extraction causing significant damage not only to Australia but also to neighbouring countries such as Indonesia, Philippines, PNG, and others in the region.

SUMMARY OF RECOMMENDATIONS

This report makes eleven recommendations, four of which relate to the current review of Australia's critical minerals policy. The report recommends that the review:

- Interrogate the demand projections for critical minerals;
- Conduct and publish a detailed investigation of the social and environmental impacts of extraction of key transition minerals in Australia;
- Include material on how Australia plans to reduce demand for transition minerals into the review;
- Develop an EV policy that assists in the recycling and reuse of EV batteries.

The report makes five further recommendations with respect to the sustainable extraction of transition minerals in Australia:

- A series of federal legislative reforms that will strengthen the ability of First Nations communities to exercise FPIC on mineral developments in their lands;
- Reforms of state and territory mining laws, including those that will strengthen the approvals process, identify protected areas that will be free from mining and improve mine clean up and rehabilitation;
- Ensure that the EPBC Act reforms currently underway empower and encourage the changes above to state and territory mining legislation;
- Implement legislation that requires the responsible sourcing of transition minerals by Australian companies;
- Make improvements to Australia's regulatory regime governing business and human rights.

The report makes two recommendations about our international diplomatic response to the question of transition minerals:

- Australia should bring up the risks of transition mineral overextraction and the need for policies to reduce demand in bilateral and multilateral meetings with international partners;
- The initiation of discussions with regional and global partners/allies about establishing mining moratoriums in selected ecosystems such as wetlands, rainforests and the ocean floor.

INTRODUCTION: CAN WE REALLY MINE OUR WAY OUT OF THE CLIMATE CRISIS?

TRANSITION MINERALS AND THE CLEAN ENERGY REVOLUTION

The world is on the brink of an industrial and energy revolution equivalent in significance to the transitions to the steam age in the early 19th century and the petroleum age in the early 20th century. As the burning of coal, oil, and gas for electricity and transport is gradually phased out in the coming years, we will move to a world where solar, wind, hydro, and geothermal energy provide almost all of our electricity generation, where our transport will become more and more dependent on EVs, and where battery storage will become more and more important.

This report starts from the assumption that the climate crisis represents the greatest challenge facing humanity in the twenty-first century: the world must decarbonise, and quickly. However, just as we will need to stop extracting fossil fuels to burn for electricity generation and transport, many believe that we will need to dig up more and more of the minerals that will be vital to provide the technological components of the new post-carbon age: wind turbines, solar panels, more electricity infrastructure, and, of course, more batteries both for storage and for EVs.

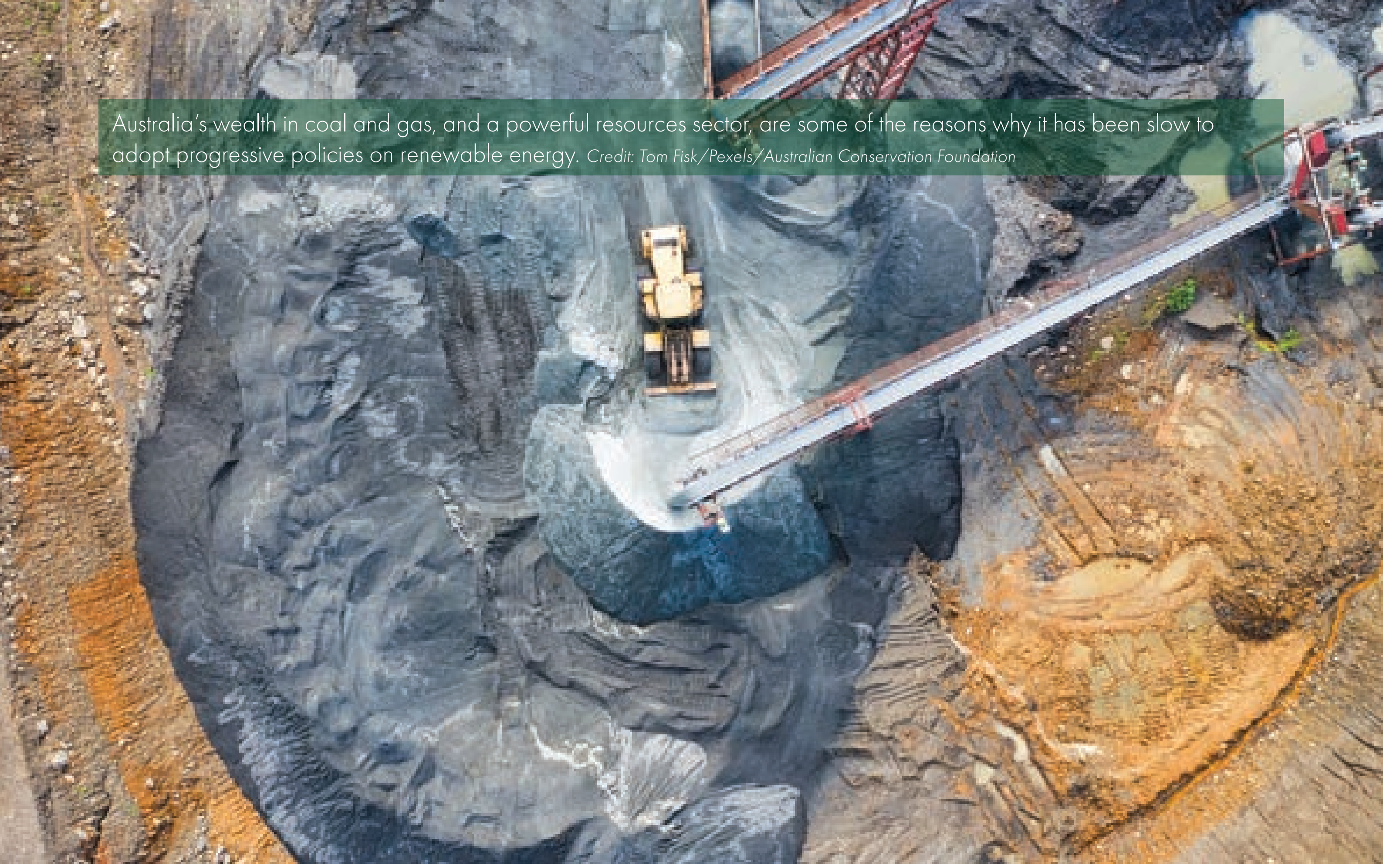
This report will call such products **transition minerals**—minerals that will be necessary in the post-carbon age, either as key components in battery technology (lithium, cobalt and manganese, nickel), magnets (rare earth elements—or REEs) or in providing the physical infrastructure that will make the transition away from fossil fuels possible (copper, nickel, and graphite). Transition minerals are to be used as opposed to **critical minerals**—the other term often used in this context—which has a longer history going back to the Cold War (and earlier) and tends to refer to a broader subset of minerals often defined as being 'vital for the economic wellbeing' rather than just referring to the energy transition.[1] The term 'green minerals' may be thought of as a synonym for transition minerals.

One of the solutions to the carbon crisis is often portrayed, including in advertising by mining companies themselves, in the simplistic terms that this will require significant amounts of new minerals to be extracted. Epitomising this is BHP's statement that critical minerals provide the 'material building blocks' for 'radically reconstitut[ing] how we produce energy' and 'there will be no energy transition without a very large increase in the production of critical minerals.'[2] These public statements are being accompanied by a TV ad campaign on Australian airwaves. A further notable example is Glencore's strategy to enable decarbonisation of global energy demand by 'providing metals such as copper, cobalt, zinc and nickel that are essential to the transition to a low-carbon economy'.[3]

Industry associations are on board with this kind of messaging. For example, the Copper Alliance speculates that with rapid uptake, copper demand solely from the EV market could shift from '185,000 tonnes in 2017 to 1.74 million tonnes in 2027'.[4] The mining industry hype has been supported by the analysis of respected international entities such as the International Energy Agency and the World Bank, both predicting huge demand spikes for key transition minerals over the coming decades.[5]

Australia is one of the countries best placed to try to take advantage of its mineral wealth. It is already the world's largest producer of lithium, and a leading producer of cobalt and rare earth elements (REEs). It has abundant reserves of other key transition minerals such as manganese, nickel and copper. Moreover, it has a large and modern mining sector that has a strong export presence in global supply chains, and many allies in government. The current review of Australia's critical minerals strategy reflects how seriously the Albanese government is taking this question.[6] Breathless news stories about the 'rush for white gold' (ie lithium) in Australia have added to the hype, and reporters have noted that environmental groups and even The Greens, Australia's fourth largest political party, see the mining of transition minerals and the potential economic manufacturing spin offs could lead to new wealth and the creation of new jobs.[7]

The interest in transition minerals has a highly geopolitical element to it. The production of transition minerals is often highly concentrated in one particular country. For example, a huge proportion of cobalt is extracted in the Democratic Republic of the Congo (DRC), most rare earth extraction is in China, and Australia dominates



Australia's wealth in coal and gas, and a powerful resources sector, are some of the reasons why it has been slow to adopt progressive policies on renewable energy. *Credit: Tom Fisk/Pexels/Australian Conservation Foundation*

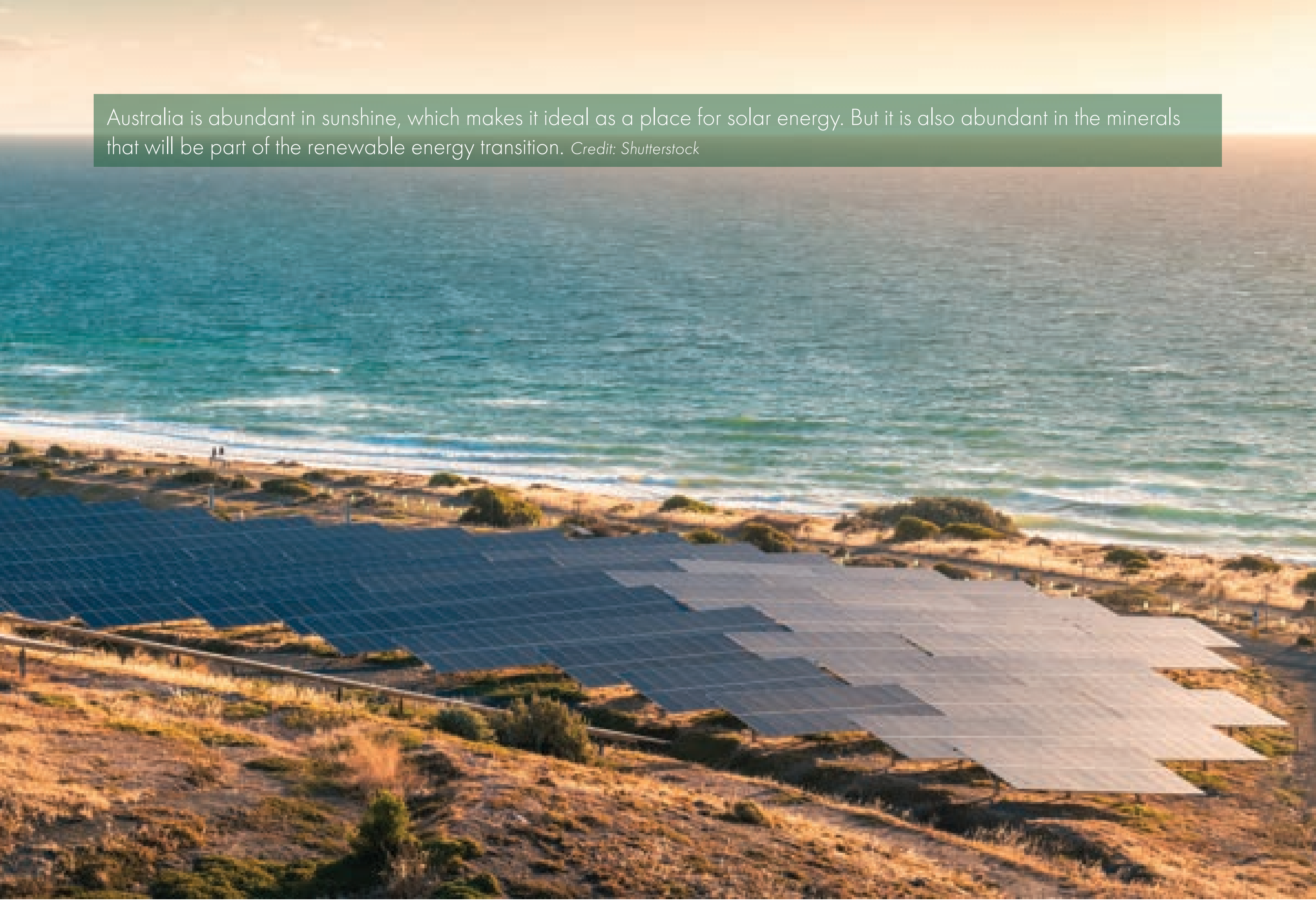
lithium extraction. Chile dominates copper production, as does Indonesia for nickel production. When it comes to processing, China is the dominant player in the processing of all the above five minerals as well as the production of REEs. Naturally, these observations have contributed to anxiety surrounding supply chains that has seen the redeployment of the Cold War obsession with critical minerals.[8] Australia, rich in transition minerals and close ally of the United States, as well as the EU and Japan, is therefore a 'country of interest' when it comes to the new extraction of critical (and transition) minerals. The rush to mineral wealth even extends to the ocean floor, with several countries attempting to convince the International Seabed Authority that it is in the global interest to mine so-called 'polymetallic nodules', which are rich in nickel, cobalt and manganese.

THE DILEMMAS OF AUSTRALIA'S TRANSITION MINERAL WEALTH

In summary, the world will be increasingly sourcing more transition minerals as the global community of nations seeks to decarbonise their economies. As a source of many of the reserves of transition minerals, and as a nation with a strong mining record, Australia has become a site of extreme interest when it comes to the acquisition of green minerals, not least because of the desire to ensure the security of supply chains at a time of ever-increasing global competition. Mining companies, climate change advocates and Australian federal and state governments are very aware of these trends and are looking to take further steps to position Australia as a centre of this new extraction.

However, Australia's transition mineral wealth, and the international interest in it, poses serious dilemmas for our leaders, politicians and other policymakers. We have already noted beyond the risk that of Australia could become involved in another flashpoint in the strategic competition between the US and China. There are three equally important reasons why we should pause and reflect before we rush headlong into a new orgy of mining extraction on this continent (or elsewhere, for that matter).

First, the amount of minerals needed for the transition remains contested, depending as it does on demand projections that do not take in to account the policy choices we have. The projected increase in demand for some transition minerals is staggering (**see chapter 8** for more details on these projections). But are these demand



Australia is abundant in sunshine, which makes it ideal as a place for solar energy. But it is also abundant in the minerals that will be part of the renewable energy transition. *Credit: Shutterstock*

projections based on reliable assumptions, or more to the point, on responsible ones? Put another way: does every car on the planet currently running on petroleum (ie using an internal combustion engine) need to be replaced with an electric vehicle running on an Li-ion battery?

Second, we must consider the social and cultural impacts of a 'mine first, ask questions later policy' on First Nations people. In Australia, as elsewhere, many of the transition minerals studies in this report are found on lands occupied by Indigenous peoples. There is a perception that Australian law gives strong social and environmental protections for all communities, including First Nations communities. Unfortunately, this perception is far from the reality. As Australia wrestles with the legacy of the Juukan Gorge incident—in which Rio Tinto's egregious destruction of cultural heritage sites in WA caused a national outcry—and as the nation looks forward towards a referendum in 2023 on the Indigenous Voice to Parliament, there is more opportunity than ever to use debates about transition minerals to strengthen First Nations groups' say about what happens on their land.

Third, it will be important to weigh up the environment impacts of a new rush to mineral extraction in this country. The climate crisis is not the only environmental crisis facing us: there is also a biodiversity crisis which, while linked to climate change, is also a consequence of industrial capitalism and agriculture's rampant need for raw materials. Of course, the focus on mining and renewables is actually a subset of a larger challenge: the necessity to reduce the social and environmental footprint of unnecessary mining projects generally. For example, it has been estimated that around a quarter of active metal mines in the world are gold mines, and 90 per cent of the gold they produce is for luxury goods.[9] The over-extraction of metals and other minerals thus has implications far beyond the renewable energy sector.

Any attempt to look at the problem of mining and the renewable energy transition must do so with all of these complications in mine. Or, as the title of a conference organised by Mining Watch Canada once asked, 'Can we really mine our way out of the climate crisis?'[10]

PURPOSE OF THIS REPORT

There is no doubt that we will need to access more transition minerals in order to achieve the green energy transition and minimise the impact of global warming. However, developing a policy enabling us to greenlight the development of dozens and dozens of new mines, without thinking through the consequences, could be disastrous for Australia and for the region. Is this push for more and more mines a policy consequence of being collectively gaslit by the mining sector, in telling us that there is no other way than to extract every economically viable transition mineral in the ground?[11] Should we greenlight extensive new green mineral extraction, or is this push for this just another case of resource industry gaslighting?

Our choice is not to double down on fossil fuels on the one hand, or to rush headlong into a frenzy of 'green extractivisim' for transition minerals on the other. There is a third way—a way for us to selectively mine in a responsible way, whilst also be developing policies that reduce demand for these minerals and to source them via more socially and environmentally responsible techniques?

The course has not been set. Just as the choices we make over the next few years will determine how many degrees of temperature rise we will have to deal with, so too will the next few years be critical in determining renewables and mining policy.

Part I: Key Transition Minerals in Australia identifies and investigates six case studies of transition minerals that are found in abundance in Australia. The six case studies in **Chapters 1-6** examine the following minerals: lithium, nickel, cobalt, manganese, rare earth elements (REEs), and copper—the constraints of space and time meant that some transition minerals found in Australia had to be excluded from meriting a case study.[12]

Each case study will examine the following questions with respect to each mineral:

- What is the renewable energy application of each transition mineral?
- Where in the region is it found, and what are the plans to mine it further?
- What are the assumptions on which the future demand projects for this mineral are based?
- What are the social and environmental impacts of mining this resource, and how can this be illustrated from case studies in the region?

Part II: Analysis starts with **Chapter 7**, which explores the evolution of critical minerals policy in Australia. It tracks how the US was the first to develop a strategic and critical minerals policy in the mid-twentieth century; policies that were given a new lease of life with the onset of transition minerals in 2010. A number of countries followed suit, including Australia, which developed its own policy in 2019 under the Morisson Government. A change of government in 2022 has seen Australia changing tack: not only planning to increase extraction but also exploring the idea of getting involved at processing and manufacturing i.e. in links further down the renewable energy supply chain.

But one thing has remained consistent despite this change in direction: a wholesale assumption of the wildly excited demand projections and a desire to enthusiastically develop new mines in this country. **Chapter 8** asks the question about whether the demand projections for transition minerals are based on problematic and dangerous assumptions. Can we reduce demand through recycling efficiency and substitution of renewable energy infrastructure and materials? And how many further demand reductions can be achieved through broader policy interventions in transport, construction, and a commitment to the circular economy?

Chapter 9 looks at what are the policy changes that we need to implement to encourage the sustainable extraction of transition minerals in Australia, reducing the destruction to the environment and the negative impacts on communities here, especially First Nations and Indigenous groups. **Chapter 10** looks at the problem from a regional perspective. It examines the social and environmental impacts that extraction of transition minerals is having or may have in key countries in the Asia-Pacific such as Indonesia, the Philippines, Papua New Guinea and New Caledonia.

The report will finish with a summary of the conclusions reached and a make number of recommendations for policymakers. The **primary audience** for this report is therefore federal and state government agencies and politicians in Australia who are interested in the issue of transition minerals. However, a number of secondary audiences may also be interested, including researchers, academics and policy specialists in Australia and the region who are also interested in the questions posed here.

Cornwall Pit in Greenbushes Lithium Mine, Western Australia. *Credit: Adwo/Shutterstock*

PART I: KEY TRANSITION MINERALS IN AUSTRALIA

Australia is awash with minerals that are needed for the renewable energy transition. The following case studies in Part I explore six minerals that Australia is well supplied with: lithium, nickel, cobalt, manganese, rare earth elements (REEs), and copper. We might also have included other minerals too, such as graphite, in which Australia is also rich; however, the limitations of the study restricted us to just six in this report.

An important conceptual definition to keep in mind here is the difference between resources and reserves. **Resources** refers to the total amount of a mineral that can be feasibly extracted. In contrast, **reserves** are the amount that can be economically mined under current circumstances. Another way of thinking of reserves is the 'working inventory' of mining companies supply of minerals. Measuring reserves is contingent on industry capacity to access minerals in each nation.[13] Australia has significant resources or reserves for the six mineral case studies chosen.

The case studies examine where the minerals are found in Australia and globally, what their applications are for renewable energy technology, what the demand projections are, where the proposed new sites for mining in Australia are, and what are the social and environmental impacts of extraction by new mines.

CHAPTER 1: LITHIUM

Lithium Summary

- Lithium is a key component of electric vehicle (EV) batteries, especially considering its ubiquity in all chemistry variations of Li-ion batteries. Notably, different products of the element are utilised in battery cathodes and electrolytes.
- Lithium is typically mined from two core deposit types, each requiring unique extraction methods. Closed-basin brines are typically found in South American nations like Bolivia and Argentina and require evaporitic extraction processes.
- Pegmatite deposits are prevalent in Australia and require hard-rock mining for extraction. Australia is at present the largest global exporter of lithium and the Greenbushes mine in WA is the largest lithium min in the world. There are many new lithium mines in development in Australia.
- Lithium's centrality to the growing EV battery market means that in nearly all projections, demand for the mineral is forecast to at least double by 2030. However, complex political and economic factors will condition whether global supply can meet such heightened demand.
- Salt-brine extraction is water-intensive, and historical extraction in water-scarce regions has caused severe humanitarian consequences for local communities. The consequences of hard-rock extraction are more speculative, yet still present prospective consequences if managed incorrectly.

Renewable Energy Applications

Lithium is a mineral associated with only one renewable energy technology—EV batteries. However, its ubiquity and centrality to the market mean that it will be a critical mineral over the next thirty years. Lithium is both light in mass and capable of efficiently storing energy, both necessities for efficient battery manufacturing.[14] Lithium's primary usage is in the form of Li-ion batteries which are commonly found in conventional technology, like phones and computers and account for 65 per cent of lithium's global end-use market.[15]

Li-ion batteries have also been crucial in the development of electric vehicles (EVs), which comprise 30 per cent of lithium's end-user market. Regarding technical usage, lithium is primarily combined with other minerals to comprise an EV battery cathode. The form of lithium used in EV batteries is typically lithium carbonate. However, researchers anticipate that lithium hydroxide's rate of growth for demand will surpass it soon. Additionally, lithium salt is also utilised for many Li-ion batteries' electrolytes.[16]

One of the key cases for lithium being a critical transition mineral is the fact that it is utilised in all chemistry variations of Li-ion batteries. While the usage of other minerals, like cobalt or manganese, is dependent on the form of the battery, lithium operates as a consistent base across all battery types.[17] Despite lithium's presence in among all battery types, there is speculation regarding the development of batteries beyond the mineral. It is thought that battery development will progress to a stage of next-generation NMC technology, before eventually developing to a stage of post-lithium batteries. However, the period of next-generation NMC is not anticipated until 2030, and battery compositions that exclude lithium are only in the research phase.[18]

Where is lithium found?

Lithium is typically found as a compound, like a rock, soil, or another form. It is relatively abundant, with every twenty parts per million of the Earth's crust comprised of lithium. There are two dominant lithium ore-deposit types. The most common is the 'closed-basin brine', comprising 58 per cent of all lithium deposits. Specific areas of groundwater contain raised levels of dissolved lithium, caused by lithium salt brines being absorbed into the water.[19]

Drilling holes for explosives in the Galaxy Mt Cattlin Mine, Ravensthorpe, WA. *Credit: Kamzara/Shutterstock*

This form of lithium is mined through a process of 'evaporitic' or salt brine extraction, which involves the pumping of brine to create pools of water, then evaporating the salt. Salt brine extraction mostly occurs in the desert regions of Argentina, Chile, and Bolivia (the Atacama Desert or Puna de Atacam). The dry atmosphere there facilitates lithium-rich brines and is conducive to evaporation.[20]

The other relevant deposit type, comprising 26 per cent of global reserves, is a form of igneous rock containing pockets of crystals of spodumene, a mineral high in lithium. This form of lithium is extracted through hard rock mining before being processed into lithium carbonate or lithium hydroxide. Although hard rock extraction is a simpler process compared to salt-brine extraction, it is more expensive.[21]

Currently, Australia is the largest single-nation exporter of lithium—Australia has eight ASX-listed companies with lithium deposits.[22] According to the *Critical Minerals Projects in Australia 2020* report, there are currently five lithium mines operating in Western Australia.[23] The largest of these is the Greenbushes mine, with total resources amounting to roughly 157 metric tonnes. This hard rock mining site is located 250 km from Perth and is now the largest lithium mine in the world.[24] In addition to Greenbushes, other significant sites include Mount Marion, Mount Cattlin and two sites in Pilgangoora. Three new sites are in preliminary feasibility or exploration stages; there are also multiple sites in Western Australia which are now decommissioned.[25]

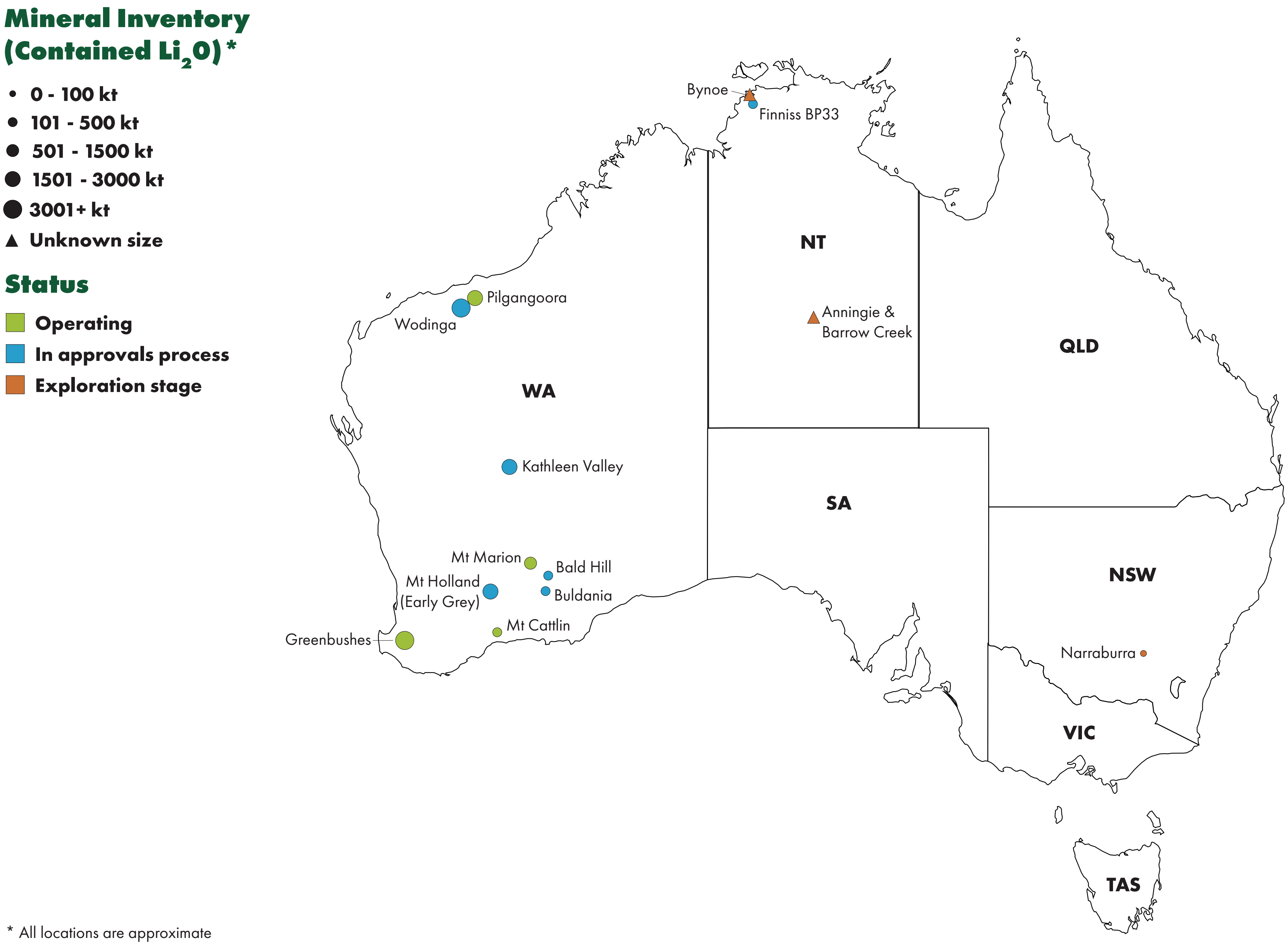
Spodumene mining has traditionally been confined to the WA, but we are now seeing sites in exploration stages in other areas. In the Northern Territory, Core Lithium's Finniss project is the most advanced, having commenced production in October 2022; Core Lithium have 500 square km of lithium tenements in the NT, mostly in the Bynoe Pegmatite Field. Several other mines are in the exploratory stage in NSW.[26]

Table 1.1: Current and planned lithium projects in Australia

State	Deposit	Operator	Mineral Inventory (Contained Li_2o)	Status/Approvals
WA	Greenbushes	Talison Lithium	3,582 kt	Operating
WA	Pilgangoora	Pilbara Minerals Ltd	2,834 kt	Operating
WA	Mt Marion	Reed Industrial Minerals (RIM)	976 kt	Operating
NT	Finniss Project	Core Lithium	194 kt	Operating
WA	Mt Cattlin	Galaxy Resources Ltd	188 kt	Operating
WA	Wodgina	Mineral Resources Ltd	3,032 kt	Development Approval
WA	Mt Holland (Earl Grey)	Covalent Lithium	2,834 kt	Mining Lease, Environmental Approval
WA	Bald Hill	Alita Resources Ltd	255 kt	Development Approval
WA	Kathleen Valley	Liontown Resources Ltd	2,184 kt	Mining Lease
WA	Buldania	Liontown Resources Ltd	145 kt	Mining Lease
NT	Anningie & Barrow Creek	Core Lithium	N/A	Exploration/Exploration Lease
NT	Bynoe	Lithium Australia NL	N/A	Exploration/Exploration Lease
NT	Bynoe (Lei)	Lithium Plus Pty Ltd	N/A	Exploration/Exploration Lease
NSW	Narraburra	Alkaline Resources Ltd	8.5 kt	Advanced Exploration/ Exploration License
QLD	Buchanan*	Strategic Minerals Australia Pty Lt; Unlisted Public Company	N/A	Scoping Study/Exploration License
VIC	Dorchap*	Dart Mining	N/A	Early Stage Exploration

* Due to unavailable data, this deposit is not featured on the lithium map.

Source: Australian Trade and Investment Commission, with Geoscience Australia & Department of Industry, Science, Energy and Resources, *Critical Minerals Projects in Australia, 2020*



* All locations are approximate

^ MapSVG, 'SVG vector map of Australia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.

Australia has, up to this point, had no significant role in the production of lithium chemicals from the extracted resources: indeed only 0.5 per cent of the total end-value of the lithium supply chain is earned by Australia. Rather, profit is found in the refining of ore, production of lithium chemicals, and creation of batteries. The vast majority of lithium extracted in Australia is exported to China for refining into lithium carbonate or lithium hydroxide—China refines roughly 50-70 per cent of the world's supply of lithium.[27] The Chinese company Tianqi Lithium owns majority of the Greenbushes mine, the largest lithium site in both Australia and globally.[28] The Institute for Energy Research also highlights that another company, Ganfeng Lithium, has a long-term agreement to underwrite all lithium raw materials produced by Australia's Mount Marion mine—the world's second-biggest, high-grade lithium reserve. In a trend that we are likely to see more of, Core Lithium has signed an agreement with Tesla to incorporate the lithium produced there into the supply chain for Tesla EVs.[29]

Demand Projections for Lithium

Although lithium will be utilised in nearly all Li-ion battery types, there is still significant variability in its demand according to which type is embraced in the future. The battery market, and therefore the demand for lithium, will be defined by two factors: the growth in EV sales and the dominant battery chemistry used.[30]

The percentage of lithium ranges from 8 per cent in LMO type batteries, to 11 per cent in NMC111, NMC8111 and NCA type batteries.[31] This relatively small range means that lithium is forecasted to dramatically increase in demand, regardless of the battery type embraced. A report by Dutch group SOMO provides three alternative scenarios forecasting the growth of mineral demand by 2030 based on varying policies. In all scenarios, lithium at least doubles, if not quintuples in the Benchmark Minerals scenario. Some analysts even speculate that demand could be up to 50 times higher than current levels. However, as the energy density of Li-ion batteries improve, this may potentially reduce mineral demand.[32]

Nevertheless, it is commonly asserted that to match the global demand for lithium, mining will need to increase fivefold by 2050.[33] The rate of demand may outpace supply as early as 2031; a scarcity that may lead to price hikes and new speculative investment in lithium mines.[34] This phenomenon already occurred between 2016 and 2018, when prices doubled due to demand from the EV market. The price surge of 2016-2018 eventually transitioned to a bust due to oversupply of lithium and a number of new mines had to be mothballed.[35]

A complex variable to consider in determining the supply and demand of minerals in the future is the effect of climate change. This is complicated by the fact that the chain of causation is circular, with the need for EV batteries fuelling increased mining, in turn fuelling climate change, in turn restricting further mining. Lithium mining is vulnerable to water stress given the high water requirements and the aridness of the ecosystems where lithium is found. Variations in environmental factors caused by climate change, like extreme heat and flooding could significantly impact the surety of supply chains, particularly in Australia and China.[36]

Although reserves and resources for lithium are ubiquitous, there are external elements that may affect prices and supply chains in the future. One such variable is the production and price of lithium chemicals like lithium hydroxide and lithium carbonate. The IEA highlights that in recent years, lithium carbonate prices have increased. These depressed prices have caused bottlenecks in the supply of lithium chemicals, largely since a small number of countries produce the bulk of global supply. Therefore, suppliers of lithium chemicals cannot match the ever-increasing demand of the battery market.[37]

Additionally, politics factor heavily in the lithium supply chain. Notably, the countries of the Lithium Triangle, like Bolivia, have had strict regulation preventing mineral extraction.[38] Therefore, estimates based on resource levels need to recognise the impact of domestic law. Furthermore, the growing dominance of China over lithium importation may ignite trade-war concerns with the USA.[39] **See Chapter 8** on the reliability of these optimistic demand projections.

Environmental & Social Impacts

The extraction of salt-brine lithium, which as we have said takes place mostly in the Atacama Desert in Latin America, has serious environmental consequences (see Box 1.1). Some literature states that hard-rock spodumene mining is less environmentally devastating than salt-brine extraction. This underplays the effects of mining on local ecosystems, communities, and the environment at large. Hardrock lithium mining involves many of the same resource-intensive processes as other conventional mining projects.[40] In fact, the small proportion of lithium to spodumene, and the relative difficulty of extraction, means that resource usage is heightened to obtain economically significant quantities of the metal. This has the effect of increasing water usage and creating significant amounts of 'waste rock' and 'wastewater'.[41] Like the Lithium Triangle, these water-dependent extraction methods are made significantly more problematic due to their location. Hardrock mining in Australia is situated in arid ecologies with limited access to water already. Therefore, there has been justified concern over the hydrological burden of lithium mines in the area. Such concerns regarding water intensity and contamination have been expressed by the Environment Centre NT, regarding a proposed lithium project by Core Lithium Ltd.[42] Additionally, the carbon footprint of lithium extraction equates to 15 tonnes of CO_2 being produced per tonne of lithium.[43]

Box 1.1: Consequences of Salt-Brine Extraction in Latin America

The environmental and humanitarian consequences of lithium extraction are no more strongly felt than in the Puna de Atacama region of South America. The salt pans encountered in this area are fragile ecosystems, where disruption from mining can be catastrophic.[44] Primarily, the impact of the technique of salt-brine evaporation has significant consequences on water as the process causes shortages and contamination. Salt-brine evaporation in the Atacama Desert is precarious as the ecology is already water-scarce, and evaporation requires what little water there is to be 'pumped out'. The process is inherently water-intensive, with nearly two million litres of water required to produce a single tonne of lithium. This intensity poses an existential threat to the ecology of the salt-flat biome.[45]

Additionally, this process of extraction may have consequences beyond its immediate area. It has been alleged that mining operations in Argentina have not considered the subterranean connections of underground water.[46] Therefore, lithium extraction may exhaust hydrological resources in peripheral areas. Additionally, the process of salt-brine extraction has the capacity to cause salination of nearby freshwater aquifers. The introduction of saltwater to freshwater sources can have irreparable consequences for the ecology. This damage is further intensified when the contamination involves toxic leaching substances used in the extraction process. Local aquatic wildlife is destroyed when leaching chemicals like hydrochloric acid are accidentally introduced into water sources.[47] This was exemplified by the Ganzizhou Rongda lithium mine in China which leaked chemicals into the nearby Liqi River, killing fish and livestock drinking from the water.[48]

Aerial view from a helicopter of a nickel mine near Warmu in the Kimberley region of Western Australia.

Credit: Philip Schubert/Shutterstock

CHAPTER 2: NICKEL

Nickel Summary

- Like lithium, nickel is a critical component in many Li-ion batteries, and is therefore projected to be increasingly sought after for the EV market.
- Nickel is a critical element used in the strengthening of steel, which means that it is also used in wind, solar photovoltaic, hydro, geothermal, energy storage and nuclear, i.e. all renewable energy technologies apart from concentrated solar power.
- Different nickel deposits typically produce different quality products and require different extraction processes. Sulphide deposits produce high-quality nickel products which are extracted through conventional techniques, whereas nickel extracted from oxide deposits is generally used in low-grade products like pig iron.
- In the region, Indonesia and the Philippines rank as two of the largest producers of nickel. However, both states have experienced domestic regulations that have limited the magnitude of nickel exports. Australia is also a major player, accounting for roughly 10 per cent of the global supply.
- As with lithium, many analysts are predicting the demand for nickel to skyrocket, largely driven by greater use in Li-ion batteries. However, there are a multitude of variables that will determine both the supply and demand of nickel in the future: the form of batteries adopted, the availability of Class 1 nickel, and the dominance of other transition minerals.
- The open-cut mining required for extracting some deposits of nickel is highly damaging to the peripheral environment, especially considering the high water usage of nickel mines, and disposal of tailings issues has cause significant headaches in many locations where nickel is mined.

Renewable Energy Applications

Nickel is abundant in the earth's crust, ranking as the fifth most common element on earth. Nickel is a silvery-white metallic element, and relevantly for mining, it is both siderophile and chalcophile, i.e. it is commonly found with both iron and sulfur. The products of the metal are distinguished by classes of purity. Class 1 products are the purest grade of nickel commercially available, comprised of at least 99.8 per cent of nickel whereas, Class 2 includes any product below the nickel percentage of Class 1. For usage in Li-ion batteries, only Class 1 nickel will be effective. Of total finished nickel production, roughly 54 per cent is classified as Class 2, with 46 per cent classified as Class 1.[49]

Nickel is used in a variety of focal technologies in the clean energy transition. Class 2 nickel products —like nickel pig iron—have primarily been utilised as a component in industrial alloys, due to their corrosion resistant qualities.[50] In fact, 65 per cent of all nickel is used in the production of stainless steel. Because of this, nickel is utilised in the following clean energy technologies: wind, solar photovoltaic, hydro, geothermal, energy storage, and nuclear, i.e. all renewable energy technologies apart from concentrated solar power.[51] The proportion of nickel used in each of the technologies varies greatly. By 2050, nickel is projected to comprise 58 per cent of the total mineral demand for geothermal technology. Additionally, nickel is integral to wind-based renewable technologies, largely being used as an element of the steel alloys necessary to manufacture turbines.

Class 1 nickel products are common components in Li-ion batteries, although at present EV batteries only represent 7 per cent of nickel's end-use. Nevertheless, nickel plays a large role in the Li-ion battery market primarily due to its usage in two critical battery types, NMC and NCA, two of the most commonly utilised in EV vehicles.[52]

Where is Nickel Found?

There is a complex interrelation between the grade of nickel and the source from which it is extracted. Globally, nickel is sourced 40 per cent from sulphides and 60 per cent from laterites. Sulphide deposits generally contain highly concentrated nickel at a high grade of purity. Therefore, ore extracted from these deposits may be utilised for EV batteries. Oxide (laterite) deposits require complex extraction methods, typically involving open-pit mining and water removal which are the two most common forms of nickel deposits in Australia. Oxide (laterite) deposits of nickel generally produce a lower grade form of the metal, and such nickel is often used in a form of pig iron, a component of stainless steel. Still, the nickel from these deposits may be converted to Class 1 products if correctly processed.[53]

The main countries exporting nickel are: Indonesia 19 per cent, Philippines 11 per cent, New Caledonia 10 per cent, Canada 10 per cent. [54]As evidenced by this list, the export of nickel is highly centralised in the Southeast Asia and the Southwest. Brazil and Cuba both have a high share of nickel reserves.[55] However, both nations have not structured their economies as focally on nickel as have the Asia-Pacific nations. Saliently, Indonesia and the Philippines will be the central players in the coming transition to clean energy technologies, especially given their large nickel reserves. The IEA forecasts that the two nations could be responsible for 70 per cent of global production growth over the period to 2025.[56] Australia currently provides nearly 10 per cent of the world's nickel supply—although this could grow if the planned projects in the table below receive approval.[57]

Nickel mining in Pomalaa, Indonesia—Indonesia is the largest supplier of nickel globally, but Australia also has many nickel resources. *Credit: Kaisarmuda/Shutterstock*

Table 2.1: Current and planned nickel projects in Australia

State	Deposit	Operator	Mineral Inventory (Contained Ni)	Status/Approvals
WA	Nova-Bollinger	IGO Ltd	234 kt	Operating
WA	Savannah	Panoramic Resources Ltd	217 kt	Operating
WA	Wingellina	NiCo Resources	1,953 kt	Mining Lease
WA	Goongarrie Nickel Cobalt Project	Ardea Resources Ltd	1,522 kt	Mining Lease
WA	Range Well	Ausinox (EV Metals)	1,466 kt	Mining Lease
NSW	Sunrise	Clean TeQ Holdings Ltd	921 kt	Development Approval
WA	NiWest	GME Resources Ltd	878 kt	Mining Lease
QLD	Gladstone	Gladstone Pacific Nickel Ltd	648 kt	Mining Lease, Environmental Approval
WA	Wilconi	A-Cap Resources Ltd	585 kt	Mining Lease
QLD	Julia Creek	QEM Ltd	465.5 kt	Mining Lease Application
QLD	SCONI	Australian Mines Ltd	456 kt	Mining Lease, Environmental Approval
QLD	Richmond – Julia Creek Vanadium	Horizon Minerals; Richmond Vanadium Technology Pty Ltd[58]	360 kt	Mining Lease, Environmental Approval
TAS	Avebury	Allegiance Mining Pty Ltd	264 kt	Mining Lease, Environmental Approval
WA	Mt Thirsty	Conica Ltd; Greenstone Resources Ltd[59]	140 kt	Mining Lease Application
TAS	Barnes Hill Project	Tasmanian Energy Metals Pty Ltd	100 kt	Mining Lease
NT	Browns Sulfide	Northern Territories Resources Pty Ltd	32 kt	Mining Lease
NT	Browns Oxide	Northern Territories Resources Pty Ltd	13 kt	Mining Lease
QLD	Lucky Break	Metallica Minerals Ltd	11 kt	Mining Lease, Environmental Approval
NSW	Nico Young	Jervois Mining Ltd	589 kt	Exploration Licence
SA	Claude Hills	Metals X Ltd	270 kt	Exploration Licence
NSW	Collerina	Alpha-HPA Ltd	159 kt	Exploration Licence
NSW	Hurlls Hill Prospect*	N/A	71 kt	Advanced Exploration
NSW	Flemington	Australian Mines Ltd	6.6 kt	Exploration Licence
NSW	Pacific Express*	Tyranna Resources Ltd	6.3 kt	Exploration Licence
NT	Wollogorang (Stanton)	Resolution Minerals Ltd	0.6 kt	Exploration Lease

* Due to unavailable data, this deposit is not featured on the nickel map.

Source: Australian Trade and Investment Commission, with Geoscience Australia & Department of Industry, Science, Energy and Resources, *Critical Minerals Projects in Australia*, 2020

Demand Projections for Nickel

Nickel could be among the fastest-growing transition minerals in terms of demand. The variability of nickel quality becomes central when considering forecasts of demand, as the Class 2 nickel required for conventional technology is significantly more accessible than the Class 1 nickel required for EV batteries.[60] Moreover, fluctuations of the supply and demand of nickel will be impacted by variables already broached in this report. These include the stability and accessibility of different extraction resources, the availability of different purity classes of nickel, the governmental regulations of major exporting countries, the dominance of certain processing countries, and the rate of demand of batteries and stainless steel.

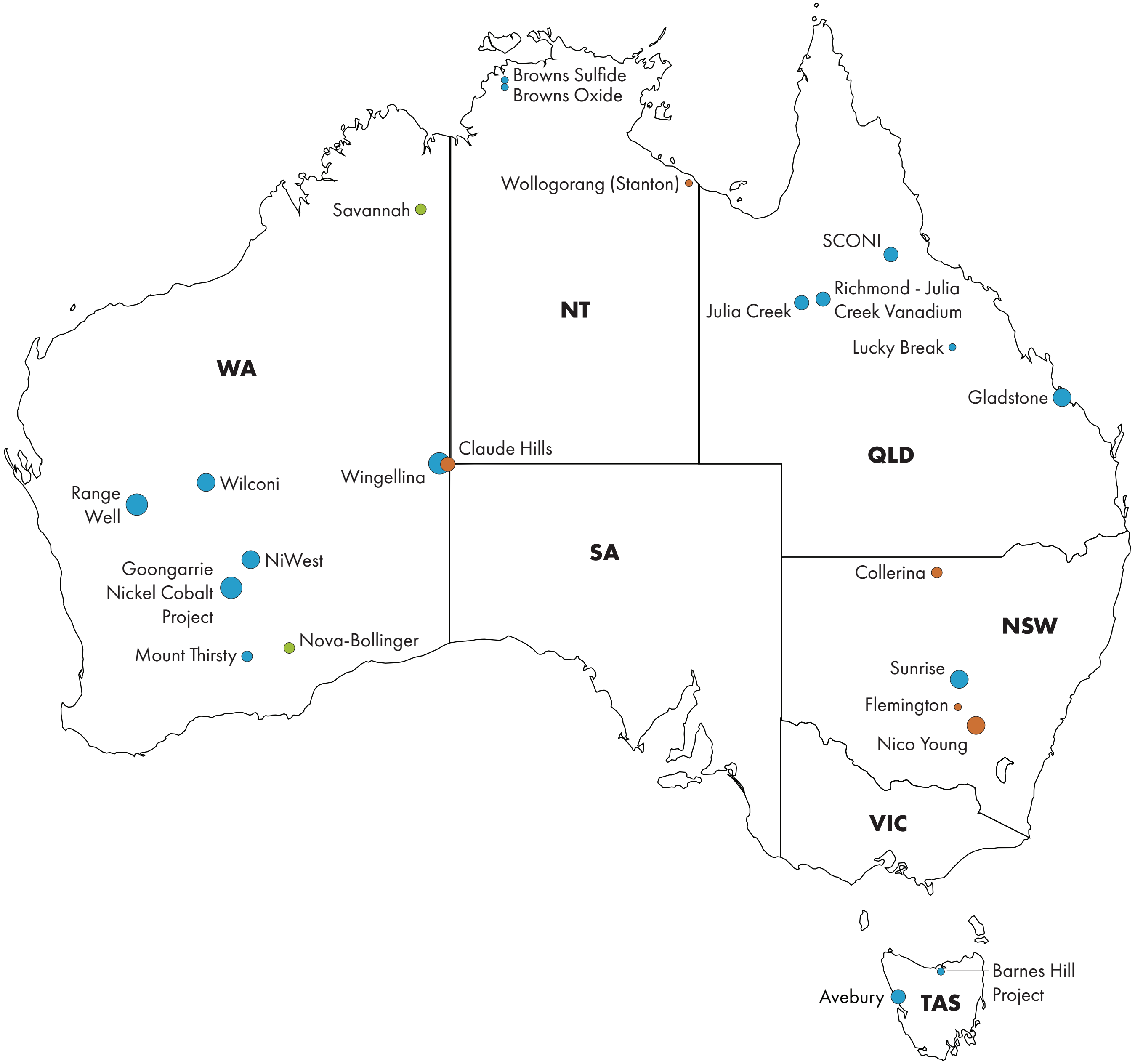
The Australian government anticipates that steel manufacturing will continue to be the bedrock of nickel demand in the future.[61] This is largely based on the actions of China, whose domestic steel industry accounts for 40 per cent of

Mineral Inventory (Contained Ni) *

- 0 - 100 kt
- 101 - 250 kt
- 251 - 500 kt
- 501 - 1000 kt
- 1001 - 2000 kt

Status

- Operating
- In approvals process
- Exploration stage



* All locations are approximate
^ MapSVG, 'SVG vector map of Australia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.

all global nickel use.[62] This immediate surety of stainless-steel demand is also present in Indonesia, where sustained demand will continue in the near-term. However, as the Australian government speculates, this short-term demand for nickel for stainless steel will eventually be supplanted by demand for Li-ion batteries.[63]

Nickel demand will likely be driven by its use in EV battery cathodes (recalling that it makes up only seven per cent of global demand at present).[64] As with cobalt and lithium, some estimates for nickel based on EV take-up are wildly optimistic. Some indicate that nickel demand may multiply tenfold in the coming ten years due to the demand of the EV industry.[65] Nickel production may increase from 2.2 million metric tonnes to 4 million by 2030.The IEA specifies that this growth could reach 25 times 2020 levels by 2040.[66] There are a multitude of variables that will determine both the supply and demand of nickel in the future: the form of batteries adopted, the availability of Class 1 nickel, and the dominance of other transition minerals.[67]

The demand for nickel will be influenced by relative demands for other minerals in the transition to clean technology. Primarily, decreases in cobalt demand could lead to a spike in demand for nickel, especially as battery chemistries are already moving away from cobalt to more nickel-dominant forms. Shifts away from cobalt usage in cathodes are prompting manufacturers to consider alternatives like NMC811, which contains eight times more nickel than cobalt.[68] The IEA highlights a trend towards the development of more nickel-dominant batteries, like NMC 532 and 622.[69] If nickel-centric cathode types become dominant in the future, the demand for Class 1 nickel will increase dramatically. Nevertheless, as has been discussed elsewhere in this report, predicting which form of battery cathode will be dominant is a largely speculative affair.[70]

Fluctuations in demand will also affect the pricing of lithium in the near and long-term future. While nickel has experienced lows in value—most recently in 2017—the prices have steadily increased and since stabilised.[71] The biggest variable impacting the future price of nickel is the same affecting supply: the uptake of batteries. Moreover, as the IEA specifies, blockages of nickel supply from source countries like Indonesia, due to regulation or other reasons, may further cause prices to spike.[72] Thus, demand, supply and pricing are inextricably linked.

Social and Environmental Impacts of Nickel Mining

Open-cut nickel mining can have devastating effects on local forest life and soil quality. This is intensified by the fact that 40 per cent of global nickel reserves are in locations with high biodiversity and protected areas.[73] A study by Prematuri et al highlights that the process of extraction disrupts the local ecosystem in a variety of ways, causing drastic changes to the physical and chemical characteristics of the land.[74] A key element of this change is the emission of toxic metals. Nickel ore from laterite mines must be processed with chemicals like ammonia or sulfuric acid. The waste produced is rich in heavy metals which carry the risk of contaminating local ecosystem.[75] The unique soil conditions of locations like Indonesia (serpentine soil) and the distinct biodiversity present are both particularly vulnerable to the intrusion of toxic chemicals.[76] In particular, the presence of open-cut nickel mines causes a decrease in the fertility of peripheral soil and a reduction in the growth of unique local plant life.[77] Therefore, poorly regulated nickel mines in sensitive ecological areas have the capacity to significantly harm local plant life.

Nickel extraction can also be particularly devastating on local hydrological resources peripheral to mining sites. Nearly 35 per cent of nickel mines are situated in areas of 'high water stress.'[78] Water contamination is particularly common near laterite-ore mining sites, as both the size of the mines and the requisite steps of acid leaching cause significant wastewater.[79] Similar to soil contamination, water contamination is caused by the intrusion of toxic metals through mine discharge, chemical weathering of rocks and soils, and surface run-off.[80] These contaminate water by entering local sources like peripheral rivers, which then carry the effluent downstream to other hydrological sites. In South-East Sulawesi in Indonesia, land stripping caused by the Pomalaa Nickel project has caused significant pollution to the local Kumoro river.[81] Moreover, the hydrological consequences are not confined to effluent in mining runoff water. There have been reports of nickel refiners in Australia discarding of tailings water in the Great Barrier Reef: the Queensland Nickel Refinery discharged wastewater into the Great Barrier Reef Park on multiple occasions between 2009 and 2011.[82] These ecological consequences have pronounced effects on the local communities near mining projects. Nickel mining has also contaminated local agriculture in Indonesia and the Philippines and has been associated with releases of toxic waste into rivers and oceans in PNG's Madang Province (**see Chapter 10** for more details).

As with lithium and nickel, EV batteries are predicted to be the main driver of demand for cobalt in the coming decades.
Credit: Jacques Tarnero/Shutterstock

CHAPTER 3: COBALT

Cobalt Summary

- Cobalt's relevance for the green energy transition is also due to its use in the cathodes of Li-ion batteries for EVs.
- Cobalt is considered a particularly scarce resource, especially in terms of land-based deposits. By far, the largest concentration of cobalt reserves worldwide (around fifty per cent), are located in the Democratic Republic of Congo (DRC)—which currently produced around two-thirds of cobalt. Significant quantities of cobalt are found on sea-beds around the Atlantic, Indian and Pacific Oceans.
- Australia is also the third-largest producer of cobalt worldwide. The Anglo-Swiss company Glencore currently mines around 27 per cent of the world's cobalt.
- Because it is often found in the presence of nickel, cobalt is also extracted in the Southeast Asian region, particularly in Indonesia and the Philippines.
- Demand projections for cobalt are uncertain: they will depend on a multitude of factors including EV sales, the type of Li-ion batteries that are manufactured, the amount of mineral recycling and whether any mining of tailings is attempted.
- It is conceivable that Li-ion battery manufacturers will substitute cobalt for nickel due to its relative scarcity vis-a-vis its more plentiful competitor.
- Cobalt extraction in the DRC is associated with serious human rights and environmental impacts.

Renewable Energy Applications

Cobalt is usually found in combination with other precious metals (commonly copper or nickel) and has historically been mined as a by-product of these minerals. Due to increases in demand, the development of mines dedicated primarily to cobalt extraction has increased in recent years.[83]

Cobalt is cited as critical to the green energy transition due to its use in the cathodes of Li-ion batteries. Li-ion batteries are used in both electric vehicles (EVs) and in stationary energy storage technologies needed to both bolster and optimise 'non-dispatchable' renewable energy networks (such as wind and solar), for which energy cannot be produced on demand.[84] By and large, EVs are envisioned as the main driver of cobalt demand in the renewable energy transition, as governments around the world commit to EV targets and the phasing out of internal combustion engine (ICE) vehicles by 2050.[85] While it is estimated that EV-related cobalt demand only comprised between 10 per cent to 20 per cent of total cobalt demand in 2017, researchers predict that this could easily grow to more than 50 per cent by 2025. Along with Li-ion batteries for EVs and stationary storage, cobalt is also used in batteries to power electronics, superalloys, tools and hard materials, and various other things.[86]

Though there are a variety of batteries used in EVs, Li-ion batteries featuring cobalt are currently the most commonly used worldwide (with the notable exception of China, where Lithium Iron Phosphate (LFP) batteries have been the most common) and are among the most efficient (both in terms of energy density and their lifespan).[87] Specifically, the Nickel Manganese Cobalt (NMC) composition of Li-ion batteries (the most popular design to date), is amongst the best-performing in terms of life-cycles, and also has excellent energy density. Comparatively, the Nickel Cobalt Aluminium (NCA) composition (the battery preferred by Tesla) also has excellent energy density and a reasonable number of life cycles.[88]

The amount of cobalt required for these batteries varies according to the battery design and composition. At present, the most common composition of the NMC design is NMC111, in which manganese, nickel and cobalt are used in equal quantities in the cathode.[89] Other designs anticipated to supersede this composition include NMC811, in which the cobalt and manganese quantities make up only an eighth of the overall nickel required. Forecasters are anticipating a gradual shift away from cobalt-dependent Li-ion batteries (due to future supply issues and ethical concerns over mining practices—particularly in the DRC, the world's largest supplier of cobalt).[90] On the other hand, cobalt-rich countries like Australia, and the companies seeking to mine there, might respond by pushing for its continued use in battery technology.[91] Any reduction in the amount of cobalt needed for Li-ion batteries would likely cause an increase in the amount of nickel required.

Where is Cobalt Found?

Cobalt is considered a particularly scarce resource, especially in terms of land-based deposits. In fact, without consideration or foresight, many projections of the cobalt consumption necessary to meet the imminent EV demand, envision land-based cobalt reserves—and even resources—exhausted within decades.

According to United States Geological Survey, there are around 25 million tonnes of cobalt resources located worldwide. Of this, just over 7 million tonnes make up global reserves;[92] or current estimates of feasibly minable deposits. By far, the largest concentration of cobalt reserves worldwide (around fifty per cent), are located in the DRC; currently, between 60 per cent and 70 per cent of cobalt is mined there.[93] Interestingly, the multinational company Glencore is responsible for the production of 27 per cent of the world's cobalt, with mines in the DRC, Australia, and Canada.[94]

Significantly, Australia has the second largest share of cobalt reserves worldwide; 19 per cent[95] or around 1.4 million tonnes.[96] In Australia, cobalt typically occurs in the form of 'nickel-bearing laterite deposits'[97] and is consequently mined in conjunction with nickel. Currently, Australia is also the third largest producer of cobalt worldwide (second to Russia), constituting roughly 4-5 per cent of global production. Given the size of its reserves, Australia has the potential to increase its share of global supply substantially.[98]

Along with the development of new cobalt mines in Australia, in the Indo-Pacific region more broadly there are new mines in development in both Vietnam and Indonesia.[99] In the case of Indonesia, there are no cobalt concentrated resources; rather, cobalt is typically extracted and processed with nickel deposits.[100] The total cobalt output amounts to roughly 50,000 tonnes of cobalt each year,[101] with mines primarily situated in South-East Sulawesi and North Maluyku.[102] A recent proposed development by PT Huayou Nickel Cobalt at Weda Bay is planned to produce up to 15,000 tonnes of cobalt per annum.[103] Interestingly, around 4 per cent of the global cobalt production occurs in the Philippines.[104] Once again, almost all the cobalt extracted in the Philippines is also sourced from nickel-cobalt laterite deposits.[105] Notable sources of cobalt in the country, like the Nonoc or Taganito mines in Surigao del Norte, are therefore more associated with nickel production.[106]

There are two other potentially significant sources of cobalt—those on certain ocean floors and those in existing mine waste, or 'tailings.' According to the U.S. Geological Survey, there are at least '120 million tons of cobalt resources' located on seabeds around the 'Atlantic, Indian and Pacific Oceans'.[107] These resources occur in the form of cobalt-rich crusts and polymetallic nodules found on ocean floors.[108] This figure (120 million tonnes), drastically increases overall cobalt resources available on earth (given that land-based or terrestrial resources amount to only 25 million tonnes). In recent years commercial and state interest in deep-sea mining has been growing. The International Seabed Authority (ISA), an independent body with 167 member states, along with the European Union established in 1982 to regulate all mineral-resource-related activities in just over half of the world's oceans.[109] Little is known about the deep-sea eco-systems where these cobalt-rich ores are located, nor about how the process of deep-sea mining may affect them. Thus, environmental groups and even car manufacturers have called for a moratorium on deep-sea mining until the potential impacts are better understood.[110]

Table 3.1: Current and planned cobalt projects in Australia

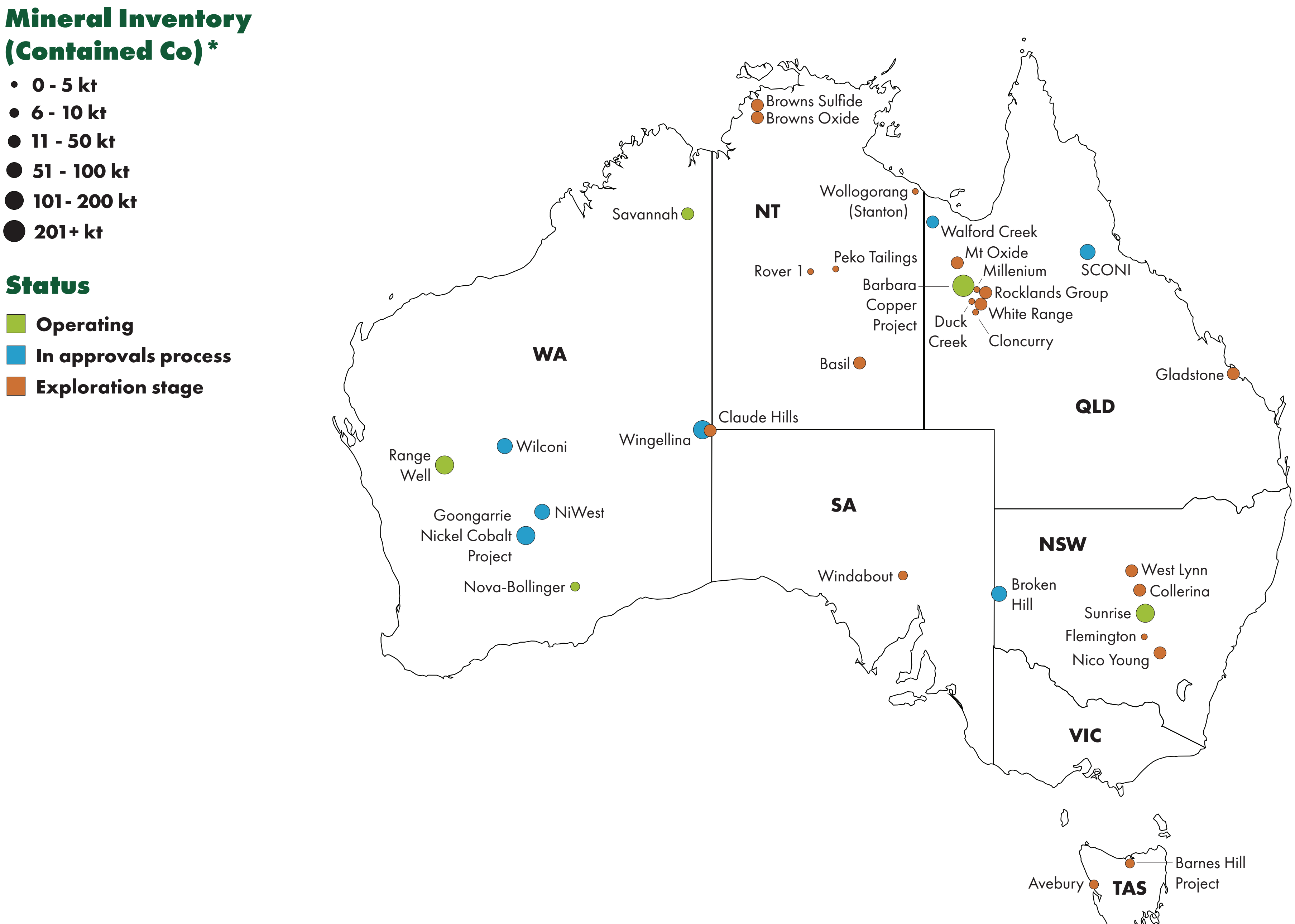
State	Deposit	Operator	Mineral Inventory (Contained Co)	Status/Approvals
QLD	Barbara	Washington H. Soul Pattinson and Company Ltd	1,463 kt	Operating
WA	Savannah	Panoramic Resources Ltd	14 kt	Operating
WA	Nova-Bollinger	IGO Ltd	8 kt	Operating
NSW	Sunrise	Clean TeQ Holdings Ltd	162 kt	Development Approval
WA	Range Well	Ausinox (EV Metals)	154 kt	Mining Lease
WA	Wingellina	Metals X Ltd	154 kt	Mining Lease
WA	Goongarrie Nickel Cobalt Project	Ardea Resources Lty	131 kt	Mining Lease
NSW	Broken Hill	Cobalt Blue Holdings Ltd	80 kt	Mining Lease
QLD	SCONI	Australian Mines Ltd	57 kt	Mining Lease, Environmental Approval
WA	NiWest	GME Resources Ltd	55 kt	Mining Lease
WA	Wilconi	Wiluna Mining Corporation Ltd; A-Cap Resources Ltd[111]	53 kt	Mining Lease
QLD	Walford Creek	Aeon Metals Ltd	50 kt	Mining Lease, Environmental Approval
QLD	Gladstone	Gladstone Pacific Nickel Ltd	43 kt	Mining Lease, Environmental Approval
NT	Browns Sulfide	Northern Territories Resources Pty Ltd	41 kt	Mining Lease
QLD	Rocklands Group	CuDeco Ltd (in liquidation)	16.6 kt	Development Approval
NT	Browns Oxide	Northern Territories Resources Pty Ltd	13 kt	Mining Lease
QLD	White Range	Young Australian Mines Ltd	11.4 kt	Mining Lease, Environmental Approval
TAS	Barnes Hill Project	Tasmanian Energy Metals Pty Ltd	7 kt	Mining Lease
TAS	Avebury	Allegiance Mining Pty Ltd	6.7 kt	Mining Lease, Environmental Approval
NT	Peko Tailings	Elmore Ltd[112]	4 kt	Mining Lease
QLD	Lucky Break**	Metallica Minerals Ltd	0.7 kt	Mining Lease, Environmental Approval
SA	North Portia**	Consolidated Mining and Civil CMC	0.59 kt	Mining Lease

State	Deposit	Operator	Mineral Inventory (Contained Co)	Status/Approvals
NSW	Nico Young	Jervois Mining Ltd	47 kt	Exploration Licence
SA	Claude Hills	Metals X Ltd	22.7 kt	Exploration Licence
QLD	Mount Oxide	Castillo Copper Ltd	21 kt	Exploration Licence
NT	Basil	Mithril Resource Ltd	13 kt	Exploration Licence
NSW	Hurlls Hill Prospect*	N/A	11 kt	Advanced Exploration
NSW	Collerina	Alpha HPA Ltd	11 kt	Exploration Licence
NSW	West Lynn	Alchemy Resources Ltd	11 kt	Exploration Licence
SA	Windabout	Coda Minerals Ltd	8.7 kt	Exploration Licence
QLD	Millenium	Global Energy Metals Corporation	4.8 kt	Exploration Licence
NT	Rover 1	Castile Resources Ltd	4 kt	Exploration Licence
NSW	Flemington	Australian Mines Ltd	2.8 kt	Exploration Licence
NT	Wollogorang (Stanton)	Resolution Minerals Ltd	1.2 kt	Exploration Licence
NSW	Husky**	Victory Mines Ltd	0.81 kt	Exploration Licence
NSW	Pacific Express**	Tyranna Resources Ltd	0.81 kt	Exploration Licence
QLD	Overlander**	Hammer Metals Ltd	0.8 kt	Exploration Licence
SA	MG14**	Coda Minerals Ltd	0.6 kt	Exploration Licence
QLD	Duck Creek**	Young Australian Mines Ltd	0.2 kt	Exploration Licence
SA	Mutooroo**	Havilah Resources Ltd	0.2 kt	Exploration Licence
NSW	Hylea Cobalt**	Lotus Resource Ltd	0.16 kt	Exploration Licence
QLD	Canteen**	Ausmex Mining Group Ltd	0.12 kt	Exploration Licence

* Due to unavailable data, this deposit is not featured on the cobalt map.

** Due to its small size, this deposit is not featured on the cobalt map.

Source: Australian Trade and Investment Commission, with Geoscience Australia & Department of Industry, Science, Energy and Resources, *Critical Minerals Projects in Australia, 2020*



* All locations are approximate

^ MapSVG, 'SVG vector map of Australia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.

Demand Projections for Cobalt

Demand for cobalt over the coming decades will be hugely contingent upon a number of key factors. These include: what battery compositions will dominate EV production; global consumer demand for EVs; government policy surrounding EV sales and the phasing out of fossil-fuel based vehicles; and the degree to which mineral recycling infrastructures and processes for cobalt-based products are created and implemented.

As a result, there have been significant inconsistencies between various demand projections. A forecast from the World Economic Forum's Global Battery Alliance suggests that cobalt demand is due to increase to 222kt by 2025—a 50 per cent increase above 2020 production levels.[113] The IEA has forecast that cobalt demand in 2040 will increase by 6-21 times the amount of 2020 levels, dependent upon a variety of factors. Twenty-one times the current rate of production (140kt annually), would, however, exceed current world resources by more than double. Another forecast sees annual demand for cobalt peaking at around 2050 at 1,966kt in 2050 (this is 1788 per cent of the current rates of production, or 423 per cent of global reserves).[114] The World Bank has also forecast a series of possible scenarios incorporating various possibilities for cobalt demand, some of which exceed resources, and some of which fall far below.[115]

The constraints of this report prevent the possibility of tracing the exact logic and calculations underpinning the various forecasts and laying bear their assumptions. However, a number of points are clear. Soaring demand for EVs is forecast to be the main driver of battery demand in the coming decades, and thus cobalt. Forecasts for cobalt vary due to the diversity of EV battery mineral compositions and various assumed technological developments. At this stage, different reports have suggested that to meet the mineral demand for EVs whilst not exhausting cobalt reserves or resources, ultimately requires markets to transition to Li-ion battery compositions favouring nickel, or to Lithium-sulfur batteries[116].

Social and Environmental Impacts of Cobalt Mining

Most of the studies of the environmental and social effects of cobalt mining come from studies focussed on the DRC. Mines throughout Congo are associated with environmental damage, including to land, air, and waterways that communities depend upon. Cobalt mines also produce huge amounts of dust and air pollution which can cause lung disease, asthma, reduced lung function, and other respiratory issues. In areas where people live in close proximity to cobalt mines, blood levels containing 43 times normal levels of cobalt have been recorded. Mining companies have also been known to pollute ground waters and rivers that communities use as their main water source for drinking, irrigating farmland, fishing, etc., without providing adequate compensation or alternative water sources. Environmentally, cobalt mines also require huge amounts of water to operate, thereby decreasing the amount of water that would otherwise flow to the natural environment. Finally, the deforestation employed to establish larger open-cut mines causes damage to eco-systems and the environment.[117]

Cobalt mining in the DRC is also associated with serious social impacts. Entire communities have been forcefully displaced when foreign companies are granted the right to mine the land beneath their homes and villages. An example of this occurred in 2011 when a new mine belonging to company Société d'exploitation de Kipoi (which is 95 per cent owned by the Australian company Tiger Resources Ltd.), prompted the forceable displacement of over 100 families from their homes.[118] Child labour is another human rights issue associated with cobalt mining in the DRC. According to a report by Amnesty International in 2016, there were an estimated 40,000 children working in mines throughout the DRC at the time of writing. Moreover, the many artisanal mines operation are not subject to formal regulations and are usually hand-dug and dangerous. Children and adults working on them are often subject to meagre pay, intense working hours, very dangerous working conditions and increased exposure to toxic chemicals, fumes, and dust.[119]

CHAPTER 4: MANGANESE

Manganese Summary

- Manganese is a component of two variations of lithium-ion batteries, lithium nickel manganese cobalt (NMC) and lithium manganese oxide (LMO). Additionally, manganese is frequently utilised in steel-intensive renewable technologies like wind turbines and solar towers.
- Manganese is comparatively far cheaper than most other minerals, as are the cost of batteries like LMO. In addition, manganese is not subject to the same concerns around availability and supply chain uncertainty as is, for example, cobalt.
- By deposit size, high-grade manganese ore is primarily found in the Kalahari Basin in South Africa, with Ukraine a distant second. However, accounting for reserves and exportation, Australia ranks as the second-largest manganese producer, primarily due to projects in the Northern Territory and Western Australia.
- China also plays a key role in global manganese trade and is often the destination for manganese ore exported from Australia, South Africa and other African nations.
- Although manganese's overall demand is forecast to increase by 2050, the rate of increase will be determined by which battery variations are adopted. Still, even the most demanding predictions estimate that manganese supply will greatly outweigh any demand.
- Manganese dust particles are a significant hazard for communities living near manganese mines. Studies which observed manganese sediment of proximate agriculture found the size of the particles is easily breathable and can cause respiratory illnesses.

Manganese is a strengthening agent in steel, which is the main structural component of wind turbines and in concentrating solar power (CSP) systems. *Credit: Jacques Tarnero/Shutterstock*

Renewable Energy Applications

Manganese will be a critical element in the transition to sustainable energy due to its availability and its utility in different technologies. Manganese is primarily used as a strengthening component of steel.[120] Although manganese may appear ubiquitous, it is important to recognise that the proportion of manganese used for renewable technology is limited. Only 15 per cent of manganese can be converted to high-grade metal or manganese dioxide via the hydrometallurgical route. The resulting metals, like electrolytic manganese metal, are primarily used in batteries.[121]

In the renewable energy sector, the primary application for manganese is once again for the use of Li-ion batteries in EVs. Lithium nickel manganese cobalt (NMC) batteries are notable for having a longer cycle life than other Li-ion batteries and are used in the batteries of a range of cars. Lithium manganese oxide (LMO) batteries are composed of a significantly greater proportion of manganese, however, their reduced energy density means they primarily find usage in electric bikes and some commercial vehicles. Accordingly, the market for LMO batteries is outrivalled by the demand for variants of NMC battery. Despite being less commonly used than other minerals in Li-ion batteries, manganese has two key features that make its application in EV battery technology desirable: it can perform various functions in different battery types and its supply chains are relatively stable. These features have led some to suggest that it may supplement cobalt in EV battery mineral supply chains given its greater availability.[122]

The lower grade pyrometallurgical manganese has a different renewable energy application: for wind power. Manganese is primarily utilised as a component of the steel comprising the bulk of the wind turbine. The sheer volume of manganese required for turbines significantly exceeds the amount for batteries: up to 7,500 kg per turbine. Similarly, the central tower of concentrating solar power (CSP) systems require substantive volumes of manganese.[123]

Where is Manganese Found?

Manganese is defined by its abundance. It is prevalent in most regions of the world and is the twelfth most abundant element in the Earth, comprising 0.1 per cent of the crust, present in around 300 distinct minerals. South Africa is the leader of mining manganese ore, containing around 80 per cent of the world's manganese reserves. More specifically, around 92 per cent of global manganese high-grade ore (the kind used in EV batteries) is located in the Kalahari Basin. Some sources estimate that Australia ranks as the second-largest exporter of manganese.[124]

There has been historically stable growth of manganese production in Australia—around four per cent from 2013 to 2018.[125] Australia is home to the world's largest manganese mine—the GEMCO mine on Groote Eylandt in the Northern Territory. This mine has been estimated by some to accounts for almost 25 per cent of the total global demand for manganese.[126] Other operational manganese projects in Australia as of 2020 include: Bootu Creek in the Northern Territory and Woodie Woodie in Western Australia—although none of these currently produce high-quality manganese.[127] Additionally, there are several other projects in exploration or scoping stages (see Table 6 below). Of particular note, two companies in WA are currently planning to produce high-purity manganese which is essential to EV batteries.[128] The largest is the Element 25 project located in Butcherbird-Yanneri.[129]

As detailed above, manganese's utility in the renewable sector is dependent on how it is processed. Technologies like EV batteries require high-grade manganese processed through hydrometallurgy to produce specific metals, salts, or oxides necessary for Li-ion cathodes.[130] Therefore, intermediate production must be considered in manganese's supply chain. Significantly, China is the dominant market for processing the mineral. It accounts for 54 per cent of the global manganese intermediate production and 53 per cent of the global manganese product production. Therefore, all manganese-exporting countries, such as Australia, South Africa, Gabon and Ghana, have strong ties to China.[131]

Manganese ore excavated from a manganese mine below. *Credit: Shutterstock*

Table 4.1: Current and planned manganese projects in Australia

State	Deposit	Operator	Mineral Inventory (Contained Mn)	Status/Approvals
WA	Woodie	Consolidated Minerals Pty Ltd	14,841 kt	Operating
NT	Bootu Creek	OM Holdings Ltd	1,094 kt	Operating
NT	Groote Eylandt (ROM)	South32	60,168 kt	Operating
NT	Groote Eylandt (Sand Tailings)	South32	1755 kt	Operating
WA	Butcherbird – Yanneri	Element 25 Ltd	26,300 kt	Mining Lease Application
WA	Ant Hill	Mineral Resources Ltd, Mesa Minerals Ltd	765 kt	Mining Lease, Environmental Approval
WA	Elsa Mary*	Sinosteel Midwest Corp. Ltd	208 kt	Mining Lease, Environmental Approval
WA	Mt Thirsty	Conica Ltd; Greenstone Resources Ltd	204 kt	Mining Lease, Environmental Approval
WA	Horseshoe Range	OM Holdings Ltd, Bryah Resources Ltd	178 kt	Mining Lease, Environmental Approval

* Due to unavailable data, this deposit is not featured on the manganese map.

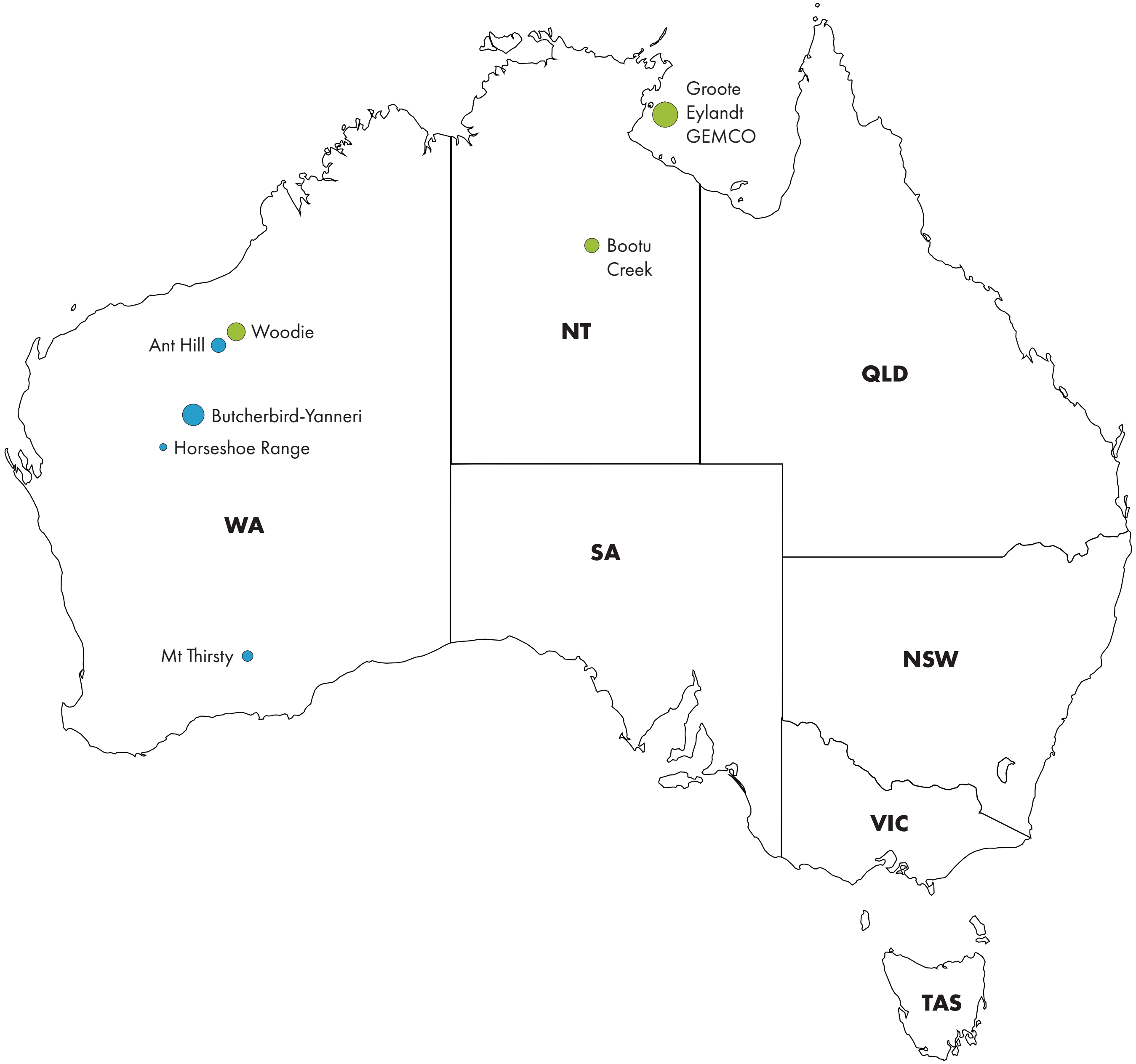
Source: Australian Trade and Investment Commission, with Geoscience Australia & Department of Industry, Science, Energy and Resources, *Critical Minerals Projects in Australia, 2020*

Mineral Inventory (Contained Mn) *

- 100 - 200 kt
- 201 - 500 kt
- 501 - 2000 kt
- 2001 - 15,000 kt
- 15,001 - 30,000 kt
- 30,001+ kt

Status

- Operating
- In approvals process
- Exploration stage



* All locations are approximate
^ MapSVG, 'SVG vector map of Australia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.

Demand Projections for Manganese

Although demand for manganese will increase in the coming decades, accurate predictions are impossible as the demand for key minerals is contingent on market developments.[132] In all circumstances, manganese's qualities of being plentiful and cheap mean that it is projected to be in demand in most, if not all, demand projections. Minerals essential to EV batteries are forecast to increase in demand up to 30-fold to 2040 according to the IEA. The compound annual growth rate of Electrolytic Manganese Dioxide (essential to battery production) was 5.1 per cent from 2015 to 2022.[133]

The demand for manganese will of course depend on the uptake of NMC and LMO battery types. The cost of manganese in comparison to other minerals, and the overall cost of the cathodes it is used in, will also drive demand. Manganese is comparatively cheaper than most other minerals, as are the cost of batteries like LMO (see table below). In addition, manganese is not subject to the same concerns around availability and supply chain uncertainty as is, for example, cobalt.[134]

Table 4.2: Availability of manganese in comparison to other metals

Mineral	Cost per lb ($US)	Global reserves (mt '000)
Manganese	0.80	680,000
Cobalt	34.98	7,100
Nickel	7.08	74,000
Aluminium	1.00	30,000,000

Source: Dominish, E. et al. UTS Institute for Sustainable Futures prepared for Earthworks, 'Responsible Minerals Sourcing for Renewable Energy', 2019.

Manganese, being plentiful and cheap, may therefore be in increasing demand to produce manganese rich battery types, supplementing rarer minerals and bolstering security. The demand for manganese will also increase if Li-ion batteries are utilised beyond EV purposes. For example, if stationary, at-home storage batteries are adopted, manganese demand may multiply.[135]

The demand for manganese in other relevant renewable energy technologies also affects projections. Significantly, if concentrating solar power (CSP) is adopted, manganese demand will increase due to the high quantities required to produce such technology. Likewise, manganese will be essential in the transition towards wind power, as it is a central component in turbine manufacture.[136] However, it should be noted that because the end-use of most manganese is not related to the renewable technology sector, fluctuations in demand related to such industries will only have a limited impact on overall demand.

However optimistic the demand projections, manganese's abundance means that demand will not surpass 14 per cent of potential reserves and will fail to reach 1 per cent of the world supply of resources.[137] The World Bank predicts 2050 demands for manganese will not exceed 4 per cent of the global production in 2018.[138] This is in stark contrast to minerals like cobalt, where demand is forecast to exceed supply.[139]

Social and Environmental Impacts of Manganese Mining

While manganese is a naturally occurring mineral in both food and water,[140] atmospheric manganese near mining projects can far exceed any healthy amount.[141] Furthermore, manganese mining can be severely damaging both to proximate communities and the environment more broadly. These threats to health and the water and air of local communities arise from pollutant waste from the extraction process. Processes like smelting and the leaching of waste slag can create contaminants in local water sources due to rainfall runoff whilst the mining itself generates high levels of manganese dust.[142]

Perhaps the most severe risk to health is the presence of manganese particles in the air of the local area.[143] Communities near mining projects have historically been exposed to heightened levels of manganese in the air.[144] There are numerous health consequences of direct inhalation of manganese including potential damage to brain functions, respiratory and reproductive systems.[145] High manganese in blood has been linked to issues in bone development, compromised immune function and neurotoxic damage to intellectual function.[146]

Alarmingly, it is particularly damaging to the development of children.[147] At the world's biggest manganese mine, Groote Eylandt, the Anindilyakwa Land Council commissioned a study on levels of manganese amongst the local population when concerns were raised about manganese exposure potentially impairing the cognitive ability and development of children. Whilst the study is awaiting formal publication, it found elevated levels of manganese in children and adults of the Groote Eylandt population. Additionally, the dust exhumed in the process of extraction has been found to be of a 'respirable' size range.[148] Such findings mirror previous studies from the 1980s which found that Indigenous peoples at Groote Eylandt had 20 times the concentration of manganese in their hair and blood samples compared to residents of Sydney.[149] The Groote Eylandt mine has been operating in close proximity to the local Angurugu Anindilyakwa population for over 50 years now and is set to continue over the next decade.

The presence of atmospheric manganese has consequences beyond inhalation or ingestion. Studies have found that manganese dust settles on the soil of nearby agriculture.[150] This has the effect of contaminating any local produce and creating another pathway to heightened manganese exposure. Examples like the Groote Eylandt mine show that the local community grows and consumes produce tested to be high in manganese.[151] Further studies suggest a correlation between oral ingestion and toxicity. Case studies in Japan and Greece have suggested high levels of manganese in drinking water is causative of developmental and neurological issues. Whilst the World Health Organization (WHO) has cautioned that these studies lack proper testing and are not probative of any causation, it should nevertheless be noted that the process of extracting manganese is a potential risk factor to the wellbeing of local communities.[152]

The pollutants caused by manganese mining can also be devastating to the local ecology. Studies from China have shown that wastewater runoff from mining has completely destroyed the natural property of topsoil of the local area. Evidence has identified high heavy metal toxicity in nearby wildlife areas, caused by effluent from slag and other forms of pollution.[153] Therefore, without adequate precautionary measures, manganese extraction can be devastating to local agriculture and ecology.

CHAPTER 5: RARE EARTH ELEMENTS

Rare Earth Elements Summary

- Rare Earth Elements (REEs) are primarily used in the creation of permanent magnets, which are part of many of the generators used in renewable technologies. This is primarily the case for wind turbines, but permanent magnets are also used in the motors of electric vehicles.
- REEs are typically found in deposits containing a mix of different elements and the process for their extraction is complex and expensive. China dominates the global REE market, both in terms of extraction and processing. However, Australia is one of the few notable suppliers of REEs outside China.
- Depending on the form of technology embraced in the future, there is a likely possibility that demand for key REEs like neodymium will increase two to three times by 2030. However, such estimates are conditional on factors like China's continuing role in the global REE market and the rate of recycling of REEs.
- The process of extracting REEs through leaching can cause significant toxic waste, damaging the nearby ecosystem. Additionally, there has been reports of water contamination in communities in China, resulting in severe health consequences.

The permanent magnets that are the primary application of REEs are used in 'direct drive turbines', making them particularly useful in offshore wind turbines. *Credit: Photofex_AUT/Shutterstock*

Applications for Renewable Energy

Rare earth elements (REEs) are not a singular mineral, but rather a grouping of 17 elements defined by their occurrence together in nature and shared catalytic, metallurgical, nuclear, electrical, magnetic, and luminescent properties. As a group, REEs are somewhat common in the crust of the earth, and thus readily accessible for extraction. Although REEs are statistically ubiquitous, they tend to be concentrated in particular geographic regions (though dispersed across 15 countries) and are often present in mineral clusters with other REEs or with other minerals. Moreover, the proportion of certain key REEs is relatively small compared to the total concentration of minerals. This results in difficulty in obtaining economically viable concentrations of specific REEs. Of the group, neodymium, dysprosium, praseodymium, and terbium are of importance to the clean energy sector with other reports placing particular emphasis on the first two.[154]

The primary technological usage of REEs—making up 50 per cent of demand—is in the creation of permanent magnets due to the inherent 'permanent magneticity' of certain REEs. The aforementioned four key REEs are essential components in 'neodymium-iron-boron' (NdFeB) form magnets. These magnets are the strongest commercially available and are of particular economical value regarding space and weight. Notably, neodymium is regarded for its capacity to function under high temperatures, and dysprosium is often added to NdFeB batteries to enhance performance properties. As praseodymium typically appears with neodymium, it is cheaper to produce a form of neodymium alloy that incorporates praseodymium. In total, REEs comprise roughly 30 per cent of these permanent magnets and are evidently key components.[155]

The primary usage of REE-based permanent magnets—particularly NdFeB type magnets—is as a component of generators powering certain renewable technologies. One such notable technology is wind energy, specifically the turbines necessary for powering wind energy technology. Permanent magnets function to create 'direct-drive turbines', a form of turbine notable for bypassing the need for a gearbox and therefore reducing the size of the turbine. The magnet-based generator operates by being directly attached to the rotor, providing a consistent rotation speed. The benefit of REE-based permanent magnets is that their relatively high power to size comparison results in higher efficiency and lower costs. Around 75 per cent of off-shore wind turbines make particular use of such magnets, which amounts to approximately 20 per cent of all wind turbines globally.[156]

The other primary usage for REE-dominant magnets is as a component in traction motors for electric vehicles—it is estimated that 90 per cent to 93 per cent of motors contain REEs. Similar to off-shore turbines, the compact quality of NdFeB magnets is highly convenient for electric vehicles.[157]

Where are Rare Earths Found?

REEs are often complex in composition: there exists upwards of 245 distinct forms of mineral deposits that contain economically significant portions of REE minerals. These mineral compounds are primarily carbonates, as well as igneous rocks known as carbonatites. The typical deposit type involves a blend of different REEs, with the light variant more common than heavy-REEs or 'magnetic rare earths'. Extracting and processing REEs are notoriously complex and expensive, qualities which make such minerals 'rare'. Post extraction, REEs must be separated before they can be transformed into functional alloys for the renewable energy market. Often, the economic benefit from acquiring REEs does not justify the cost of extraction.[158]

China plays a dominant role in the global REE supply. It is estimated that China extracts around 60 per cent and processes around 80 per cent to 90 per cent of the global supply of REEs.[159] China has additionally come to dominate the processing and manufacturing of REE alloys and magnets, due to its Made in China 2025 policy which prioritised domestic manufacturing.

Australia serves as one of the few reliable alternative sources of dysprosium besides China, ranking as the second-largest producer of the ore.[160] Other localities possess significant portions of the elements. Russia, Brazil, and Vietnam all contain significant reserves but have not instituted the economic and technical requirements to extract the elements. Meanwhile, extraction projects are underway in South Africa, Canada, and Greenland.[161] Greenland may play a significant role in the future, given the nation has the largest untapped resource pool of REEs.

Deep excavation hole of open pit mine for rare earth elements (REEs). *Credit: Photofex_AUT/Shutterstock*

Table 5.1: Current and planned rare earths projects in Australia

State	Deposit	Operator	Mineral Inventory (Contained TREO)	Status/Approvals
WA	Mt Weld	Lynas Corporation Ltd	3,000 kt	Operating
WA	Eneabba By-Product Stockpile	Iluka Resources Ltd	N/A	Operating
WA	Yangibana	Hastings Technology Metals Ltd	238 kt	Operating
NT	Nolans	Arafura Resources Ltd	1,456 kt	Mining Lease, Environmental Approval NT EPA
NSW	Dubbo	Alkane Resources Ltd	662 kt	Development Approval
WA	Cummins Range	Rarex Ltd	147 kt	Advanced Exploration
WA	Brockman	Hastings Technology Metals Ltd	86.94 kt	Mining Lease Application
WA	Browns Range	Northern Minerals Ltd	57 kt	Mining Lease, Environmental Approval
NT	Charley Creek	Enova Mining Ltd	233 kt	Exploration Lease
NSW	Narraburra	Paradigm Resources Pty Ltd	35 kt	Exploration Lease
VIC	Fingerboards	Kalbar Resources Ltd	490 kt	Retention Licence
VIC	Avonbank	WIM Resource Pty Ltd	N/A	Retention Licence
VIC	Wedderburn	WIM Resource Pty Ltd	N/A	Retention Licence
VIC	Wimmera*	Iluka Resources Ltd	N/A	Retention Licence Application
VIC	Bungalally	WIM Resource Pty Ltd	N/A	Retention Licence
VIC	Goschen	VHM Ltd	N/A	Exploration Licence

* Due to unavailable data, this deposit is not featured on the rare earth elements map.

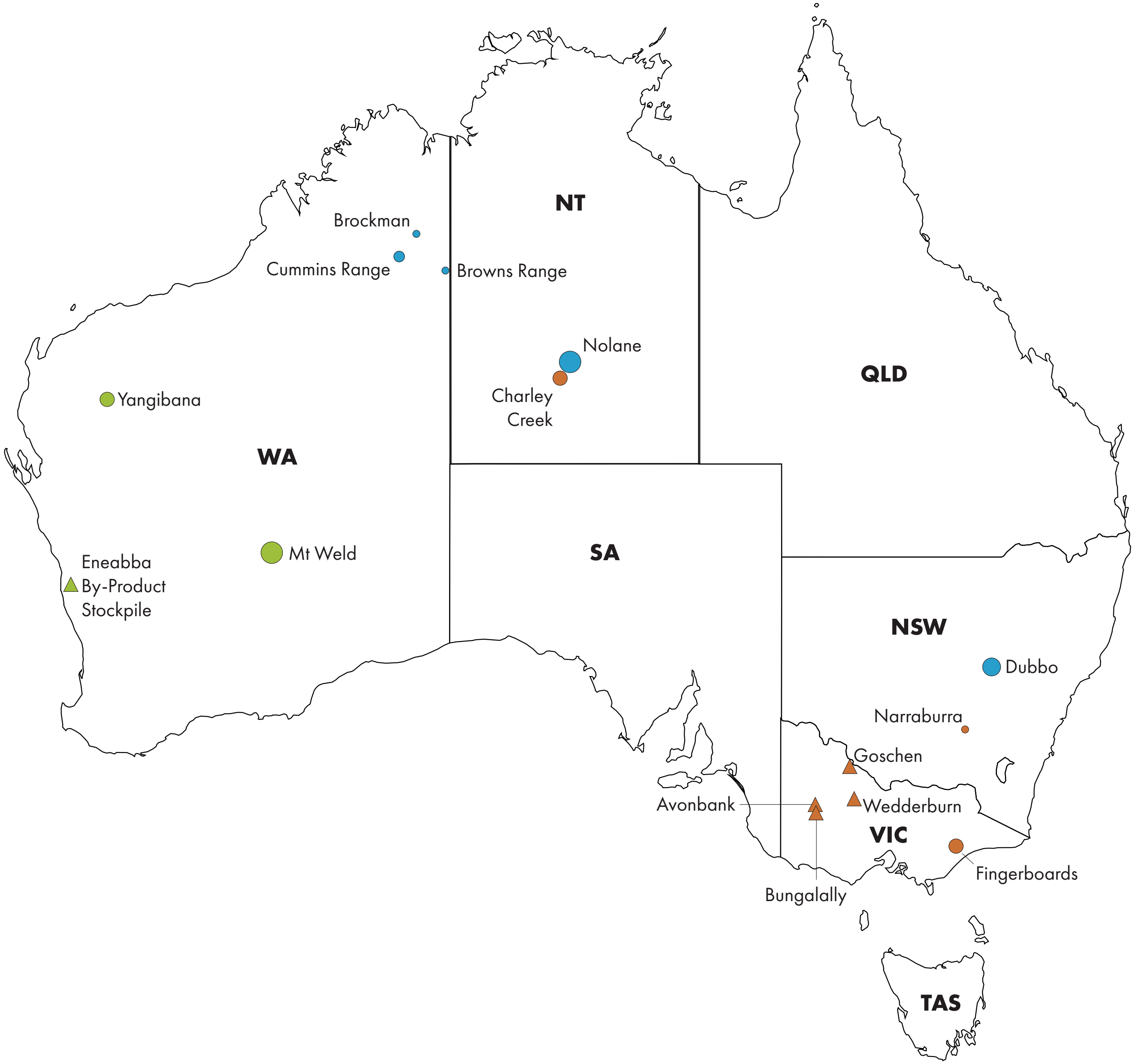
Source: Australian Trade and Investment Commission, with Geoscience Australia & Department of Industry, Science, Energy and Resources, *Critical Minerals Projects in Australia, 2020*

Mineral Inventory (Contained TREO)*

- 0 - 100 kt
- 101 - 200 kt
- 201 - 500 kt
- 501 - 1000 kt
- 1001 - 3000 kt
- ▲ Unknown size

Status

- Operating
- In approvals process
- Exploration stage



* All locations are approximate

^ MapSVG, 'SVG vector map of Australia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.

Demand Projections for Rare Earths

As REEs are central to two core renewable energy technologies (wind and electric vehicles), it is widely speculated that demand for core elements like neodymium and dysprosium will rapidly increase. The core industry driving this growth will be electric vehicles, largely due to the commercial growth of the sector and the rapid uptake of EVs by consumers.[162] Estimates regarding the future demand of certain REEs vary. However, the IEA speculates that—depending on the renewable policy uptake of different countries—demand for REEs like neodymium may increase anywhere from two to three times by 2040.[163] Concretely, there have been studies claiming that—depending on the scenario—demand for REEs may grow from 200,000 tonnes a year in 2021 to 450,000 tonnes in 2035.[164] IRENA specifies that should uptake in various technologies like wind continue, then REE production would require an 11- to 26-fold expansion.[165] However, this is highly contingent on variables that will be discussed below.

It should be noted that the increase in demand for REEs may be conditioned by the different end-uses of the elements. For example, as clean energy technologies only represent 15 per cent of total neodymium demand today, fluctuations in the growth of renewable technology requiring the element will have a limited impact on demand in comparison to more neodymium-intensive technologies. Moreover, the end-use percentage of neodymium for renewable energies may increase up to 25 per cent in coming years.[166]

The relative demand for core REEs may be alleviated by technological developments which supplement neodymium and dysprosium with other minerals. However, whilst there are alternative motor technologies in development, these technologies will only be available in the distant future and for now, REEs are the standard.[167] A further variable impacting the increased demand of REEs is the variability of core technologies. Offshore wind turbines are REE intensive, with onshore variants being less so.[168] Depending on the policies embraced by leading economies, the presence of geared turbines not requiring REEs may vary dramatically. The World Bank has modelled various scenarios in which demand for neodymium varies depending on the take-up of direct drive wind turbines.[169]

Another variable impacting the availability of REEs is Chinese export policy. In 2010, China restricted the availability of REEs to other nations. A repeat of this history could wreak havoc on REE global supply chains.[170] Indeed, this very action by China has presumably prompted a desire by other countries to develop diversified supply sources of REEs and/or develop technologies that bypass the need for REEs altogether.[171]

A final variable that may significantly affect the availability of REEs is the recycling rate of specific elements. Currently, neither neodymium nor dysprosium are recycled to any substantial level.[172] However, the IEA has cited the potential for REEs to be extracted from deposits of nuclear fuels which contain significant amounts of REEs[173] Such a form of extraction could be a panacea to the scarcity of REEs. As Bourg and Poinssot highlight, processes for separating REEs from nuclear fuels have matured to a stage that is ready for industrial usage.[174] At present, the process of recovering neodymium and praseodymium from spent nuclear fuel is costly in comparison to conventional forms of extraction.

Social and Environmental Impacts

Examining the environmental and humanitarian impacts of REE extraction is challenging due to the relative lack of mines and their global concentration. This is exacerbated by the lack of environmental information published about REE mines in China.[175]

REE extraction intrinsically involves a complicated process of separation and processing due to their mixed ore-types. There are two distinct extraction processes for REEs, both of which involve toxic chemicals and prove costly for the environment.[176] The two methods of REE mining—leaching and PVC pumping—both involve a significant output of toxic waste. A report by Harvard International Review specifies that per ton of REE, extraction produces '13 kg of dust, 9,600-12,00 cubic meters of waste gas, 75 cubic meters of wastewater, and one ton of radioactive residue'[177] Additionally, the unique chemical composition of some REEs means that when exposed to leaching chemicals, they produce significant contamination. Beyond the mining stage, there are generally two variations of waste management for REE extraction: tailings and waste rock stockpiles.[178] Often metal by-products are created through these processes which easily enter the environment via air or water. Once these metals have contaminated the environment, it is incredibly difficult to reverse effects. Tailings waste management is particularly problematic, as often small mineral particles in tailings contaminate nearby water sources. The release of these contaminants into water can be particularly devastating for marine life.[179] A further problematic factor is that REEs are often encountered in deposits shared with thorium and uranium, both elements that have potentially damaging environmental and humanitarian effects.[180]

Beyond ecological impacts, the effects of REE mining can have severe consequences on the health and livelihoods of peripheral communities. In China, several large mining projects which have failed to implement functional preventative measures and negated due diligence considerations of contamination risks, have caused contamination of drinking water sources of local villages.[181] For example, in Bayan-Obo, due to the presence of thorium, radioactive tailing water managed to pollute the Yellow River. Rivers like the Donjiang, Ganjiang, and Yangtze have likewise been affected by REE contamination.[182] The impact of REE extraction on peripheral communities in China is of such severity that the term 'cancer village has been used to describe the health consequences.[183]

As with other critical minerals, REE extraction can be severely detrimental to the health of local mine workers.[184] The vast majority of the world's supply of REEs come from mining sites that expose workers to a heightened risk of health complications.

There is limited information on the impact of REE extraction in other countries like the US.[185] Therefore, it remains speculative whether the effects of REE extraction in China can be detached from its context of limited regulatory oversight. At present, there is little information about the environmental and social impacts of Australian REE mining. However, Australian REE mining operations are causing negative humanitarian and environmental consequences abroad. Notably, AID/WATCH highlights that the Australian company, Lynas Rare Earth, has faced opposition due to its dumping of toxic and radioactive waste in Kuantan, Malaysia. Notably, the Lynas Advanced Materials Plant in Malaysia receives REE ore extracted from Mount Weld in Western Australia for processing. The waste caused by processing includes thorium, uranium and toxic heavy metals, and sustained exposure to such contaminants can cause severe adverse health issues for local residents.[186] This is highly problematic considering the processing plants proximity to local communities. Evidently, while the environmental consequences are not occurring in Australia, the international supply chain of REEs means that Australian companies contribute to adverse consequences in other nations.

CHAPTER 6: COPPER

Copper Summary

- Copper is present in almost all renewable technologies, reflecting its varied usage as a base component in a range of conventional technology. Copper is used in the electrodes of Li-ion batteries, in the internal combustion systems of EVs and in the wiring and cabling of wind turbines. However, the most dominant renewable usage is in the heat exchangers, wires, and cables of solar PV systems.
- Copper can either be extracted through underground mining or solution mining (which involves using chemicals to dissolve deposits). The majority of copper production occurs in the Global South, with China dominating most supply chains. Whilst Australia's copper supply has fluctuated, emerging projects suggest an increase in production in the future.
- The increase in demand for copper will be conditional on key variables such as the uptake of EVs, which could increase global demand to 1.74 million tonnes by 2027. However, demand may be alleviated if recycling and substitution methods are adopted for used copper.
- There have been documented examples of copper mines causing adverse environmental, health and human rights consequences in countries like Indonesia, Papua New Guinea and the Philippines, as well as many South American nations. Such consequences include: critical water depletion, water contamination, respiratory illnesses, and community conflict and exploitation.

Applications for Renewable Energy

Copper is primarily utilised as a base metal and correspondingly, is ubiquitous in all industries: wiring, plumbing, infrastructure, building construction, appliances and electronic equipment.[187] Copper has unique functionality due its high electrical conductivity. It is the central metal used in electricity networks and 'a cornerstone for all electricity-related technologies. For example, around a third of all copper is used for electricity grids.[188]

Copper's omnipresence as a base requirement for *all* general technology means that it is also central to renewable technology. Copper is an integral component of the manufacturing of lithium-ion (Li-ion) batteries. Whereas many of the other major elements like nickel and cobalt—are integral to the cathode of the battery, copper plays a key role in the creation of the other electrode, the anode. Although batteries do not account for the majority renewable end-usage of copper, it is anticipated that this will shift by 2035. Beyond usage in batteries, copper also has utility in electric vehicles themselves. Notably, copper is utilised in the 'internal combustion engines' of EVs. The intensity of copper consumption varies by vehicle type, with battery electric vehicles (BEVs) using up to '83kg of copper'.[189]

Solar power is currently the primary renewable end-usage for copper, projected to be the main consumer of copper until 2035. Copper is a primary constituent of the inverters used in distributed solar Photo Voltaic (PV) systems; in components like heat exchangers; and in the 'thin film' technology of copper indium gallium selenide (CIGS), another crucial element of solar technology. Therefore, copper's utility to solar power is a blend of its conventional functionality and its usage in emerging technology. Copper is also the central ingredient in the creation of offshore wind turbines, which use almost three times as much copper per unit of energy produced than onshore wind turbines.[190]

A breakdown of copper's usage in renewable energy is: conventional functionality in cabling wiring (53 per cent), turbines (24 per cent) and turbine transformers (19 per cent).[191]

Where is Copper Found?

There are a variety of different copper ore deposit types; low grade igneous intrusions (60 per cent of global supply) and higher grade found in sedimentary rock layers (20 per cent of global supply). The type of copper extracted from

Copper's use as a base requirement for general technology makes it central to most renewable technologies, but its use inverters for solar photo-voltaic panels is one of its major use. *Credit: myphotobank.com.au/Shutterstock* both these deposits consists of two key forms: copper oxide and the more common copper sulphide.[192] The processing of copper sulphide occurs in three key stages: first, the separation of any waste rock and minerals from the copper; second, purification through smelting the copper ore; and third, refining the copper through electrolytic methods to produce a final product with a purity of roughly 99.99%. Different methods are used to process copper oxide and copper sulphide.[193]

Copper can be extracted through several mining processes. These include: surface mining (i.e. open pit mining); underground mining; and solution mining involving the use of chemical solutions. The usage of such chemicals elicits concern regarding contamination and environmental damage.[194]

The global supply of copper is plentiful. The International Copper Supply Group (ICSG) estimates that current identified copper resources amount to roughly 2,100 metric tonnes—or roughly 5,600 metric tonnes if one includes 'undiscovered' resources.[195] These figures do not account for underwater supplies of the mineral. Considering annual copper production currently amounts to roughly 19 million tonnes, the chance of resource depletion may seem low.[196] However, as discussed further below, the low grades of many copper deposits and the serious environmental impacts of extraction, may mean that it is not viable to extract large swathes of this resource.

Notably, around 50 per cent of global copper reserves and 57 per cent of copper production occurs in Global South countries. South America dominates with nearly 39 per cent of total resources. This is followed by North America with 23 per cent and North Central Asia, Africa and the Middle East all with 8 per cent each. The two primary producers of economically extractable copper are Chile and Peru. These countries are followed by economic powerhouses like the USA and China as well as nations that occupy the so called 'African Copper Belt'.[197]

China has come to dominate global supply-chains of copper, fuelled by a need to supply the demand of the growing renewables sector in the country. This has seen Chinese corporations investing in regions with particularly fragile environmental regulations and prone to conflict—for example, Peru, Ecuador, and the DRC. China's dominance is particularly evident in South America, with several countries present and exerting control over crucial mines in the region.[198]

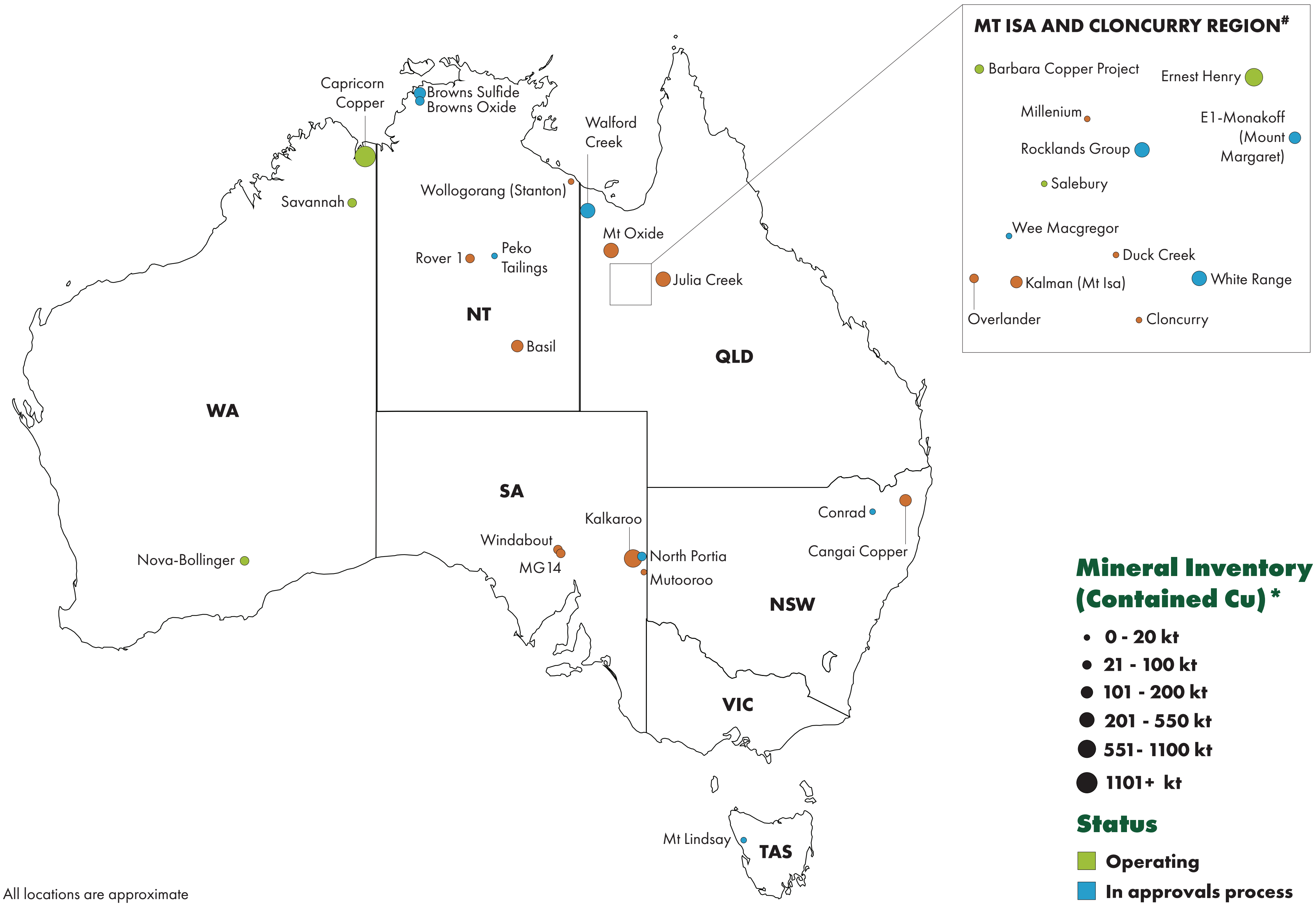
Australia's output of copper has fluctuated in recent times, with a significant downturn in 2019 due to mine closures causing 'lower production'. However, it has been forecast that new projects will be established in the near future. A notable copper mine located in Australia was the Redbank copper mine located in the Northern Territory, which operated for three years and ceased production due to copper price fluctuations.[199] However, despite only operating for a limited period in the 1990s, it left a lasting impact on local residents. Regulatory failures resulted in contamination of local water sources yet, no charges were brought against the operating company, a decision that surprised the Northern Land Council.[200] The effect of mines on local communities could prove to be problematic in future developments.

Table 6.1: Current and planned copper projects in Australia

State	Deposit	Operator	Mineral Inventory (Contained TREO)	Status/Approvals
QLD	Capricorn Copper	Capricorn Copper Holdings Pty Ltd	1,686 kt	Operating
QLD	Ernest Henry	Evolution Mining Ltd	952 kt	Operating
WA	Savannah	Panoramic Resources Ltd	100 kt	Operating
WA	Nova-Bollinger	IGO Ltd	94 kt	Operating
QLD	Barbara	Washington H. Soul Pattinson and Company Ltd	67 kt	Operating
QLD	Rocklands Group	CuDeco Ltd	366.4 kt	Development Approval
QLD	Walford Creek	Aeon Metals Ltd	303 kt	Mining Lease, Environmental Approval
QLD	White Range	Young Australian Mines Ltd	214.6 kt	Mining Lease, Environmental Approval
NT	Browns Sulfide	Northern Territories Resources Pty Ltd	158 kt	Mining Lease
QLD	E1- Monakoff (Mount Margaret)	Glencore PLC	101 kt	Development Approval
NT	Browns Oxide	Northern Territories Resources Pty Ltd	77 kt	Mining Lease
SA	North Portia	Consolidated Mining and Civil CMC	28 kt	Mining Lease
TAS	Mount Lindsay	Venture Minerals Ltd	13 kt	Mining Lease
QLD	Salebury (Cloncurry East)	Magnum Mining and Exploration Ltd	12 kt	Development Approval
QLD	Wee Macgregor	Cohiba Minerals Ltd	10 kt	Development Approval
NT	Peko Tailings	Elmore Ltd	9 kt	Mining Lease
NSW	Conrad	Silver Mines Ltd	5.3 kt	Mining Lease
SA	Kalkaroo	Havilah Resources Ltd	1,097 kt	Mining Lease
QLD	Julia Creek	QEM Ltd	548.4 kt	Mining Lease Application
QLD	Mount Oxide	Zhongjin Lingnan Mining (HK) Co. Ltd	225.6 kt	Exploration Licence
NT	Basil	Mithril Resources Ltd	151 kt	Exploration Lease
QLD	Kalman (Mount Isa)	Hammer Metals Ltd	122 kt	Exploration Licence
NSW	Cangai Copper	Castilo Copper Ltd	108 kt	Exploration Licence
SA	MG14	Coda Minerals Ltd	22.7 kt	Exploration Licence
NT	Rover 1	Castile Resources Ltd	83 kt	Exploration Lease
SA	Windabout	Coda Minerals Ltd	22.7 kt	Exploration Licence
QLD	Overlander	Hammer Metals Ltd	21.3 kt	Exploration Licence
QLD	Duck Creek	Young Australian Mines Ltd	14.1 kt	Exploration Licence
QLD	Cloncurry	ActivEX Ltd	12.4 kt	Exploration Licence
QLD	Millenium	Ausmex Mining Group Ltd	10.7 kt	Exploration Licence
SA	Mutooroo	Havilah Resources Ltd	3.3 kt	Exploration Licence
NT	Wollogorang (Stanton)	Resolution Minerals Ltd	1.1 kt	Exploration Lease
NT	White Violet**	Thor Mining PLC	0.3 kt	Exploration Lease
NT	Samarkand**	Thor Mining PLC	0.3 kt	Exploration Lease

**Due to its small size, this deposit is not featured on the copper map below.

Source: Australian Trade and Investment Commission, with Geoscience Australia & Department of Industry, Science, Energy and Resources, *Critical Minerals Projects in Australia*, 2020



* All locations are approximate

Inset distances are not to scale, however, inset deposit sizes are to scale in relation to the rest of the map.

^ MapSVG, 'SVG vector map of Australia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.

Demand Projections for Copper

Demand predictions regarding copper vary dramatically depending on the variables considered. One of the most important factors to consider when evaluating copper's future demand is that the renewable energy sector only accounts for a portion of the mineral's end use. As already stated, copper is omnipresent in a vast array of other industries. Correspondingly, major fluctuations in the renewables market will have a limited impact in copper demand, compared to minerals like lithium and cobalt. However, it should also be considered that copper is also omnipresent within the renewable sector, in addition to outside of it. Copper's usage in nearly every relevant technology signals that should dramatic fluctuations impact the sector as a whole, copper's 'absolute' demand will increase to a substantial degree.[201]

The IEA estimates that, in a scenario that meets the Paris Agreement Goals, demand for copper could rise upwards of 40 per cent.[202] Others speculate that it is possible the demand for copper could 'increase by as much as 350 per cent by 2050'.[203] Some experts believe that for copper supply to match demand, new mines will need to be established; failing that, it is speculated that by 2030, supply may fall up to '10 million tonnes' short of demand.[204] The World Bank highlights that it is important to treat these estimations with caution, as copper is used not only in renewable technology, but also in ancillary infrastructure.[205] Therefore, estimations may vary depending on whether such infrastructure is considered. It is important to collectively examine the underlying variables affecting demand to gain a fuller picture.

As with lithium, cobalt, etc, the demand for copper also depends on the uptake of EVs. The Copper Alliance speculates that with rapid uptake, demand solely from the EV market could shift from '185,000 tonnes in 2017 to 1.74 million tonnes in 2027'.[206] Another variable to consider is the capacity to substitute copper with other minerals: although copper is dominant with wiring and cabling, should supply be limited, it can be substituted with alternatives like aluminium.[207] A final variable already referenced elsewhere is copper's declining quality. It must be recognised that the lower ore grade of the mineral will invariably impact the resources required for extraction, and correspondingly, condition supply in the future.[208] Ultimately, the effect of these variables is unpredictable, especially considering copper's enduring demand outside the renewables sector.

Social and Environmental Impacts

Copper extraction has caused a range of environmental and ecological consequences, both temporary and long-term. One of the primary environmental issues stems from the ever-declining grade of copper ore being mined. High-grade copper ore has historically been extracted earlier in a mine's life-cycle whereas lower grade ore requires substantially more machinery and energy. For example, the quality of Chile's copper exports have declined by up to 30 per cent. The corresponding increase in production to extract such low-quality ore has, according to the IEA, exerted 'upward pressure on production costs, greenhouse gas emissions and waste volumes'. This is problematic also when considering the fact that 15 per cent of the world's copper is sourced from areas with 'low governance scores and high emissions intensity'. Copper already requires a high amount of energy for production and the rapid decrease in ore quality is forecast to rapidly increase the amount of CO_2 emitted in the extraction process. These combined factors create a situation where the ever-intensifying production of copper may cause irreversible environmental damage.[209]

Copper mines have faced accusations of unethical conduct pertaining to a range of issues, including problems regarding access to water and health impacts.[210] This emphasis on water is particularly salient considering roughly 50 per cent of all copper is extracted and processed in areas of 'high water stress' like in Andean nations, Chile and Peru, where copper mining is intense and access to water is low.[211] In the case of Chile, high water consumption is particularly problematic as several other proximate industries, like agriculture, are also dependent on water sources. The rapid consumption of water has caused the area to lose approximately '1,750-1,950 litres per second more than it receives'.[212] This water stress has been intensified by the presence of other mining operations, some for key minerals referenced in this report, like lithium.

Copper mining has also been causative of a range of health issues, the effect of which varies according to the form of mining employed. Acid mine draining is a serious problem in copper mines, with acid elements in the tailings allowing copper and heavy metals to leach into river systems. The Mount Morgan Mine in Queensland is one of the most notorious examples of mining pollution in Australia's history. Leaching of copper into the river system from acid mine drainage has caused the river system turn a stunning blue; meanwhile the same phenomenon has seen rain filling up the mine pit that has the same pH level as battery acid. Similar pollution from copper leaching has occurred in the Redbank copper mine in the Northern Territory and the Baal Gammon Mine in Queensland.[213]

Contamination is even worse in the case of tailings dam failures or spills. This has been particularly devastating to nearby farming communities where copper mining has contaminated irrigation water with heavy metals like lead and zinc, as witnessed in the case of copper mines in the Jiangxi Province of China.[214] Tailings dam failures are particularly problematic in copper porphyry mines, where spills from copper mines have caused 'contamination of drinking aquifers, contamination and loss of fish and wildlife and their habitat, and risks to public health'.[215] Additionally, the lower ore quality has caused higher contamination rates, with the 'arsenic content in Chilean concentrate' doubling in the last 20 years.[216] Such pollution causes serious health issues to nearby communities and workers. Famous tailing systems failures have occurred in PNG, both with Rio Tinto's Panguna mine in Bougainville and BHP's Ok Tedi mine in Western Province.[217]

Beyond water and environmental contamination, there have been other cases of health impacts in major copper producing nations. In the case of underground extraction of copper, Zambian miners have inhaled silica and suffered long-term tuberculosis. In China, the processing of copper has brought its own risks, with workers operating smelters suffering arsenic exposure.[218] Whilst some geologists have stated mining has 'gotten cleaner' with safeguards imposed to safely process ore, they still concede that there is more that needs to be done.[219]

Polluted water from the Panguna mine pit entering the Kawerong river. *Credit: Dina Rui*

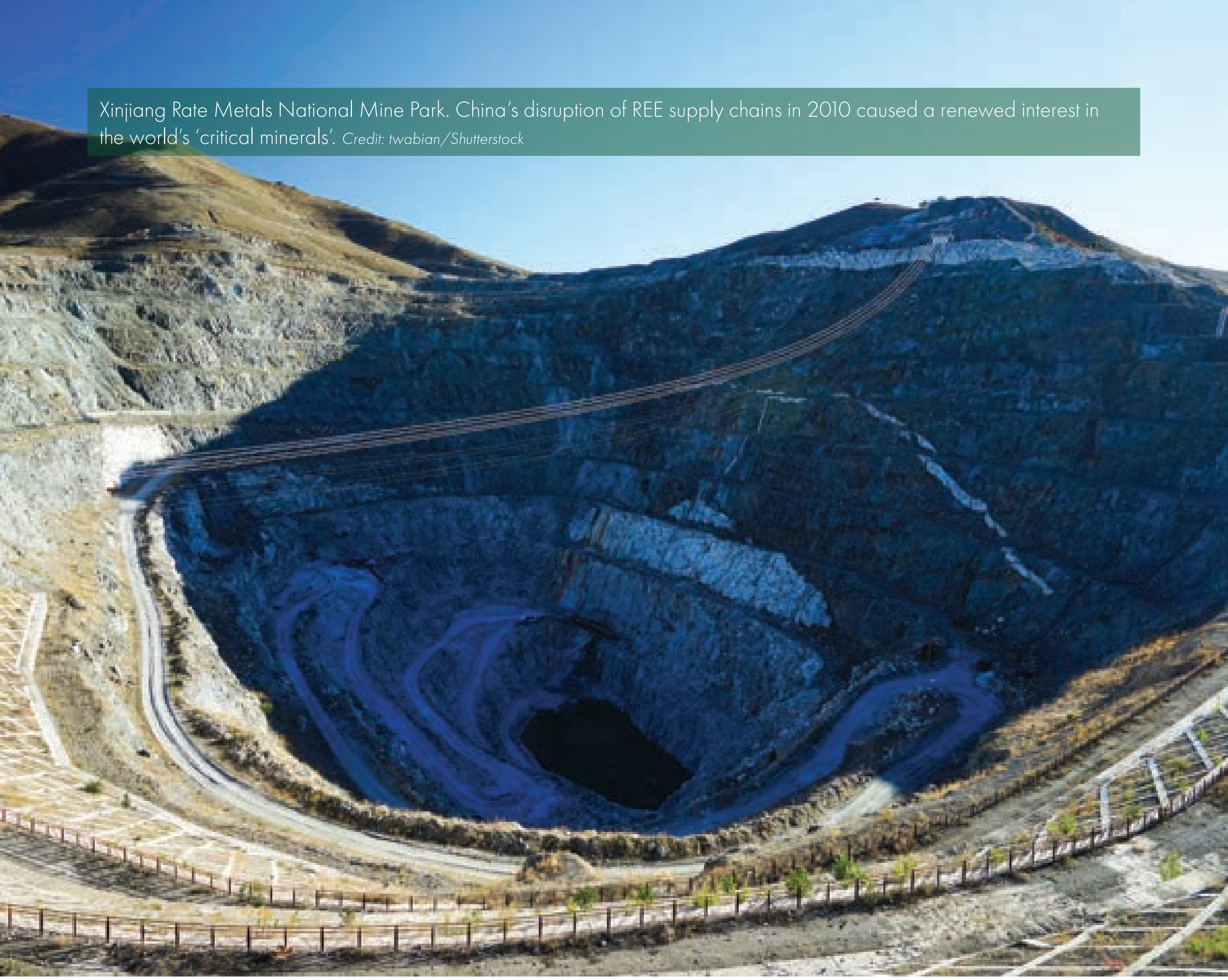
PART 2: ANALYSIS

Part II commences by examining the evolution of critical minerals policy in the Australian context in **Chapter 7**. From a foreign policy perspective, our critical minerals policy once again puts Australia in the middle of a geopolitical struggle for resource control—between its closest geopolitical allies on the one hand (the US, the EU, Japan) and its largest trading partner (China) on the other. It also forces us to consider whether Australia's economic structure that emphasises raw materials over manufacturing and other higher value sectors is one which we want to remain committed to. The new Albanese government dual emphasis on the 'diversification of supply chains' and 'adding value' by moving up the supply chain into manufacturing, for example gives a suggestion of where it seeks to land on these two dilemmas. Nevertheless, the new approach shows no signs of questioning the 'false scarcity' narrative around critical minerals.

The drive to open up new extraction for transition minerals has been criticised as being spurred by demand projections. To that end, **Chapter 8** asks, are these demand projections realistic and more importantly, are they responsible? Can recycling and alternative, non-extractive sources of supply bring about a different narrative? Furthermore, can policy choices and solutions also play a role in reducing demand and thus, reducing the alleged 'scarcity'? Policy choices around recycling, decisions about the amount of EV vehicles on the road, the size and type of those vehicles, the types of Li-ion batteries used, and the potential of non-extractive sources of supply, are all ways that will help reduce demand for many of the transition minerals that Australia possesses. Similarly, we can reorient our transport policy, energy policy, housing and construction policy, and urban design in a way that will ensure that the new energy transition will be more sustainable than the previous one.

Chapter 9 asks the question: what would sustainable extraction for transition minerals in Australia actually look like? Fortunately, some of the steps that we must take to implement such a regime are already on the legislative agenda for this parliament, such as the need to change the Indigenous cultural heritage regime in the wake of the Juukan Gorge incident and the planned changes to the EBPC Act in the wake of the Samuel review. Equally, state and territory mining laws are in need of serious reform, and a more robust corporate accountability regime needed to be able to sanction companies, including mining companies, that do not respect the environment or human rights in their operations.

Part II concludes by looking at transition minerals from a regional context in **Chapter 10**. Although the Asia-Pacific region does not contain the diversity of riches in transition minerals as the Australian continent, it does contain significant amounts of nickel and copper, as well as some cobalt. Mining transition minerals in Australia has a range of social and environmental risks as the above chapters have shown. If anything, the mining of transition minerals in the Asia Pacific region is even more fraught when it comes to the potential harms to people and the environment.



Xinjiang Rate Metals National Mine Park. China's disruption of REE supply chains in 2010 caused a renewed interest in the world's 'critical minerals'. *Credit: twabian/Shutterstock*

CHAPTER 7: AUSTRALIA—A CRITICAL MINERALS POWERHOUSE?

Summary

- The critical minerals concept has historical origins in US policymaking, playing an integral role in the US' economy and geopolitical relations during World War Two and the Cold War.
- The transition mineral implications in recent years has seen the EU, Japan, and India all developing critical minerals policies of their own.
- Thus, it comes as no surprise that Australia has also been developing a more active critical minerals policy, with a vision to become a 'global critical minerals powerhouse' by 2030.
- Australia's critical minerals policy also includes a greater emphasis on manufacturing and production of critical minerals to benefit from the economic opportunities of the green energy transition.
- As Australia transitions into a more significant critical minerals role, questions of geopolitical tensions, diplomatic relations and political economy remain at the centre of Australia's critical minerals strategy.

Critical Minerals: A History

The desire to ensure a secure supply of critical or strategic minerals has a long history in the US and a strong historical connection to the nation's perceived military needs. In 1922, the US Government created the Army and Navy Munitions Board which was tasked with, among other things, ensuring that US armed forces would have all the raw materials necessary for national defence. The board created a list of 42 minerals needed for wartime production that informed the Strategic Materials Act of 1939 at the onset of WWII. The legislation was amended after WWII with the Critical Materials Stockpiling Act of 1946. The Korean War saw further stockpiling and congressional appropriations skyrocket: the value of the US strategic material inventory was now greater than four billion dollars. Through the 1950s and 1960s, new conflict realities and scenario planning saw the stockpile continue to grow. In 1979, Congress passed new legislation, the Strategic and Critical Minerals Stockpiling Act. By 1989, the height of the stockpile, the inventory covered 62 materials and was valued at US$9.6 billion.[220]

The US Department of Energy (DOE) developed a new critical minerals strategy in 2010 after a trade dispute between China and Japan which led to a restriction in REE exports and a hike in prices. Soon after, the DOE established a Critical Minerals Institute and several countries joined the United States Trade Representative (USTR) in bringing a case against China at the WTO. In the meantime, investors sought to start or re-start new REE mines in Australia, Indonesia and the USA. The Trump administration followed by adopting a fast mine permitting system which incentivised companies to mine or process critical minerals in the USA, including REEs. In 2019 the US Department of Commerce released a report with 61 recommendations that was focussed on increasing domestic mining of critical minerals in order to reduce supply on foreign, especially Chinese and Russian, sources of supply.[221] One observer noted that the administration's call to action closely resembled many previous US policies on critical minerals, particularly the anxieties about energy and raw materials independence in supply chains.[222] This was followed by December 2020 legislation, passed in conjunction with a COVID relief bill, which created a new Critical Minerals Consortium, allocated another $1.5 billion over five years for extracting REEs, coal and coal by-products and supported more mapping and research.[223]

In the meantime, the EU, Japan, and India all developed critical minerals policies. In September 2020 for example, the European Commission released an Action Plan on Critical Raw Materials, which saw European officials citing the same anxieties as US policymakers about security of supply and the need to benefit economically from the renewable energy transition. At the release of the report, Thierry Breton, Commissioner for Internal Market, said:

> *A number of raw materials are essential for Europe to lead the green and digital transition and remain the world's first industrial continent. We cannot afford to rely entirely on third countries – for some rare earths even on just one country. By diversifying the supply from third countries and developing the EU's own capacity for extraction, processing, recycling, refining and separation of rare earths, we can become more resilient and sustainable.*[224]

As a dominant importer of minerals, Japan's international resource strategy is structured upon securing a stable supply of mineral resources. In an attempt to counteract China's monopoly on the critical minerals industry, Japan has increasingly diversified its supply of REEs by investing in foreign mining projects and partnering with other resource-rich countries. As such, Japan has reduced its import dependency on China by over 30 per cent since 1990, aiming to reduce reliance to 50% by 2025.[225] Testament to the global effort to diversify supply chains, in 2021, Australia, Japan, India and the US formed the Quadrilateral Security Dialogue (**The Quad**).[226] Various pacts have ensued from this multilateral initiative, including the new Australia-Japan Critical Minerals Partnership in late 2022 which provides a framework for Australia to supply Japan with REEs, lithium and other critical minerals for clean energy technologies.[227]

India's critical mineral policy is intertwined with the ambitious 'Make in India' initiative which aims to simultaneously bolster domestic manufacturing and reduce reliance on foreign imports. Despite possessing the fifth largest REE deposits in the world, India lacks commercial scale technologies to explore mineralised zones, extract and refine the minerals.[228] To tap into India's geological potential, India's Ministry of Mines has introduced an expert committee to facilitate domestic exploration, extraction and procurement of critical minerals.[229] In addition to expanding domestic extraction, India's strategy also involves collaborating with mineral-rich economies like Australia in order to transition to an industrial, low-carbon and digitised economy.

The issue of critical minerals is becoming a frequent topic of interest at international fora. At the 2022 G20 Bali Summit, government leaders recognised the transition to clean energy is incredibly mineral intensive compared to fossil fuel technologies. It was projected that in order to limit the rise in global temperature to 'well below 2 degrees Celsius', demand for copper, iron, lead, neodymium and zinc may increase by more than 200 per cent by 2050 whilst production of graphite, lithium, and cobalt will increase by more than 450% by 2050. As such, government speakers emphasised the need for enhanced international collaboration, transparency and good governance to ensure a smoother transition to clean energy and make future energy security more robust'.[230] Notably, G20 members underscored the need for governments and the private sector alike to mitigate corruption risks in the renewable energy sector which disrupt supply chains, delay clean energy transitions and consequently, frustrate climate change targets.

The Emergence of Australia's Critical Minerals Policy

In light of these international partnerships and Australia's abundance of such minerals, it should be no surprise that successive Australian governments have started to develop a more active policy in recent years, using the 'critical minerals' framing. In 2019, the Department of Industry, Science, Energy and Resources released its first critical minerals strategy. It then released an updated strategy in March 2022. The vision underlying the strategy is one where Australia becomes a 'global critical minerals powerhouse' by 2030. The three objectives underlying the strategy were: first, establish a stable supply so that Australia can make 'significant contribution to meeting the growing global demand for critical minerals'; second, increase Australia's sovereign capability in terms of skills, technology, manufacturing, intellectual property and capturing more of the value chain; and third, contributing to regional jobs and growth.

These three objectives were matched by three 'action areas': de-risking projects by providing technical support and strategic investments; creating an enabling environment through, for example, research and development, or standards and accreditation; and strengthening international partnerships with key countries such as the United States, Japan, the Republic of Korea, the UK, India and the EU. The absence of China from this list of key countries is, of course, no accident. It is a reflection both of the geopolitical nature of the discussions that are currently occurring around critical minerals, and of the dominant role that China currently plays as a buyer of critical minerals and of their manufacture into finished products. It is also no surprise that the US, India, Japan, and the EU have also all developed critical mineral policies of their own.

The Australian government, in a separate publication by the Australian Trade and Investment Commission (Austrade), defined critical minerals as those that are 'vital for the economic well being of the world's major and emerging economies, yet whose supply might be at risk due to geological scarcity, geopolitical issues, trade policy or other factors'. This is obviously a very broad definition, and it is therefore not surprising that the government has now identified 26 critical minerals of interest that are found in Australia.[231] The Austrade prospectus identified 44 critical minerals projects that were 'seeking investments or offtake agreements.' This included seven cobalt projects, six for REEs, two for lithium, and one for manganese (all minerals that will likely play a major role in the renewable energy transition).[232] The prospectus was just one of the many ways that the Australian Government has been seeking to get these mining projects off the ground.

Other policies by the Morisson Government included the provision of direct financial support at the extraction, processing and manufacturing parts of the product cycle. The centrepiece of this program is a $2 billion **Critical Minerals Facility** that will be administered by Export Finance Australia, Australia's export credit agency. The facility's purpose is to provide public finance to support new projects that are having trouble accessing private finance. The Morisson Government also developed a critical minerals accelerator initiative and a 'modern manufacturing strategy.

The 2023 Critical Minerals Strategy

With an election in May 2022 and the new Albanese Government assuming power, the new government, led by the Resources Minister and the Treasurer, have been taking an even more energetic approach to the critical minerals question. This is probably a reflection both of a desire to be more proactive about the potential economic opportunities as well as of the geopolitical dynamics that are driving the renewable energy transition. The Australian Treasurer, Jim Chalmers, noted in his speech to a critical minerals summit in November 2022 how Indonesian government counterparts specifically and repeatedly brought up Australian lithium at the 2022 G20 meeting in Bali, as well as the Biden Administration's interest in the topic.[233] Further reflecting the differences with the previous government, the Albanese Government appears to be taking a more consultative approach in releasing a discussion paper and asking for public submissions before finalising its new critical minerals policy.[234]

There is no doubt that in making the move to develop its critical minerals, Australia is responding to geopolitical anxieties about the Chinese dominance of critical mineral supply chains. The Chalmers speech cited the major role that China plays in the processing of graphite, lithium, nickel and cobalt. In addition, Chalmers noted that China produces three quarters of all Li-ion batteries. Chalmers went on to warn about the dangers of mineral-rich producer countries locking in deals with manufacturing countries—as has apparently been mooted by some Latin American and Asian producer nations. This would only lead to an 'OPEC-lie set up for critical minerals' when we are better off diversifying global supply chains rather than locking them down.[235]

In an increasingly uncertain world, naturally, it makes sense from a geopolitical perspective to diversify both extraction and processing as much as possible. However, there are inherent dangers of playing into new cold war or even xenophobic anti-China rhetoric when discussing critical minerals policy. This is something that the Australian Government is no doubt well aware of as it seeks to tread a difficult path between playing the role of loyal US ally while rebuilding its relationship with Beijing.[236] Given the strains placed on the China-Australia relationship by the pandemic and by Australia's enthusiastic participation in perceived anti-China coalitions such as The Quad, it is clear that any rebuilding efforts will be challenging and will require strategy.

Anthony Albanese, Australia's prime minister and Fumio Kishida, Japan's prime minister meet in Tokyo, in Sept 2022. Japan and other western aligned countries are looking to secure supply of transitional minerals from paces like Australia.
Credit: Salma Bashir Motiwala/Shutterstock

Making Australia a Better Quarry vs Adding Value

Compounding these complicated geopolitical and diplomatic questions is the unresolved question of political economy. Specifically, should Australia be trying to assert greater autonomy over its critical minerals? The academic and policy analyst, Clinton Fernandes, has argued in his provocative book, Sub-Imperial Power, that Australia's desire to increase exploitation of its mineral riches belies a policy which, though appearing to be a nationalist one, actually only serves to enrich and empower foreign corporations, particularly in the US. There are two parts to his argument. First, the dominant foreign ownership of Australia's largest mining companies by US investors (BHP, Rio Tinto, Woodside Petroleum, Newcrest) raises the question as to whether these companies will necessarily act with Australia's national interest at heart (unless forced to).[237]

Second, and perhaps more importantly, Fernandes argues that the Canberra foreign policy elite has wholesale swallowed the economic doctrine of 'comparative advantage'. That is, Australia continually pursues a mining policy that preferences the export of raw materials as part of Australia's role in a global supply chain, rather than trying to develop a domestic manufacturing sector which would add greater wealth to the nation. This plays out as much with critical minerals as with mining in general. In order to prevent this, not only could Australia be developing domestic battery manufacturing, for example, but it could even establish a 'nationally owned company that exercised ownership and control of Australia's critically important strategic minerals'. Instead, Fernandes argues:

> *[...] Australia's Department of Industry is a true believer in the doctrine of comparative advantage. Its Critical Minerals Strategy is not concerned with nation-building or increasing economic complexity but with creating a permissive environment for foreign investors to carve up Australia's critical minerals. Its aim is to make Australia a better quarry.*[238]

There are suggestions that this may be changing. The aforementioned Department of Industry call for submissions on Australia's critical minerals policy includes a request for input on how Australia could 'add value to our raw materials and develop critical minerals downstream processing facilities'. The discussion paper associated with the review also references the importance of developing downstream processing and manufacturing capabilities, removing obstacles to Australia moving up the value chain, and helping the industry move further downstream and develop new sovereign capabilities.[239] Senior members of the Albanese government have stated that this is the direction in which they would like to see Australia progress. As Jim Chalmers noted in his above-mentioned speech:

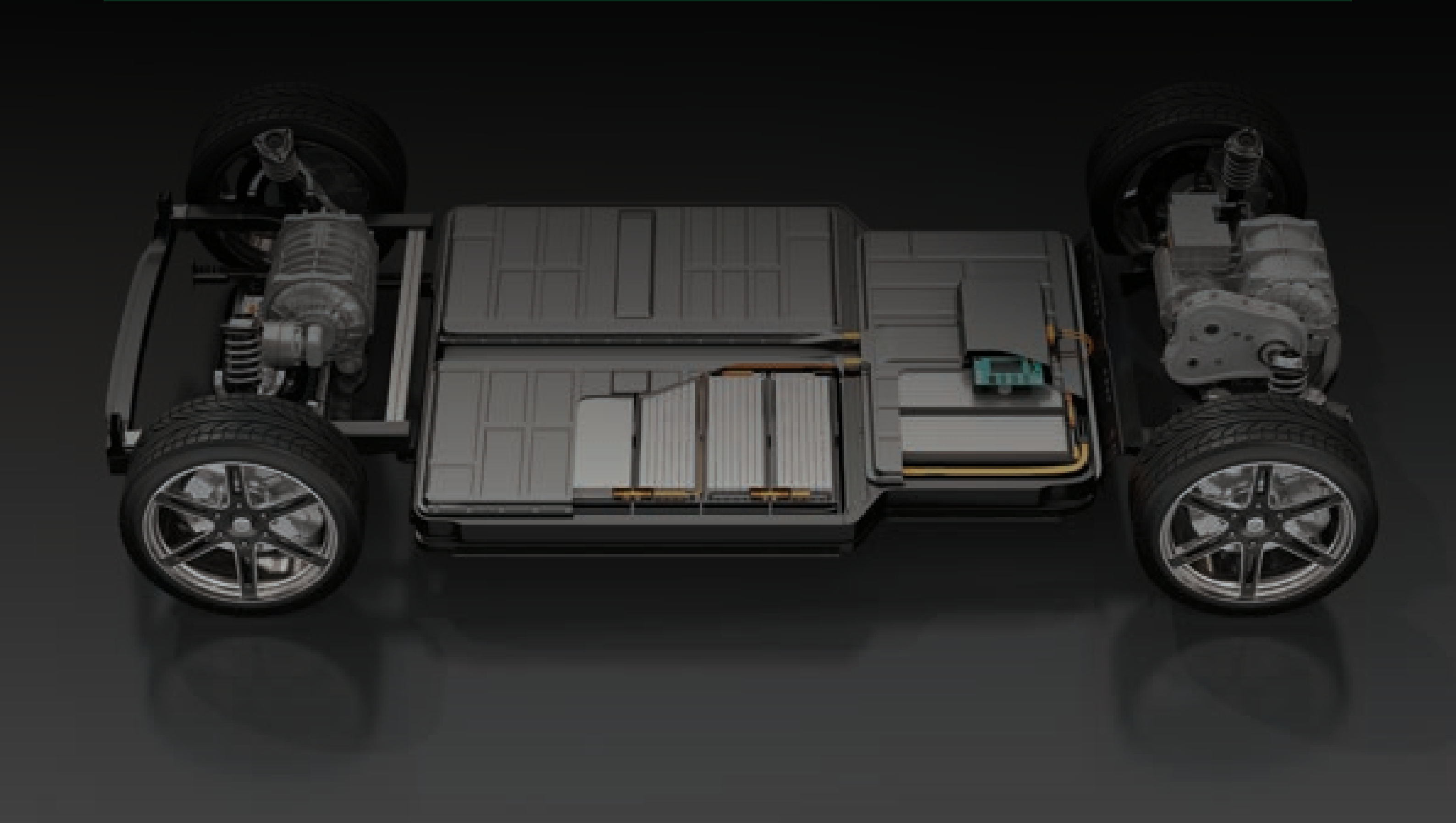
> *[...] this is where our great opportunity lies – not just in extracting and then exporting the rare earths that we have and that the world needs, but also in moving our way up and along the value chain, through processing, refining, upgrading, manufacturing, reusing and recycling – powered by renewable energy.*[240]

In the speech, the Treasurer also discussed ambitions to make Australia a 'global critical minerals powerhouse'. Striking an at times nationalistic tone, the Treasurer said that while Australia welcomed foreign investment in the sector, it is important to ensure investment 'at all stages of the value chain'.[241] Similar claims have been made by climate NGOs such as Beyond Zero Emissions, which calculates that the energy metals industry could directly provide21,500 new jobs and a further 53,000 indirect employment opportunities.[242]

As interesting as these developments are, we must remain wary that if Australia were to assert more autonomy over its critical minerals and develop manufacturing capacity to extract greater value over its mineral resources, this does not *necessarily* mean that extraction will occur in an environmentally and socially responsible way. Perhaps the most worrying aspect of the Australian critical minerals discussion paper is 'Section 5: Supporting clean energy technologies' which focuses on the issues material to this report. Naturally, it discusses the role that critical minerals can play in decarbonisation and in meeting the global Paris commitments. Primarily, it discusses the dependence that solar PVs and onshore and offshore wind infrastructure have on critical mineral inputs. However, the forecasts for critical minerals are derived directly from the IEA report that was mentioned at the introduction this paper. In other words, by premising itself on the IEA report, Australia's critical minerals strategy with respect to transition minerals is completely philosophically aligned with the type of demand projections made by IEA and others.

But are the projections realistic or are they creating and/or playing into a 'false scarcity' narrative? These are the questions that will be examined in the next chapter.

Increasing the efficiency of EV batteries and limiting the size of EVs are two ways that demand can be reduced for many transition minerals including lithium, nickel, cobalt and manganese. *Credit: Chesky/Shutterstock*



CHAPTER 8: DEMAND PROJECTIONS AND THE FALSE SCARCITY NARRATIVE

Summary

- Projections for a huge spike in demand for critical minerals are drawn from a number of sources, but the most bullish and influential of these predictions come from the International Energy Agency (IEA).
- However, recycling transition minerals in accordance with circular economy principles can significantly reduce primary demand. Studies have shown that recycling minerals from Li-ion EV batteries can reduce demand by up to 55 per cent in some cases.
- Other reductions in demand can come from substitution and efficiency gains in the design of renewable energy products such as EV batteries.
- Policy discussions at the national and international level are urgently needed not only in relation to transport but also energy, housing and urban planning.
- The demand for many of the transition minerals in this report (lithium, nickel, cobalt and manganese) is conditional upon the demand for electric vehicles (EVs) and whether governments adopt policies that reduce car dependence and improve mass transit.
- Initiatives reducing the amount of energy to power the grid are also integral for reducing demand for key transition minerals.

Demand Projections for Transition Minerals

It will be recalled that the push to open up new mining projects for transition minerals often rests on reports about how the transition to clean energy will radically increase demand for certain key minerals. The International Energy Agency (IEA) report, the most influential of the studies, estimates that transitional mineral demand will increase enormous amounts by 2050, as table 8.1 shows. The report estimates that demand for lithium will increase between 13-42 times, and that the demand for nickel and cobalt will increase by around 6-20 times. There will be smaller, but still significant, increases in demand for manganese and for REEs (between 3-8 times). Copper demand, in contrast, was only expected to increase by around 2-3 times. The IEA also projected that the proportion of transition mineral demand going to clean energy technologies will rise from quite low levels (generally under 20 per cent but slightly higher for lithium) to much higher ones (between 70-90 per cent for lithium, 30-60 per cent for nickel, and 30-45 per cent for copper, for example).[243]

Table 8.1: International Energy Agency 2050 Demand Projections for Key Transition Minerals

Mineral	Increase in transition mineral demand as a multiple of base year (2020=1)
Lithium	13-42
Nickel	6-19
Cobalt	6-21
Manganese	3-8
REEs	3-7
Copper	1.7-2.7

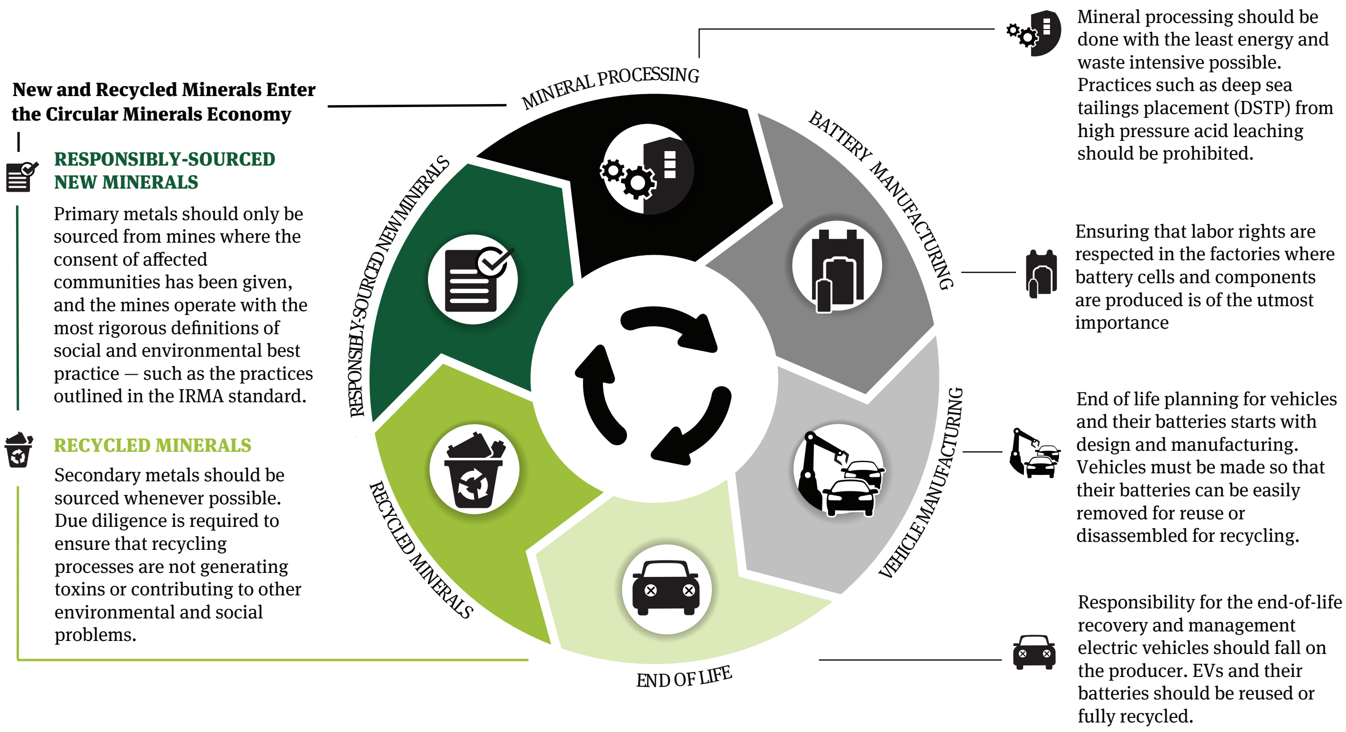
Source: International Energy Agency (IEA), 'The Role of Critical Minerals in Clean Energy Transitions', Paris: IEA, May 2021, 47.

Other studies might not appear quite so bullish as the IEA projections, although this is partly due to differences in the way that the calculations were done. The World Bank, for example, projects that lithium demand for renewables in 2050 could be five times the total demand in 2018, cobalt demand could be four and a half times, and demand for nickel would be about the same.[244]

These appear an order of magnitude less than the IEA projections, however it is important to note here that much of the discrepancy would be due to the fact that the World Bank study measures the increase as a percentage of total usage for the base year (2018) in contrast to the IEA study which measures the demand increases as a proportion of renewable energy usage in the base year (2020). Given that the percentage of usage for renewables of most transition minerals would be in the realm of around 10-20 per cent in the 2018-2020 period, this would logically result in the IEA projections being around 5-10 times higher than the World Bank projections. It is plausible that another source of the difference arose from the fact that the World Bank study assumed a greater rate of mineral recycling than the IEA study.[245] In any case, the IEA projections are the ones that have tended to garner the most attention. Anyone doubting how influential these IEA projections are need only consider that they were heavily featured in the Australian government's December 2022 critical minerals discussion paper, and they formed the intellectual basis for its claim that 'achieving the global Paris commitments requites a significant scale up in the production of the critical minerals underpinning these clean energy technologies.'[246]

The rest of this chapter considers the various policy interventions that could reduce demand both for battery minerals and for other transition minerals. It shows that there is an alternative to the 'business as usual' scenarios on which the most extreme demand projections, especially those of the IEA, are based.

Circular economy principles applied to the EV battery supply chain not only would have implications for battery manufacturing, vehicle manufacturing and recycling (discussed in this chapter), it would also imply responsible sourcing for the mineral components of EV batteries (see next chapter). *Credit: CEarthworks*



Reducing EV Mineral Demand Through Recycling, Efficiency and Substitution

One way to effectuate an alternative to the business as usual scenario would be to reduce demand through recycling, efficiency and substitution. The circular economy is one based on the regeneration and reuse of material or products: the concept itself is associated with the desire to reduce humanity's environmental footprint and cut down unnecessary waste. Recycling, efficiency and substitution are all ways that we can reduce demand for key minerals as we make the transition to a zero-carbon economy. These are all strategies that adopt circular economy principles.

There is already substantial research regarding the potential opportunities for recycling used Li-ion EV batteries. Research for Earthworks by UTS' Institute for Sustainable Futures (ISF) found that it is technologically possible to recover all four principal metals used in EV batteries (cobalt, nickel, lithium and copper) at rates of above 90 per cent. The research also found that a combination of policy indifference and a lack of strong economic drivers are the current impediments to achieving such a target. The report similarly found that there may be other ways of reducing demand for EV batteries, such as the extension of battery lifetimes from the current 8-15 years towards 20 years. Another way to reduce demand would be to give EV batteries a 'second life' for stationary storage or for grid storage. The report found that all of these strategies cumulatively give recycling the potential to reduce primary demand (by the year 2040) by up to 25 per cent for lithium, 55 per cent for copper and 35 per cent for cobalt and nickel. Recent modelling by UC Davis shows that recycling of lithium in Li-ion EV batteries could reduce demand by half.[247] Nevertheless, the report found that significant policy gaps exist across most jurisdictions that currently prevents this sort of level of recycling.[248] Other modelling by UC Davis researchers shows that recycling of lithium in Li-ion EV batteries could reduce demand by half. Chapter 5 outlined the possibilities that recycling could bring when it comes to REEs.

There are a number of policy solutions that would improve recycling of these EV minerals. Policymakers could encourage or require the development of recycling pathways for car owners, dealers and repair shops to return batteries to manufacturers; they could standardise better shape, size and labelling; they could introduce policy which encourages the reuse of batteries for a second life; and they could invest in research and development that improves battery systems. All of these steps would foster the development of a 'circular economy' for EV battery transition minerals and reduce the amount extracted through destructive mining.[249]

Recycling is not the only way to adopt circular economy principles to EV usage. Research has suggested that reducing both EV vehicle weight and size as well as EV battery size will significantly reduce demand for lithium—the one indispensable raw material product for EV batteries. It should be noted that EV vehicle size and EV battery size operate in tandem; bulkier vehicles require larger EV batteries.[250]

Furthermore, substituting some of the more harmful, heavier metals for other minerals, like potassium, will also offset current demand projections. Other alternatives such as dual-carbon batteries and sodium ion batteries could be developed instead of lithium-ion batteries for EVs—but as these elements are far more abundant than lithium, nickel, etc, sourcing the raw materials would do much less damage to the environment.[251]

Even where substitution is not possible, manufacturing choices for the types of EV batteries will also be important for determining which transitional minerals attracts greater demand. NMC111 and NMC811 are both variations of Li-ion batteries in which lithium is an essential component. The former requires substantial lithium, cobalt and manganese, yet relatively little nickel. NMC811 requires less lithium but with significantly heightened demand for nickel.[252] Moreover, as iterated in the case studies, while current manufacturers prefer cobalt-rich Li-ion batteries, the conflict-prone nature of the cobalt supply chain means that some analysts are predicting a switch to nickel-rich Li-ion batteries. Decisions made about battery composition will therefore impact decisions made about extraction, and vice-versa.

Building, Housing, Urban Planning and Manufacturing: The Circular Economy

One could apply the same approach of recycling, substitution and efficiency beyond the transport sector to other sectors, such as construction energy, housing and urban planning. Solutions that implement energy efficiency, local energy solutions (e.g. rooftop solar) and planning initiatives such as those encouraging green cities will not only make cities more liveable but will reduce the amount of energy required to power the grid. Less energy will require less wind turbines and less solar panels, and in turn, less copper wiring, all of which will reduce demand for key transition minerals. Likewise, increasing what the UNEP has called 'material efficiency' in buildings, homes and cars would also significantly decrease the demand for all sorts of minerals. Such improvements would not only reduce global greenhouse gas emissions as the UNEP work shows, it would also reduce the global footprint of mining.[253]

These approaches connected with the principle of the 'circular economy' or even, the 'circular society', a concept that incorporates but which goes far beyond recyclings. A much deeper and more effective application of these principles would see a radically different approach to manufacturing, one where a 'cradle-to-grave' approach is applied to product design and where 'planned obsolescence' became a thing of the past.[254]

Policy Choices to Reduce EV Usage

Finally, in car-loving cultures such as the USA and Australia, there is the very controversial question of car ownership versus other alternatives such as alternative methods of transport. As we have seen in this report, the growth of many of the transition minerals covered in this report will be conditional upon the rate of demand for EVs. Some estimates predict the number of EVs on-road will be 11 million by 2025 and 30 million by 2030.[255] However, the number of EVs on-road will naturally be a consequence of the policies adopted by governments worldwide. Buses and other forms of public transport might also use Li-ion batteries, but policy choices will determine not only the ratio of cars to buses, but also the ratio of public to private transport in the future. Policies, for example, that encourage the use of car-sharing, could significantly reduce the size of the EV fleets in many cities.[256]

Likewise, e-bikes and other smaller electronic vehicles are a much more efficient method of transport than cars when it comes to the mineral intensity of e-bike batteries as opposed to EV batteries. E-bikes are not appropriate for all ages and all classes of people, or for longer trips, but they are great for the relatively healthy members of the population for their shorter inn-er city trips. Studies have shown that e-bikes are among the most energy-efficient means of transport, as well as bringing a range of other benefits.[257] And an increased e-bikes certainly usage vis-a-vis cars will certainly require less lithium and other transition mineral components.

What are the relative gains that may be developed from reducing demand through circular economy techniques, compared to the more challenging process of implementing widespread policy changes to our habits and lifestyles? An initial answer to this question, at least with respect to EVs and Li-ion batteries, has been provided by a UC Davis study that looks at the various incremental gains from reducing demand through three different strategies: (1) reducing battery size; (2) recycling of lithium; and (3) public transport policies that would reduce car dependence and use. The study found that reducing the size of EV batteries would reduce lithium usage by 42 percent; implementing a strong recycling regime would reduce usage by 50 per cent; and policies that reduce car dependence and improve mass transit would reduce dependence by a tremendous 71 per cent. Not only does this study undermine the puffery surrounding lithium demand projections mentioned at the start of the report, but it also demonstrates how much else can be achieved if we really put our mind to creating a green economy that is both carbon-free and minimises extraction by the clever and effective use of other strategies.[258]

Mining Without New Mines

There is a third way to reduce demand for the development of new mines which paradoxically involve innovative mining techniques. Mine tailings, the waste materials remaining after the removal of the target minerals, contains mineral by-products, many of which are harmful. But mine tailings waste also often contains significant amounts of transition minerals. For example, the US DOE estimated that there is as much cobalt in the tailings waste in the state of Pennsylvania as in all of the DRC—the number one source of cobalt. Likewise, the USGS has estimated that tailings waste sites in New York have significant amount of REEs. In California, several companies are currently piloting these to extract lithium from brine using ion-exchange or membrane technologies, which they claim will be much lower impact than the evaporative process and hardrock mining currently in operation. However, this hasn't been used at commercial scale before and there is still uncertainty as to what the impacts will be. These are just a few examples of the potential to mine tailings from old or disused mines.[259]

The Role Australia Could Play

As a mid-sized economy, the impact that would be made by Australia adopting these sorts of policies to reduce demand for transition minerals would be relatively small. Much more important would be the policy choices made by larger economies such as the US, China, the EU, India, Japan, Brazil, etc. However, as a country that possesses so many transition minerals, Australia has substantial international sway on these matters. If it were to implement these policies, Australia could set an example for other nations. And it could use its voice at international policy meetings to ensure that the 'false scarcity' narrative and demand reduction policies for transition minerals are discussed and debated. Governments and international groups will need to start talking about these issues relatively soon if we are to avoid a dash for new lithium, manganese, cobalt and nickel, which would have serious environmental consequences for Australia and the countries of this region.

CHAPTER 9: TRANSITION MINERALS, THE ENVIRONMENT, AND FIRST NATIONS PEOPLES

Summary

- Australia must amend current legal and regulatory regimes which continue to deny the rights of Traditional Owners. Adequate consultation, obtaining the Free, Prior Informed Consent (FPIC) of Traditional Owners and introducing stronger standards on cultural heritage protections are some of the many measures which may be implemented to safeguard the rights of Indigenous Peoples in future mining decisions.
- Disposal of mining waste, mine closures and rehabilitation are the biggest environmental challenges currently facing the mining industry.
- Regulation of the mining sector is the responsibility of each state and territory; stronger state-based regulation is critical to reducing mining's environmental footprint.
- Federal legislation must not be neglected. The proposed EPBC reforms, although a positive step forward, must be supplemented with a more robust system of environmental permits and more stringent requirements for protected areas, including the creation of exclusion zones.
- Consumer pressure, third party verification schemes and national legislation addressing environmental and social license issues are all credible solutions to reducing harmful extraction by multinational corporations.
- As a key figure in the future of mineral extraction, Australia must exhibit a strong system of governance to ensure responsible sourcing of transition minerals by the private sector.

Indigenous Peoples and Free, Prior and Informed Consent

As we have seen in this report, mineral extraction often has significant harmful impacts on the communities located near the deposits. Research has shown that 69 per cent of transition minerals are found on or near Indigenous or peasant lands.[260] Studies by Jubilee Australia and various local partners in the Pacific region indicate that in places like Papua New Guinea and Fiji, local communities face many challenges when it comes to exercising their right to FPIC in the face of large mineral extraction.[261] A study looking at land rights in Amazon communities also found that Indigenous peoples in the Amazon region enjoy few rights to the minerals on their land including the right to consent to mineral exploitation or the right to say no.[262]

There is an inherent misconception that Australian law affords strong social and environmental protections for all communities. Put simply, a 'just transition' to a clean energy economy is one that must be pursued in consultation and in partnership with Indigenous peoples. However, the legal and regulatory regime that is currently in place makes the achievement of a 'just transition' in Australia well-nigh impossible.

The Juukan Gorge tragedy in Western Australia is an example of the type of behaviour that must not be repeated when it comes to transition minerals. In May 2020, Rio Tinto destroyed two rock shelters—containing culturally priceless artefacts that were part of the heritage of the Puutu Kunti Kurrama and Pinikura (PKKP) peoples—in order to improve access to a nearby mineral deposit. The grief of the PKKP people was and remains, unmeasurable. Although mining companies have likely exhibited this type of behaviour frequently in the history of Australian mining, in 2020, this sort of action was no longer acceptable. In the public outcry that ensued, Rio Tinto was forced to take serious action such as replacing many senior staff, including the CEO.[263]

Likewise, a report by RMIT University examined the challenges that Indigenous peoples in Australia face in safeguarding their land against destructive mineral and gas extraction. The report included three in-depth case studies: gas fracking in the Beetaloo Basin (Northern Territory), zinc-lead extraction at the McArthur River mine (also in the Northern Territory) and the Carmichael coal mine (Queensland). The report concluded that a lack of FPIC was observable in all three cases, and that this problem was directly connected to inadequate protections under federal and state law. It recommended, among other things, that the Australian government amend the Native Title Act 1993 (Cth) to bring Australia's legislative regime in line with its obligations under the UN Declaration on the Rights of Indigenous Peoples (UNDRIP).[264]

According to the National Native Title Council (NNTC), Australian law does not produce a level playing field when it comes to the capacity of First Nations peoples (often called Traditional Owners in the Australian context) to negotiate agreements—including mining agreements—which concern their lands.[265] Due to the imbalance of negotiating power, Traditional Owners who may want to refuse a development are often unable to exercise their right to FPIC and say 'no'. FPIC is enshrined in the UN Declaration of the Rights of Indigenous Peoples (UNDRIP), to which Australia is signatory. However, according to NNTC CEO, Jamie Lowe, Australia has not properly instituted its obligations under the UNDRIP: doing so would mean revising the Native Title Act 1993.[266]

A federal parliamentary inquiry by the Joint Standing Committee on Northern Australia produced A Pathway Forward, a detailed report into the Juukan Gorge tragedy in October 2021. The inquiry effectively endorsed the view that First Nations cultural heritage legislation in Australia was inadequate; that Australia had fallen short in upholding obligations under UNDRIP; and that an unbalanced negotiating regime favours extractive companies at the expense of Indigenous peoples. The report included eight recommendations about how to improve the regulatory regime for cultural heritage. It recommended, among other things, implementing newer, stronger standards on cultural heritage protection through federal legislation; a review of the Native Title Act (1993) that would strengthen the negotiating position of Traditional Owners; and more funding for the entities that make decisions for Indigenous communities.[267]

Actions by the current government suggest it is committed to adopting the recommendations of A Pathway Forward. But the history of government actions when it comes to safeguarding the rights of Indigenous communities foreshadow the potential for backpedalling and/or the watering down of commitments, especially if there is strong commercial pressure from mining companies As Australia looks towards a 2023 referendum on the Indigenous Voice to Parliament—as recommended by the Uluru Statement—how the issue of First Nations' cultural and economic sovereignty is resolved will test our collective mettle to prioritise the needs of our Indigenous communities over the desire for mining company profits.

Minimising the Environmental Damage from Transition Minerals

Environmental Assessment and Approvals

The mining of transition minerals can have a destructive ecological footprint and has been associated with adverse social impacts both in Australia and in the region. Mining transition minerals is extremely water intensive, which can lead to water stress for local environments. Mine waste is a particular problem both for the minerals in this report, as well as for hard rock mining in Australia generally. Research by prominent mining expert, Professor Gavin Mudd, in 2007 found that waste rock produced by coal, copper, gold and uranium mining in Australia had increased dramatically since the mid-twentieth century and especially since 1980. Mudd observed that 'if the ratio continues to increase over time as is apparent for many minerals, this will lead to ever increasing volumes of waste rock to be managed' and that waste rock overburden was a 'critical issue' facing the mining sector in Australia and worldwide.[268] It is not clear that anything has changed since this report was published.

Although mining in a way that is socially and environmentally more responsible is possible, it does carry economic implications that will have price implications all the way up the value chain. A deep dive into how the mining sector could minimise its social and environmental impacts through a circular economy view of mining waste is provided in a publication in *Minerals* in 2019. The research suggests that more sustainable mining that better manages mine waste and has a smaller ecological footprint is possible, but critically requires cultural change and, of course, new legislation.[269] Sustainable extraction, in other words, is costly in terms of time and money. Mining companies and their shareholders are often reluctant to pay those extra costs and downstream suppliers (and end-point consumers) are reluctant to insist upon them.

The Mary Kathleen uranium mine in Queensland was Australia's first major rehabilitation project of a uranium mine. The land has been rehabilitated and is now capable of grazing cattle. *Credit: Andrew Picone/Australian Conservation Foundation*

For all of these reasons, decisions made at the environmental assessment and approvals stage are particularly vital. In too many states and territories in Australia, the balance of forces favour the developers over the environment. This must change. Australian states and territories need regimes with robust and comprehensive environmental assessments; biodiversity impacts to be offset, or even better, avoided altogether; better community consultation including FPIC for First Nations communities; accountability and transparency in decision-making; and finally, the minimisation of impacts on water resources. The Environmental Defender's Office (EDO) submission to the critical minerals strategy review elaborates on these requirements in more detail.[270]

Mine clean-up and rehabilitation

Another hugely challenging problem is mine closure and rehabilitation. The 2007 report by Professor Mudd, which studied mine abandonment and rehabilitation, found that:

> *By 2003 in Western Australia, it has been estimated that a total of 165,040 ha has been disturbed by mining while only 36,952 ha has had preliminary rehabilitation ... In Queensland 73,586 ha has been disturbed with only 20,313 ha having been rehabilitated ... This gap is likely to be similar across Australia (although the cumulative totals would vary).*[271]

Professor Mudd observed that there was a lack of evaluation and knowledge about the effectiveness of rehabilitation methods used and no uniform standards for 'acceptable' rehabilitation.

Supporting this work, research by The Australia Institute in 2018 estimated between 460 to (just under) 3,000 operating mine sites (definitional issues make finding exact estimates challenging). The report further estimated a staggering 60,000 abandoned mine sites, noting that this was not a just a historical problem. For example, the report found that approximately one mine site is abandoned in Victoria every year. At the time of publishing, there were 'no examples of major, modern open cut mines completing rehabilitation to the point where the site can be relinquished.'[272] From the perspective of mine waste, mine closure and mine rehabilitation, it is clear that Australia is not ready for a new mining boom inspired by critical or transition minerals—given it is barely managing the existing mining situation. To address this, Australia should implement a requirement for mining companies to take responsibility over the entire life-cycle of the mine, including clean-up and regeneration of the mine site.

Planning and Sensitive Areas

Third, we must consider the concept of sensitive areas and exclusion zones, which many believe will be vital if we are going to be able to restore the planet's ecosystems on which all life depends. The EDO has suggested a number of strategies that could minimise adverse impacts through careful decision-making in the planning stage. For example, governments could prioritise critical minerals projects on land that has already been developed, impacted or degraded. Furthermore, governments could identify areas that are off-limits to critical minerals development—this could include national parks and World Heritage Areas but also high conservation value land, critical habitats, including wetlands, and areas of special cultural significance.[273]

Sensitive areas forms part of a larger debate and discussion about 'exclusion zones'—areas of land and water where all mining is prohibited because of their inherent value: areas such as rainforests, prime agricultural land and glacier areas.[274] Whilst the Australian Government is yet to declare any exclusion zones, in July 2022, Australia's Environment and Water Minister, Tania Plibersek, rhetorically pledged a '30x30' target: the Australian Government will commit to protecting 30 per cent of Australia's land and seas by 2030 (joining at least 50 other nations committed to this target).[275] The 30x30 target involves reserving 30 per cent of Australia's land and marine areas purely dedicated to protection and maintenance of biological diversity. At present, 45 per cent of Australia's Exclusive Economic Zone (EEZ) is protected by way of Marine Park status.[276] As for the terrestrial environment, 24 per cent, or approximately 184 million hectares of land in Australia is protected by the National Reserve System (NRS).[277] It is important to qualify that Marine Park and NRS status does not equate to exclusion or 'no go' zones nor completely protect the areas from resource extraction.[278] A close analysis reveals that of all NRS registered land in Australia, only 8.10 per cent are classified as Categories I to IV sites, where activities like mining are precluded.[279]

Governance and transparency:

Finally, there is the question of governance and transparency. Having strong laws are important, but without robust oversight and public transparency, there are too many incentives to undermine environmental regulation in favour of development needs. This is particularly the case at the state-based level where so many decisions are made. The Environment Centre Nothern Territory (ECNT) and the Arid Lands Environment Centre (ALEC) submission to the critical minerals review (mentioned above) found that compliance, monitoring and enforcement functions in the Northern Territory were either weak or completely absent.[280] Any reforms should adhere to the following principles: strict separation between the mining regulator and the mining promoter; adequate funding for the regulator; statutory provisions requiring adequate public reporting to improve transparency; a strengthening of provisions around enforcement and compliance; and stronger regulations on the funding and management of mine closure.

State vs Federal Reforms

In Australia, regulation of the mining sector is largely the responsibility of the states. This includes everything from rigorous and mandatory environmental impact assessments prior to the approval of exploration and mining permits; the rights of local communities and regional governments to refuse mining in their territory; and to consider the problem of toxic mine waste and the impact of mining on precious water sources. Strengthening regulation of the mining regime at the state level is therefore critical. Unless states give environmental and biodiversity protection laws more power and teeth, any federal reforms may have limited impact.

Australia's water resources could be seriously impacted in the event of a significant increase in the permitting of new transition minerals—especially if such permitting does not consider water impacts with great care. In their submission to the critical minerals strategy review, the ECNT and ALEC highlighted serious deficiencies in water allocation and governance threatening water resources in the Northern Territory, especially aquifer water. The water-intensive aspect of transition minerals mining will almost certainly cause more damage unless such steps are taken.[281] ALEC and ECNT's submission further discusses a number of important changes that need to be made to mining laws in the NT: an end to the on/off tenement approach; regulatory separation; extra resourcing, expertise and capacity of the responsible departments; strengthening of care and maintenance laws; and better legislation protecting indigenous cultural heritage.[282] Many of Australia's other state and territory mining laws have similar deficiencies.

In terms of the federal context, in 2019, an independent review found that there were serious deficiencies in Australia's federal environmental regulatory regime after two decades of neglect. The Samuel Review recommended 38 separate changes be made to the Environmental Protection and Biodiversity (EPBC) Act to better protect Australian ecosystems, including its wildlife.[283] Incoming Environment Minister formally responded to the Samuel Review in December 2022 with a *Nature Positive Plan*. The plan promised to introduce stronger environmental laws and a new Environmental Protection Agency to enforce them. However, the announcement also promised that the laws would be 'better for business' and a 'win-win' for business and the environment.[284] Reactions from large environmental organisations were mixed, welcoming some of the announcements but expressing concern about others. However, the focus of the criticism has mainly focussed on the timing of the plan—whether it will address the destructive practice of land clearing and whether it will include a 'climate trigger' that would allow veto of carbon-intensive developments.[285]

There has been very little discussion thus far about the implications of the EPBC Act reform on mining and on transition minerals, in particular. At present, the EPBC Act is only triggered when there is an environmental impact on a listed matter. However, current debate surrounding the EPBC Act and the Nature Positive Plan are important as a more robust federal environmental protection regime could have implications for state laws. Including a 'water trigger' in the reformed EPBC Act has already been mentioned above and is just one example of how a reformed Act could help protect Australia's environment and regional communities from avoidable harms in new mineral extraction. There is the potential for the *Nature Positive Plan* to set new normative standards and for current EPBC Act reform debates to potentially trigger new and tougher laws at the state level.

Supply Chain Solutions: Consumer Pressure, Verification Schemes and Legislation

How can we ensure that companies who extract minerals or who benefit from transition mineral supply chains practice responsible sourcing? There are numerous responsible sourcing initiatives and guidelines provided by the OECD and elsewhere. the OECD Guidelines for Multinational Enterprises, which are a comprehensive set of rules that govern responsible business conduct across OECD nations. In tandem, the Responsible Minerals Initiative (RMI) provides programs and resources to encourage companies to adhere to these OECD guidelines. There are also various initiatives that relate solely to the source and supply of specific minerals, especially cobalt, such as the EU Mineral Due Diligence Regulation and the US Dodd-Frank Act.[286] However, these relate to the nexus between mineral supply chains and conflict zones, which is not necessarily the primary consideration in the region, and certainly not in Australia.

The third-party verification scheme with the most potential is the 2018 Initiative for Responsible Mining Assurance (IRMA). IRMA is an independent, multistakeholder, third-party verification scheme which certifies social and environmental performance at industrial scale mine sites. Some lithium mine operators in the US have indicated a willingness to seek IRMA verification. Moreover, some automakers and electronic manufacturing companies such as Ford, BMW and Microsoft have decided to use only IRMA-authorised mines in their supply chains.[287] Nevertheless, the IRMA scheme is still in its infancy and can be improved.

Voluntary certification schemes like IRMA often benefit from, and operate symbiotically with, consumer pressure. For example, if consumer pressure forced all automakers to sign on to IRMA, this would impel mining companies to abide by IRMA rules. Consumer and civil society pressure can also influence downstream suppliers to boycott producers or countries whose record is considered too problematic to be associated with. Although more prominent in other sectors, a notable example in the transition minerals sector was the open letter issued by a number of Indonesian and international environmental NGOs to Elon Musk in July 2022. The letter recommended that Tesla cease sourcing any nickel for its Li-ion EV batteries from Indonesia due to the country's poor environmental record of nickel mining.[288]

Whilst consumer pressure on car companies and other retailers undoubtedly plays a role, it is unclear whether consumer pressure and voluntary certification schemes alone are enough to guarantee that the supply chains for lithium—and other Li-ion battery minerals—are transparent and that the system is operating functionally. Another limitation of the consumer pressure approach is that it is not as effective for renewable energy materials which are less consumer-facing (such as wind turbines, for example). There is also a general critique that voluntary certification schemes and consumer campaigns likely require stronger legislation to be able to create genuine change in the sourcing behaviour of companies.[289]

What carries the most potential would be for countries to adopt legislation that addresses both environmental and social license/consent issues with respect to transition minerals. At present, such legislation is in its infancy, though the potential to effect change is significant. In December 2022, a new Battery Directive was passed by the EU requiring companies to demonstrate that batteries that have been manufactured from responsible-sourced materials, which includes an assessment of all social and environmental risks associated with extraction.[290] As the new regulations will not come into effect until 2025, it is impossible to assess the effectiveness of this approach in reducing harmful extraction.

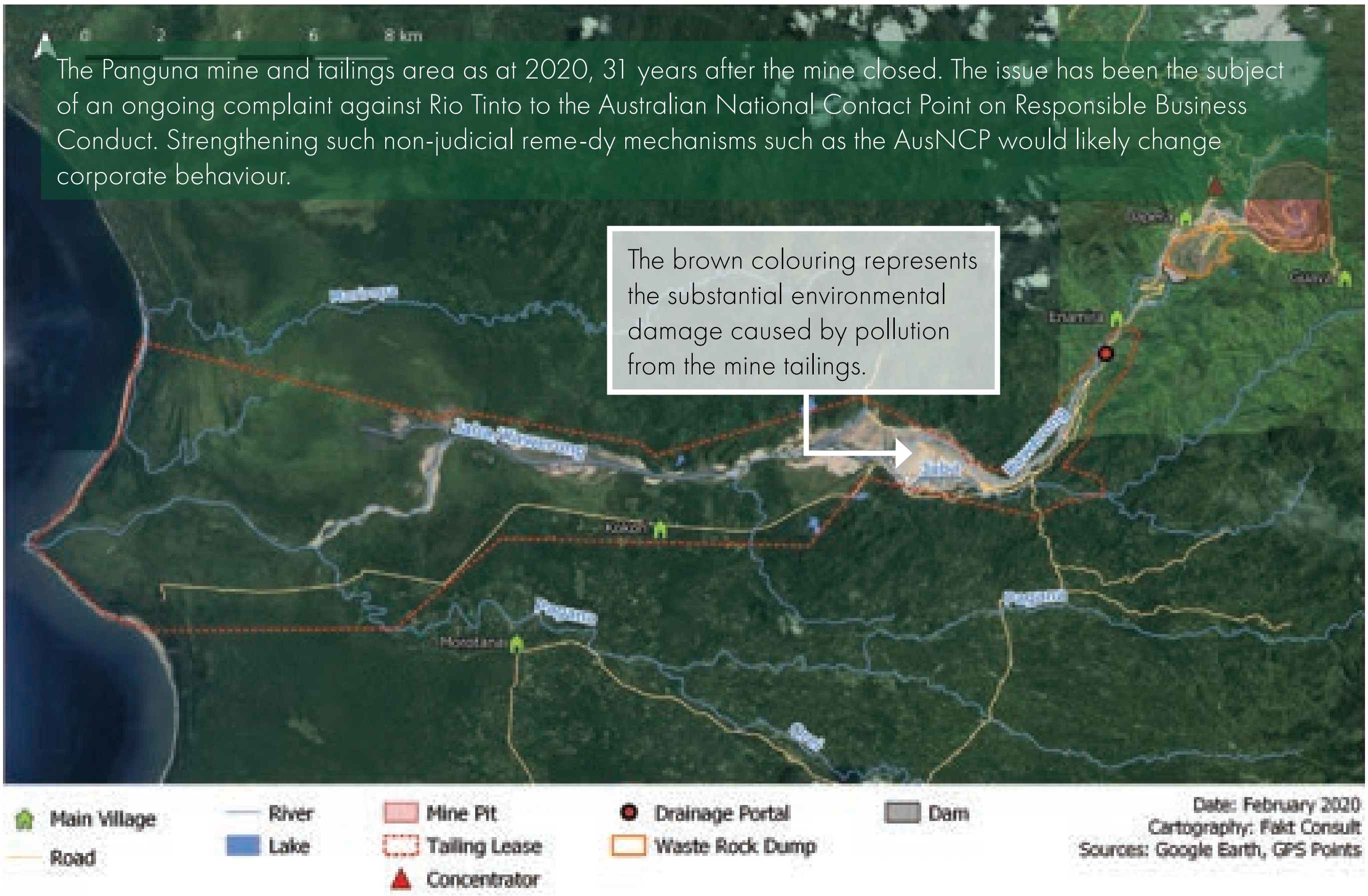
The combination of a vigorous third-party verification process, consumer pressure and robustly enforceable supply chain legislation could be revolutionary in terms of minimising the harm of transition minerals. This is part of a general move towards legislating supply chain due diligence globally, as witnessed in the areas of modern slavery and forest protection, both areas where Australia has taken a stand. However, while a legislative approach to supply chain management is probably the most formidable solution, the opaque operations of many global corporations, the complex nature of supply chains and common under-resourcing of enforcement agencies means that even this more robust approach is not without loopholes.[291]

Strengthening the Corporate Accountability Regime in Australia

Given the concerns raised in the previous section, there enduring questions regarding the effectiveness of supply chain solutions, even of the most robust, legislative approaches. As has been noted, Australia is a relatively small global market for end-use renewable energy products. Therefore, any supply chain approaches implemented domestically will have significantly reduced impact on the value chain compared to similar enforcement regimes in the US, the EU, China, Japan, etc. For that reason, it could be argued that the most effective steps that Australia can take when it comes to disciplining company behaviour would be to implement a strong system of governance overseeing the behaviour of multinational enterprises participating in extraction—especially in light of the potential growth of Australia's resource extraction sector.

We have already discussed above how state and federal environmental and cultural heritage legislation will be important tools in minimising major social and environmental harms. However, another important strategy would be to strengthen the overall regime governing business and human rights—such a step would not only regulate the behaviour of corporate actors in transition minerals but more broadly across mining and other sectors. There are several steps that could be taken to improve the corporate accountability regime in Australia, including as it relates to the minerals sector.

First, the OECD guidelines (as mentioned above) require each nation to operate a National Contact Point on Responsible Business Conduct (NCP). This is effectively a non-judicial grievance mechanism for cases brought by communities or other civil society actors when they believe that companies operating or based in the home jurisdiction of the NCP have breached the guidelines.[292] The Australian NCP went through a process of review in recent years. Since then, it has taken on a number of cases relating to mining companies: for example, Rio Tinto over actions in connection with the Panguna Mine in Bougainville, and PanAust in relation to the proposed Frieda River Mine in PNG's Sepik region. Importantly, complaints can also be brought against multinational companies headquartered overseas but operating on Australian soil.[293] While there is hope that the new reforms have improved the ability of the Australian NCP to manage complaints (called 'specific instances'), more amendments could and should be made, such as having the power to make its own investigations and the power to apply sanctions to companies that do not comply with its rulings.



The Panguna mine and tailings area as at 2020, 31 years after the mine closed. The issue has been the subject of an ongoing complaint against Rio Tinto to the Australian National Contact Point on Responsible Business Conduct. Strengthening such non-judicial reme-dy mechanisms such as the AusNCP would likely change corporate behaviour.

Another potential change to the business and human rights regime in Australia would involve the enshrinement in law of mandatory human rights due diligence legislation, modelled on examples that have been enacted in France and Switzerland. Any due diligence legislation should adhere to the OECD Guidelines for Responsible Business Conduct and the UN Guiding Principles on Business and Human Rights.[294] Such due diligence would potentially force Australian companies to demonstrate that they are not involved in any practices which contravene the rights of communities where they operate, including the right to water, the right to livelihood, and Indigenous peoples' rights to Free, Prior and Informed Consent, etc. As mentioned above, there are precedents for this type of supply chain legislation when it comes to Australian law, although, such approaches are not perfect and their impact has yet to be fully measured. Notwithstanding, mandatory human rights due diligence by companies carries the potential to make companies re-evaluate commencing mining projects that are going to harm people or the environment. Australia could also improve its commitments to the overall business and human rights regime by giving its support to the call for a UN Binding Treaty on Business and Human Rights. This would elevate the profile of the issue internationally and thus, encourage stronger rules on business and human rights in jurisdictions outside Australia.

Third, we would strongly endorse that Australia improve on its commitments to corporate transparency and accountability by implementing the Extractives Industry Transparency Initiative (EITI). The EITI is the global standard for transparency and accountability in the mining, oil and gas sectors. As Publish What You Pay has argued in its submission to the Critical Minerals Review: 'independent and peer-reviewed research has demonstrated that the EITI can contribute to national outcomes including an improved investment climate, increased tax revenue, economic development, governance reform, mitigating corruption and building accountability in resource governance.' Implementing EITI would importantly complement the government's proposed tax integrity and transparency initiative, which includes a beneficial ownership register.[295]

Finally, the Australian government can display leadership when it comes to responsible sourcing by setting an example for business actors. Ensuring that both trade and investment policies and aid and procurement policies uphold sustainable extraction of natural resources would send a strong message that Australia is at the forefront of responsible sourcing of transition minerals.

CHAPTER 10: A REGIONAL PERSPECTIVE

Summary

- Indonesia is the world's largest nickel producer. In the Asia Pacific region, the Philippines and New Caledonia are also significant producers of nickel.
- Nickel mines are greatly destructive of agriculture, polluting local water sources and fish stocks and thus, gravely threaten the health and livelihood of local communities in the region.
- Protests and conflicts are common however, there is an inherent lack of legal redress and remedy in the region; the Philippines regularly ranks the deadliest place in the world for environmental activism.
- Papua New Guinea, the Philippines and Indonesia all contain significant reserves of copper, which is often found together with gold deposits in the region.
- Like nickel mines, copper mines have elicited widespread environmental destruction and community conflict across the region. The environmental catastrophes of the Panguna mine in Bougainville and Ok Tedi mine in Papua New Guinea serve as cautionary tales for newly proposed copper-gold projects in PNG: the Wafi-Golpu project and Freida River mine.
- Issues of Free, Prior and Informed Consent of communities loom large over existing and planned nickel and copper-gold mines in the region. Dissent and opposition to mining projects have perpetuated community conflict and violence.

Although the focus of this report has been on Australia, it should not be forgotten that the Asia-Pacific region is also abundant in transition minerals, especially nickel and copper. The location of these resources, many in vital ecosystems like rainforests and near large population centres, means that the extraction of these minerals poses unprecedented social and environmental risks. To conclude this report, this chapter contextualises the Australian situation by providing a brief overview of the transition mineral scene in neighbouring countries such as Indonesia, PNG, the Philippines and New Caledonia.

Nickel Mining in the Region

According to most reports, Indonesia is currently the global leader in nickel production.[296] Notably, this encompasses all forms of nickel, including Class 1 purity. The IEA states that global nickel supply meeting demand in the future will largely be conditional on Indonesian growth.[297] Recently, the Indonesian government imposed a ban on the export of raw ores, including nickel; the purpose of these regulations was to develop the processing industry in Indonesia.[298] However, these regulations have had a dual converse effect on the nickel industry in Indonesia. Firstly, they have created an economy of extraction and secondly, the regulations have the effect of excluding small-scale extraction projects and consolidating the nickel industry in the hands of wealthy transnational mining companies.[299] This has the effect of further globalising the supply chain of nickel and fostering an economy of extraction. Indonesia has had strong historic export ties with China, and Chinese companies' capacity to export processed nickel has continued despite regulations.[300]

Reflecting Indonesia's dominance over the nickel market, the government has issued over 290 nickel mining permits in the country.[301] The country has two core geographical hubs for nickel production. The Indonesia Morowali Industrial Park is located in the Central Sulawesi province and is majority owned by Tsingshan Holding Group—currently, plans are underway to integrate the operations into a battery supply chain.[302] The Indonesia Weda Bay Industrial Park is situated in the North Maluku province—the nickel project occupies a significant portion of Halmahera Island and has caused significant adverse environmental and humanitarian consequences.[303]

Land clearing associated with the Pomalaa Nickel Mine. Nickel mining and refining of the ore in Indonesia is associated with a raft of environmental and social problems. *Credit: Kaisarmuda/Shutterstock*

The Philippines is the other dominant nation in the production of nickel. In 2020, 29 of the 50 operating metallic mines in the Philippines were nickel projects. However, like Indonesia, the government has imposed regulations to address the severe human and environmental impacts of nickel extraction. Notably, in 2015 the government closed 19 nickel mines, prompting a severe decline in nickel exportation.[304] However, in 2021 these regulations were overturned, partly to assist in economic recovery from the COVID-19 pandemic.[305] Today, the Caraga region, situated on the island of Mindanao, is occupied by several 'large-scale mining firms'. Notably, Nickel Asia Corp and Global Ferronickel Holdings are two of the largest mining companies in the nation, and both are situated in Caraga.[306] Additionally, the island of Tawi-Tawi also houses several major mining companies. Finally, in the province of Palawan, the recent reversal of the mining ban has renewed interest in a potential increase in nickel mining.[307]

There is significant nickel extraction occurring in the rest of the Pacific. New Caledonia, which contains 25 per cent of the total resources of global nickel, was once ranked as the top nickel exporter globally.[308] After a decline in the twentieth century, production has since recovered and nickel now accounts for nearly 95 per cent of New Caledonia's exports.[309] However, the centrality of mining to the territory's economy has attracted concerning humanitarian and ecological consequences. For example, the open-pit Goro mine in the South Province of New Caledonia—one of the world's largest nickel reserves—recently attracted international scrutiny. Notably, since 2010, the mine has caused five recorded acid leaks, contaminating local drinking water and devastating vegetation and fish supply which are critical for livelihood. Moreover, the mine has prompted several environmental protests by Indigenous Kanak peoples concerning pollution and autonomy over local resources. With Prony Resources acquiring the mine from previous operator, Vale, and electric vehicle giant, Tesla announcing its technical and industrial partnership with Prony Resources in 2021, it remains to be seen whether these concerns will be addressed.[310] In Papua New Guinea, a Chinese company operates the large Ramu Nico mine near the Ramu River (see below).[311]

Social and Environmental Impacts

The presence of nickel mines is also destructive of the agriculture of local communities.[312] Research has found that toxic metal contamination has reached nearby agriculture communities in the Philippines, carried by rivers used for the farming of rice paddies. Additionally, this water pollution has decreased fish stock, consequently harming the livelihoods of local fishermen. The effect of mining projects on health and agriculture carries additional risks to the human rights of those seeking to defend their lands and waterways. Fisherfolk in Indonesia are protesting mines due to the damage caused to local water sources and the fish stock therein.[313] This has occurred on the island of Wawonii, where the operations of mining company PT Gema Kreasi Perdana (PT GKP) threaten to displace—or in some cases, have already displaced—local residents.[314] Additionally, the establishment of the PT Weda Bay Nickel mine involved failures to obtain FPIC from the affected community; a lack of adequate compensation; and for locals who refused the mining company, a lack of legal remedy when the mine was established anyway.[315] In the Philippines, violence against environmental defenders and activists is a systemic issue. Protesters have faced backlash in the form of harassment, criminalisation, forced displacement and cyber-attacks.[316] According to Global Witness, the Philippines consistently ranks as the deadliest place to defend land rights for the environment.[317] In 2018, it recorded the highest number of killings in the world, with 30 land and environmental activists killed for opposing mining, logging, and agribusiness industries. A notable example is the Manicani Island nickel mine—which only recently resumed operations after two decades of sustained opposition and conflict from local communities—in which 58 war protestors were gravely injured and one was killed in 2001.[318]

Submarine tailings disposal (sometimes called deep sea tailings disposal or DSTP) at the Ramu nickel and cobalt mine and processing plant in Papua New Guinea polluted the nearby Ramu River and Basamuk Bay. Ramu mine operators have pumped 14,000 tonnes of toxic waste each day into the ocean, equating to millions of tonnes in the period since it commenced operations in 2012.[319] Moreover, two major tailings pipe leaks occurred in the last five years, both of which were caused by poor training of staff and poor maintenance.[320] This greatly impacted the livelihood of the local indigenous community, particularly as nearly 30,000 fishermen use the water source. Heightened levels of 'arsenic, cobalt, cadmium and manganese' were found in local fish stocks (nearly half a million people depend on the food obtained from the local fisheries). Such devastating environmental damage has prompted conflict between local communities and the operators of the project, culminating in a negligence lawsuit seeking restitution of 18 billion kina. The spills bring to light the reality of the toxic waste being pumped into the ocean every day.[321]

Amidst the global quest to reduce carbon emissions and the strong regard for EVs to assist us in doing so, soaring demand for battery-grade nickel has meant top producers of nickel, like Indonesia, have sought to increase nickel production.[322] What this inevitably means is more mining projects, more high pressure acid leaching (HPAL) plants—used to process low-grade nickel oxide ore into EV-grade nickel—and in turn, billions more tonnes of toxic tailing waste requiring disposal. This toxic waste carries a huge environmental footprint given it needs to be either stored and treated in a tailings management facility, or as above, discharged into the ocean via DSTP. Problematically, given the large quantities of toxic waste being produced, mining companies in Indonesia are progressively proposing to use DSTP as their chosen method of waste disposal. Indonesia already has a copper-gold mine that operates a DSTP facility, with irreversible impacts on the local ecosystem. To allow further nickel projects to dispose their waste into the sea would adversely affect the livelihood of coastal fishing communities, not to mention, irreversibly reduce the biodiversity of coral reefs which form part of the Coral Triangle.[323] Currently, two major HPAL projects at Indonesia Morowali Industrial Park and Obi Island have suspended proposals to use DSTP following immense backlash from local communities and environmental organisations.[324]

Additionally, nickel mining can cause a range of health problems for nearby communities. The open-cut mines prevalent in the Asia-Pacific exhume atmospheric dust which cause respiratory illnesses and cancer.[325] This is due to the significant presence of toxic metals such as oxidic nickel in the dust.[326] This spread of dust also occurs at the transportation and refining stages of production, further spreading the toxicity.[327] The effect of such pollution has been demonstrated by the Rio Tuba mine in Palawan, Philippines, where a worker at the mine died due to inhalation of toxic chemicals.[328] This dust also contaminates local agriculture and plant life.

Perhaps, the most environmentally destructive aspect of nickel mining is that the extraction of nickel is contingent upon deforestation of vast swaths of land. To access nickel deposits concentrated in ultramafic igneous rock, bulldozers must raze forest lands and scrape off topsoil layers. Over the past two decades, Indonesia has accounted for more than 50 per cent of total mining related deforestation. It is anticipated that nickel mining will soon overtake palm oil as the largest determinant of deforestation in Indonesia.[329]

Aside from the obvious adverse implications of deforestation including soil erosion, large-scale pollution, loss of biodiversity and increased levels of CO_2 in the atmosphere, in Indonesia, deforestation irrevocably destroys indigenous communities. In the last decade, Sulawesi island, home to Indonesia's largest nickel reserves, has seen approximately 550,000 hectares of rainforest destroyed.[330] This is further exacerbated by the fact that eight new nickel mines have recently been granted by the Indonesian government in the Tompotika peninsula in Sulawesi.[331] Home to many endemic species and over 107 local communities, such extensive deforestation for nickel mining will be vastly detrimental to the region.

In the wake of the 2022 G20 meeting in Bali, it is manifest that Indonesia must walk the delicate line of satisfying international demand for clean energy whilst needing to protect the health of local communities and landscapes.[332]

Copper Mining in the Region

Although the Asia-Pacific does not rank as a significant copper region by production metrics, copper mines have played and could continue to play a large role in the region. The controversial Panguna mine in the Autonomous Region of Bougainville and the Ok Tedi mine in Western Province have both played large roles in the history of Papua New Guinea. Plans to reopen the Panguna mine in Bougainville have been mooted and large new copper mines in the Sepik region (the Frieda River Mine) and in Morobe Province (the Wafi-Golpu Mine) are also proposed.[333] Elsewhere in the Pacific, there are plans to develop new copper mines in Fiji, including the Namosi mine on Viti Levu.

Another highly important copper-gold mine in the region is the Tampakan project. Situated on the second-largest island of the Philippines—Mindanao—the mine is owned by Sagittarius Mines Inc. (SMI). The company possesses a 25-year agreement to excavate the area. Notably, the original permit was provided to Western Mining Corp. (WMC), an Australian operation, before being transferred to SMI.[334] However, extraction has not yet commenced due to a range of political and legal factors.

The establishment of copper mines has also spurred significant environmental damage and community conflict in the region. A prime example is the Panguna mine in Bougainville.[335] This mine was at one point among the leading copper sites in the world. The mine, developed by Conzinc Rio Tinto of Australia (a predecessor of Rio Tinto), deposited around one billion tonnes of mining waste into the Kawerong and Jaba rivers between 1972 and 1989, with devastating environmental consequences.[336] Massive siltation and contamination of surrounding lands deprived the affected peoples of their livelihoods and cultural assets. The environmental destruction caused by the mine has irreversibly polluted the river, restricting access to drinking water and causing serious health conditions for local communities. The mine was also one of the catalysts for Bougainville's devastating war of independence, which followed the closure of the mine in 1989. There has since been interest by leaders in the region to recommence operations.[337]

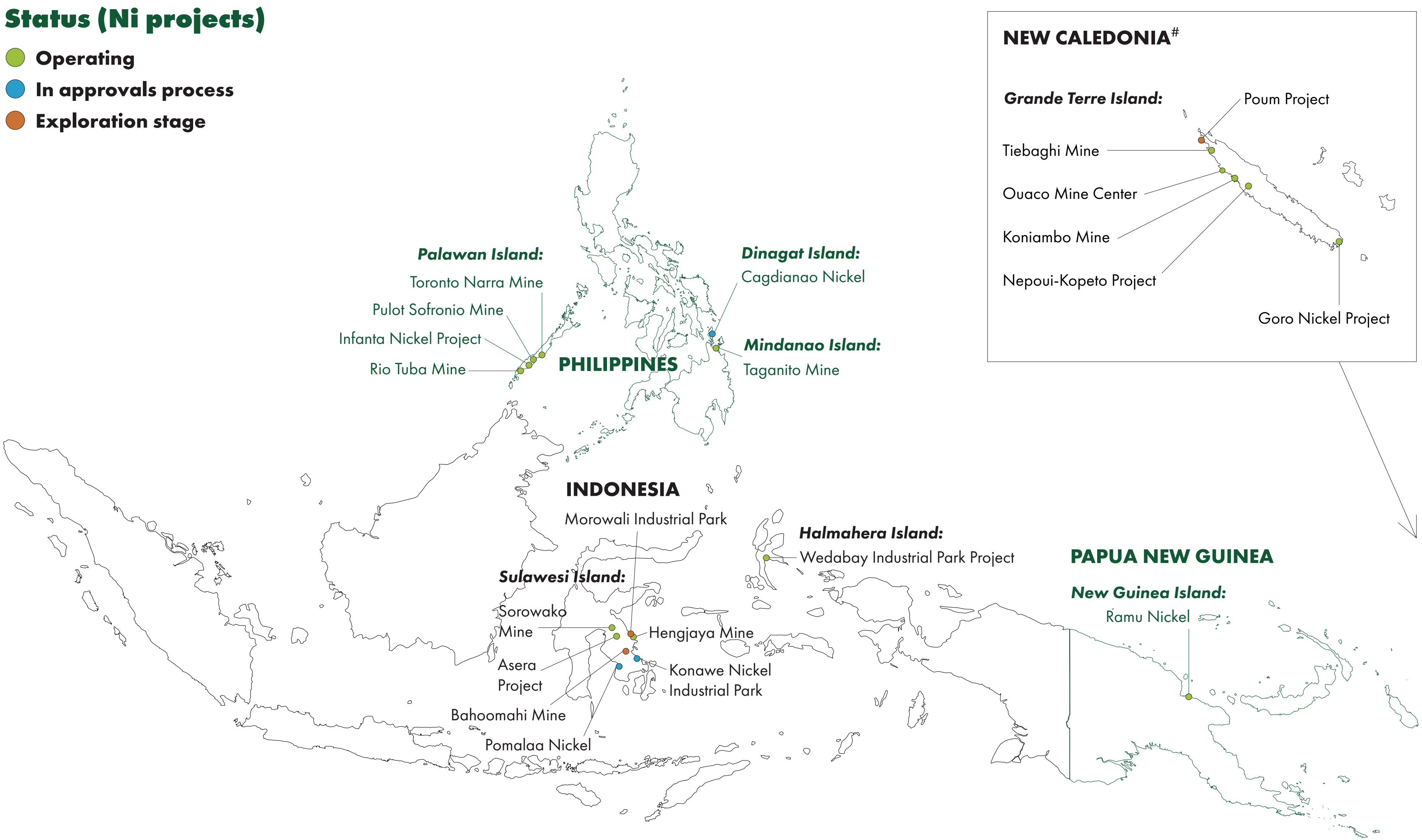
Alongside Panguna, the Ok Tedi copper-gold mine is considered the site of one of Papua New Guinea's worst environmental catastrophes. Situated on the Ok Tedi River in the Western Province of the country, issues arose from the failure to develop a tailings dam to dispose of waste. Consequentially, waste rock and tailings were disposed of in the river system itself. This riverine tailings disposal destroyed the livelihoods of those who used the water downstream, as it did on the Panguna mine. Notably, the chemically contaminated water was undrinkable and precluded any attempt to cultivate nearby soil for food. The humanitarian consequences of the Ok Tedi copper-gold mine are incalculable.[338]

Two new copper-gold projects loom large over PNG: the proposed Wafi-Golpu project in the Morobe Province which intends to use marine tailings disposal and the proposed Freida River Mine in the Sepik region which plans to use an integrated tailings dam. At the time of writing, both are the subject of active opposition by organised campaigns and are subjects of complaints to the Australian National Contact Point on Responsible Business Conduct, involving allegations of a lack of Free, Prior and Informed Consent and inadequate assessment of environmental risks.[339]

Questions of consent also haunt the Tampakan project in Indonesia. A national ban was imposed on open-pit mining, only being overturned in 2021. Furthermore, the province in which the mine is located imposed a similar ban, not overturned until 2022 despite sustained opposition.[340] Additionally, consultation between the mining company and the local indigenous communities has failed to 'meet international standards', particularly with respect to obtaining Free, Prior and Informed Consent.[341] Local communities were not appropriately informed as to the alternative options to open-pit mining. Furthermore, the project has also facilitated community violence. Protesters and the military have clashed, resulting in numerous deaths of locals.[342]

Table 10.1: Major nickel mines in operation or development in Southeast Asia and the Southwest Pacific

Location	Nickel Project	Operator	Planned or Operating
Indonesia	Angel Nickel Project	Nickel Industries and Shanghai Decent Investment (Group) Co Ltd	Operating
Indonesia	Asera Project	Solway Investment Group Ltd	Operating
Indonesia	Bahoomahi Mine	Solway Investment Group Ltd	Planned
Indonesia	Hengjaya Mine	Nickel Industries	Operating
Indonesia	Konawe Nickel Industrial Park	Virtue Dragon Nickel Industry	Developing
Indonesia	Morowali Industrial Park	Shanghai Decent Investment (Group) Co Ltd and Indonesia PT Bintangdelapan Group	Planned
Indonesia	Pomalaa Nickel	PT Vale Indonesia	Developing
Indonesia	Sorowako Mine	Vale SA	Operating
Indonesia	Weda Bay Industrial Park Project	Tsingshan Holding Group Co Ltd	Operating
Philippines	Cagdianao Nickel	Cagdiano Mining Corporation	Operating
Philippines	Infanta Nickel Project	Ipilan Nickel Mining Corporation	Operating
Philippines	Pulot Sofronio Mine	Citinickel Mines and Development Corporation	Operating
Philippines	Rio Tuba Mine	Rio Tuba Nickel Mining Corp. and Coral Bay Nickel Corp	Operating
Philippines	Taganito Mine	Taganito Mining Corporation	Operating
Philippines	Toronto Narra Mine	inickel Mines and Development Corporation	Operating
New Caledonia	Goro Nickel Project	Prony Resources	Operating
New Caledonia	Koniambo Mine	Koniambo Nickel SAS - Société Minière du Sud Pacifique (SMSP) and Glencore	Operating
New Caledonia	Nepoui-Kopeto Project	Societe Le Nickel	Operating
New Caledonia	Ouaco Mine Center	Societe Miniere du Sud Pacifique SA and POSCO Holdings Inc	Operating
New Caledonia	Poum Project	Eramet SA	Planned
New Caledonia	Tiebaghi Mine	Eramet SA	Operating
Papua New Guinea	Ramu Nico Mine	Metallurgical Corporation of China	Operating



New Caledonia not drawn to scale, in relation to the other countries on this map
* All locations are approximate
^ MapSVG, 'SVG vector map of Indonesia', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.
^ MapSVG, 'SVG vector map of the Philippines', URL: http://mapsvg.com/maps/australia, accessed on 21/02/2023.
^ Free Vector Maps, 'Map of New Caledonia with Provinces' URL: http://freevectormaps.com/new-caledonia/NC-EPS-02-0002 , accessed on 21/02/2023.
^ Free Vector Maps, 'Map of Papua New Guinea with Provinces' URL: http://freevectormaps.com/papua-new-guinea/PG-EPS-02-0002, accessed on 21/02/2023.

Climate justice is not just about a clean energy transition as quickly as possible: how we make that transition is also important. *Credit: Andrii Koval/Shutterstock*

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

This report aimed to weigh up the following dilemma when it comes to transition minerals: how do we balance the need to swiftly transition to clean, renewable energy on the one hand, versus the need to protect the planet's biodiversity and respect the sovereignty of impacted local communities (especially First Nations communities) on the other hand? The geographical focus of this report has primarily been on Australia, but it is clear that the findings have implications in the broader Asia-Pacific region, which is also rich in certain transition minerals, especially nickel and copper. The following conclusions may be drawn from the material which has been presented.

First, large amounts of transition minerals are found in this country. Australia is rich in deposits of lithium, manganese, and rare earth elements (REEs); it is one of the world's largest cobalt producers and is a significant producer of copper and nickel as well. There are plans to increase the expansion of all six of these minerals, as detailed in the case study chapters in this report, as well as in minerals that were not covered here, such as graphite.

Second, the mining of many of these minerals have a large and damaging ecological footprint and have been associated with adverse social impacts both in Australia and in the region. Mining many of these minerals is very water intensive, which can lead to water stress for local environments. Management of tailings has proven problematic, especially in vulnerable ecosystems, and in particular, when tailings are discharged into local waterways. Dust particles and sedimentation can be hazardous to human health and can impact agricultural land. As is often the case with mining projects, local communities do not enjoy the right of Free, Prior and Informed Consent. The details of the social and environmental impacts differ in immensely for each of the six minerals discussed. However, one generalisation applicable to all six minerals is that the type of approach and the technologies used are particularly determinative. Whilst mining in a way that is socially and environmentally more responsible is possible in some cases, it carries implications. Sustainable extraction is costly in terms of time and money; mining companies and their shareholders are often reluctant to pay those extra costs and downstream suppliers (and end-point consumers) are reluctant to insist upon them.

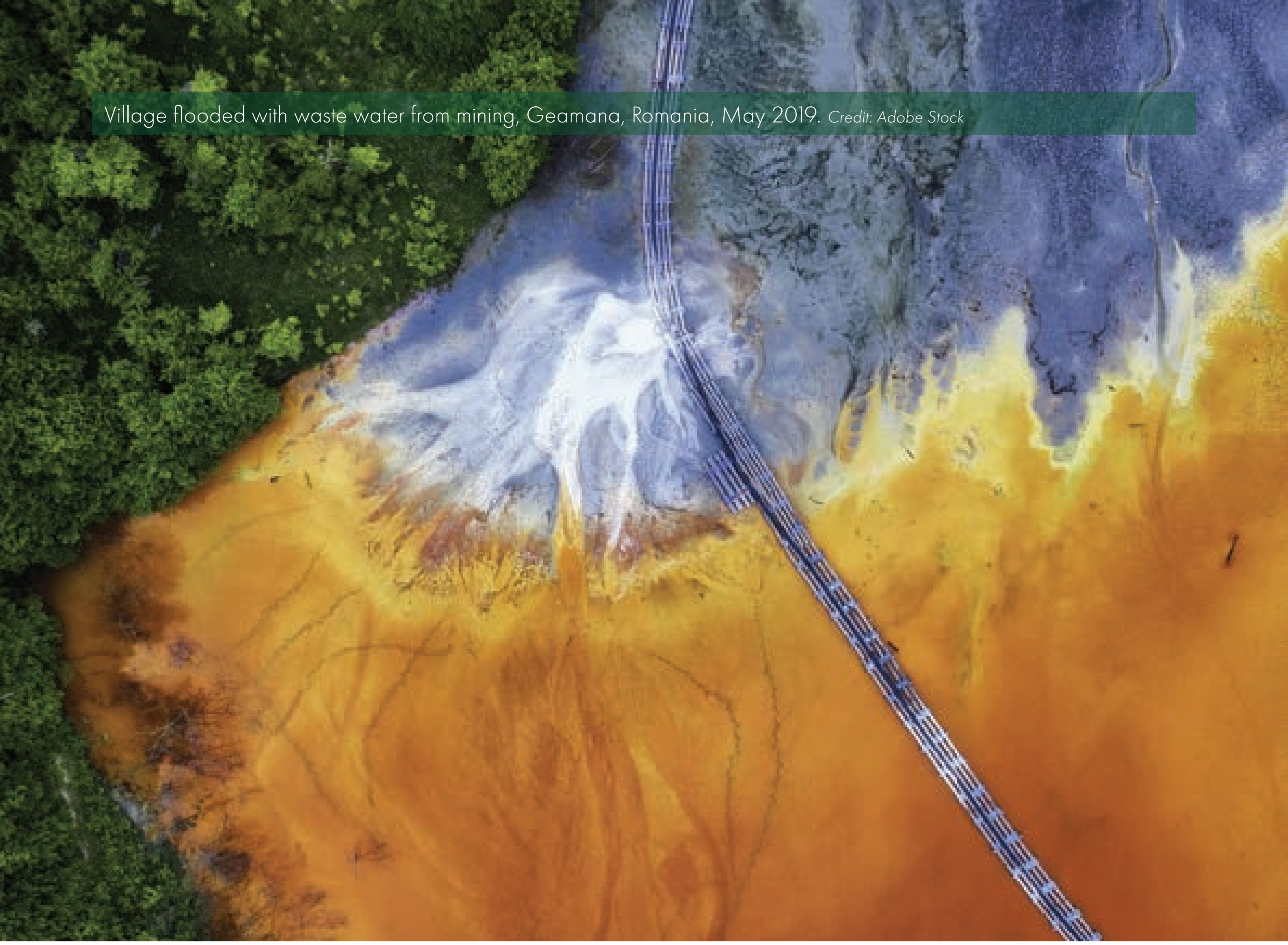
Third, transition minerals are a subset of 'critical minerals'. The story of critical minerals (first called strategic minerals) goes back at least to WWII, and perhaps even earlier, and it is an area that the US has long taken an interest in. During WWII and the subsequent Cold War, the geopolitics of critical minerals related to US concerns about strategic dependence regarding supply chains for both military and non-military products. Australia started to develop its own critical minerals policy in 2019 under the Morisson government and is currently undergoing a strategic review that has been initiated by the new Albanese government.

The **fourth** finding of this report is that we simply cannot predict what the demand for these minerals will be. The rush by many companies and governments to open up new mines for transition minerals is buttressed on very rosy demand projections that are themselves, contingent upon certain assumptions regarding the transition to a clean economy. Such assumptions include the increased uptake of electric vehicles that rely on Li-ion batteries; the continued increase in wind turbines and solar panels; and the need for electrical infrastructure which rely on key base metals, like copper. However, these demand assumptions are problematic. There are alternative sources of supply, such as mining of tailings and other similar methods, that could see demand for raw extracted minerals significantly reduced. Reuse and recycling could also significantly reduce demand as could the development of new batteries that rely on minerals more abundant, and thus less complicated to extract, than lithium, nickel, cobalt and manganese. Moreover, for nickel, manganese and cobalt, demand for minerals and choices over Li-ion battery type for EVs will both feed into each other.

Fifth, the trend of Australia's critical minerals policy under the new government appears to involve not just developing new mines but also developing new capacities for manufacturing that will increase Australia's industrial presence in links further down the supply chain. Despite Australia's critical minerals policy engaging in debates on the demand questions mentioned above, it has rather swallowed the extreme demand projections wholesale. Australia's policy does not discuss the sorts of strategies that might reduce the demand for new mines, either by encouraging material recycling, improving energy efficiency of renewable energy technologies or by pursuing general policies that change our current patterns of transport use, choice of building materials, etc. Lack of consideration of all of the above-mentioned strategies means that Australia risks developing a transition minerals policy that is overly wedded to the 'false scarcity' narrative.

Sixth, although recycling and remining of tailings will reduce demand to a certain extent, it is inevitable that some amounts of these minerals will still be mined. As a transitional mineral rich country, Australia must develop stronger policies that facilitate responsible sourcing. These policies should revolve around ensuring that affected communities, especially Indigenous communities, enjoy Free, Prior and Informed Consent to veto or amend potential mining projects on their lands and waterways; that environmental protection regimes are robust; the establishment of protected or 'no-go areas' in regions that are too environmentally precious to be imperilled by new mining projects; and that appropriate human rights due diligence mechanisms are put in place to disincentivise companies from behaving irresponsibly.

Seventh and finally, we must not forget that this is a global problem requiring global solutions. Supply chains in our globalised economy are not restricted by national borders. Other countries in the region, especially Indonesia, but also the Philippines, PNG and New Caledonia are rich in transition minerals like copper and nickel.



Village flooded with waste water from mining, Geamana, Romania, May 2019. *Credit: Adobe Stock*

Solutions will need to be regional and global if destructive over-extraction is to be avoided and the international conversation regarding the false scarcity narrative and alternatives to extraction needs to happen now.

The irony of the current situation with respect to transition minerals is this: what we face, regionally and globally, is a potential market failure similar to the very kind of market failure that is seeing the world continue to develop new fossil fuel resources that are very soon likely to become stranded assets. This failure could see a speculative myriad of new mines developed, and the extraction of minerals on an unnecessarily prolific scale. Not only are there risks of social and environmental impacts from mines that extract these minerals, there is also the risk of stranded assets once we realise that some of these mines may only end up operating for a portion of their life-cycle because there is no longer a market for the minerals they produce. Action must be taken imminently to avoid these outcomes.

Having surveyed the situation when it comes to the transition mineral dilemma facing Australia, we might pose the dilemma to our leaders and policymakers in the following way: Are we going to allow dollar-hungry mining industry boosters and desk-based economic analysts in overseas think tanks to goad us into digging up more minerals from this country than the world actually needs? And if so, what cost will this extraction have on the precious water resources of this continent, on our unique plant and animal biodiversity, and to the cultural heritage and autonomy of our First Nations people, the guardians of the world's longest living culture? Or are we going to bravely initiate conversations with our international allies about policy measures that all countries must adopt to minimise green mineral extraction, ensure that the extraction which does occur will happen in an environmentally and socially responsible manner, and prevent damage to the integrity of our ecosystems and the health and wellbeing of our communities, including First Nations communities?

The choice is ours.

RECOMMENDATIONS

This report recommends the following regarding the overall framing of the Australian governments critical minerals policy and the issue of demand management through policy alternatives.

Recommendation 1: Australia's current review of its critical minerals policy interrogates the demand projections being promoted by the mining industry and discusses the risk of a subsequent over-extraction of Australia's mineral resources and the potential for stranded mine assets.

Recommendation 2: As an urgent priority, Australia should conduct and publish a detailed and thorough investigation into the social and environmental impacts of the extraction of key transition minerals in Australia, including the ones in this report.

Recommendation 3: Australia's review of its critical minerals policy contains a detailed section on reducing the demand for transition minerals through the following: recycling, substitution and efficiency for EV batteries, changes to transport policy to reduce car dependence and other policy changes in energy, construction, etc.

Recommendation 4: Australia should develop an EV policy which requires companies to implement policies that assist in the recycling and reuse of EV batteries.

This report recommends the following to the Australian federal and state governments with respect to the sustainable extraction of transition minerals:

Recommendation 5: Australia must reconfigure the federal legal regime to rebalance the unequal playing field in negations between mining companies and First Nations groups, to strengthen cultural heritage protection and to address the weak and inconsistent application of FPIC. Specifically, the Federal government should:

> **Recommendation 5.1:** Enable proper resourcing of Traditional Owner groups so that they have the capacity to review, assess and negotiate agreements and have the economic power to choose alternative income sources to mining if they so desire;
>
> **Recommendation 5.2:** Enact substantive reform of the 1993 Native Title Act to ensure it is fully consistent with the government's commitment to implement and respect FPIC;
>
> **Recommendation 5.3:** Enact standalone cultural heritage legislation that is developed in partnership with Indigenous organisations.

Recommendation 6: State and territory governments must review and reform state laws along the following lines:

> **Recommendation 6.1:** Laws governing the approvals of mining to enable robust and comprehensive environmental assessment; biodiversity impacts to be avoided when possible and offset when not possible; best practice community consultation including FPIC for First Nations communities, accountability and transparency in decision-making; the minimisation of impacts on water resources.
>
> **Recommendation 6.2:** Laws enabling a sufficient amount of protected areas and 'no-go zones' so as to: first, facilitate the identification and prioritisation of transition minerals projects on land that has already been developed, impacted or degraded; and second to allow identification of areas that are off-limits to minerals development because of their unique status as wetlands, critical habitat or formal protected areas.
>
> **Recommendation 6.3:** A requirement for mining companies to take responsibility over the entire life cycle of the mine, including clean-up and regeneration of the mine site.
>
> **Recommendation 6.4:** Governance and transparency reforms requiring: a strict separation between the mining regulator and the mining promoter; adequate funding for the regulator; statutory provisions requiring adequate public reporting to improve transparency; a strengthening of provisions around enforcement and compliance.

Recommendation 7: Australia should ensure that the 2023 revisions to the Environmental Protection and Biodiversity Act are strong and detailed enough to enable and empower states and territories to address the four issues in recommendation 6.

Recommendation 8: Australia should initiate a responsible sourcing regime for transition minerals.

> **Recommendation 8.1:** Australia should develop laws that mimic the EU sustainable battery legislation—and should encourage other jurisdictions to follow suit.
>
> **Recommendation 8.2:** Australia should review its trade and investment policies, including the aid and export credit programs, to ensure sustainable extraction of natural resources and ensure all public procurement sets the criteria for social responsibility including for renewable energy products.

Recommendation 9: Australia should take steps to strengthen the regulatory regime around business and human rights through the following steps:

> **Recommendation 9.1:** Strengthen the operation of the Australian National Contact Point on Responsible Business Conduct (AusNCP) by giving it greater powers and resourcing for investigations and the sanctioning of companies found to be in breach of OECD guidelines;
>
> **Recommendation 9.2:** Require all ASX listed companies and large private mining companies to prevent adverse human rights impacts in their operations via mandatory human rights due diligence legislation;
>
> **Recommendation 9.3:** Corporate regulations, including the *Corporations Act 2001*, should be revised to impose clear responsibilities on companies, and their directors, to avoid causing economic, social, human rights and environmental harm in the areas in which they work.
>
> **Recommendation 9.4:** Commit to domestic implementation of the Extractive Industries Transparency Initiative (EITI).
>
> **Recommendation 9.5:** Support the adoption of a UN Binding Treaty on Business and Human Rights.

This report recommends the following to the Australian federal and state governments with respect to the sustainable extraction of transition minerals:

Recommendation 10: Australia should ensure that any diplomacy on the topic of transition minerals bilaterally and at international fora (such as the G20, the G7 and both UN Climate Change and Biodiversity COPs) discuss issues such as demand reduction through policy alternatives (see recommendation 3) and the responsible sourcing of minerals.

Recommendation 11: Australia should begin discussions with global and regional partners for the establishment of mining moratoriums in selected ecosystems—for example, rainforests, wetlands, critical habitat areas and deep sea ecosystems.

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Trucks transporting coal at an Australian coal mine. *Credit: Magnus von Koeller/Australian Conservation Foundation*

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