



Australian Government

Australian Trade and Investment Commission



# Australian Critical Minerals Prospectus 2022



AUSTRALIA



**Acknowledgements**

Austrade would like to thank Geoscience Australia, Critical Minerals Office, Australia's state and territory geological and investment agencies, WideRange Consulting, and the organisations profiled in this report for their contributions in updating this Prospectus.

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## Acknowledgement of country

In the spirit of reconciliation we acknowledge the Traditional Custodians of country throughout Australia and their connections to land, sea and community. We pay our respect to their elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

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Printed December 2022







# Foreword

Critical minerals are integral to the development of low-carbon economies and the realisation of net zero goals. Critical minerals are core inputs for lithium-ion batteries, sintered magnets, high performance alloys and semiconductors. These intermediate goods are essential components in electric vehicles, hydrogen electrolyzers, smartphones, computers, solar panels, and a range of defence and medical equipment.

The International Energy Agency's (IEA) World Energy Outlook 2022 notes that demand for critical minerals is set to rise two to fourfold by 2030.<sup>1</sup> At the same time, there's a need to avoid vulnerabilities arising from volatile prices or highly concentrated supply chains. If not adequately addressed, price and supply chain issues could delay energy transitions or make transitions more costly.

Industry end users are increasingly aware of the urgent need to shore up secure and stable supplies of critical minerals. To manage these risks – and develop new opportunities – there is an urgent need to secure new sources of supply through upstream investment. The Australian Critical Minerals Prospectus showcases 55 investment-ready Australian critical minerals projects that have significant potential to address anticipated production shortfalls, build supply chain security, and help deliver progress on a net-zero future.

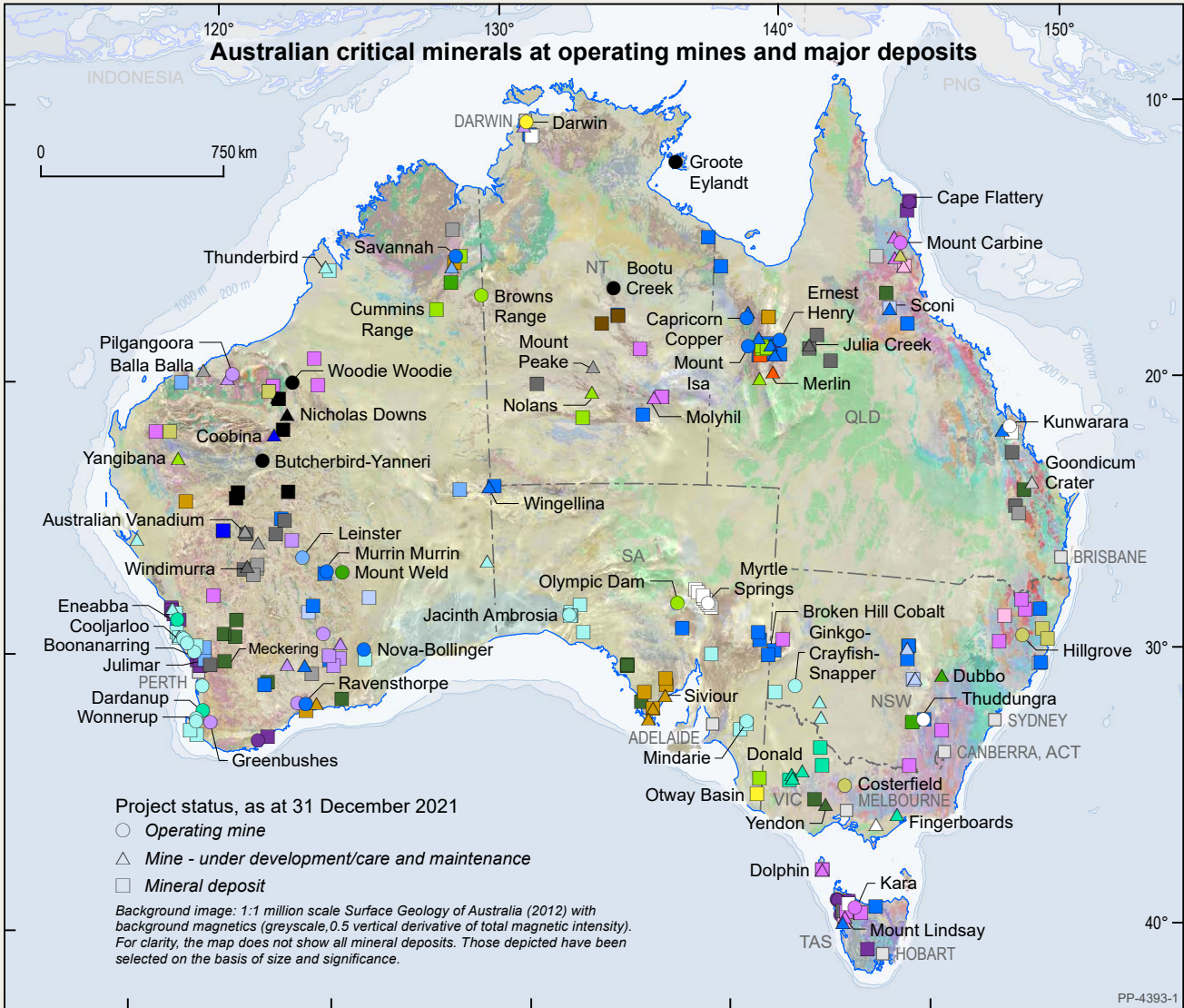
The Australian Government, following the release of the first Australian Critical Minerals List and inaugural National Strategy in 2019, has supported the development of critical minerals projects through the annual publication of the Critical Minerals Prospectus. This 2022 edition provides a timely update on potential investment opportunities in Australia-based critical minerals projects. Notable changes since the previous edition include:

- an increase in the number of project profiles from 44 to 55;
- coverage of high-purity alumina and silicon projects following their inclusion on the Australian Critical Minerals List; and
- an expanded 'Unlocking the Midstream' summary to reflect recent developments.

High-value critical minerals exports can become a new source of economic growth for Australia and, at the same time, spur the development of new local processing capabilities. Australia has a long history as a global leader in the development of resources projects.

Australia has a skilled workforce, world-leading environmental, social and governance (ESG) practices and a transparent regulatory environment. These advantages put Australia in prime position to lead the exploration, extraction, production and processing of critical minerals.

1. IEA (2022) World Energy 2022, IEA Paris



**Commodity type**

- Aluminium (HPA)
- Antimony
- Bismuth, +/- Cobalt, +/- Indium
- Chromium, +/- Cobalt, +/- PGE
- Cobalt
- Platinum Group Elements (PGE), +/- Cobalt
- Scandium, +/- Cobalt, +/- PGE
- Graphite
- Helium
- Indium
- Lithium, +/- Tantalum, +/- Niobium
- Magnesium
- Manganese ore
- Heavy Mineral Sands (HMS) - Titanium, Zirconium
- HMS - Titanium, Zirconium, REE
- Rare Earth Elements (REE)
- REE, Zirconium, Niobium, +/- Hafnium, Lithium, Tantalum, Gallium
- Rhenium
- Silicon
- Tungsten
- Titanium
- Titanium, Vanadium
- Vanadium







# Australian critical minerals

The Australian Government identifies critical minerals as those metals, non-metals and minerals that are considered vital for the economic well-being of the world's major and emerging economies, but whose supply may be at risk due to geological scarcity, geopolitical issues, trade policy or other factors. A list of 24 critical minerals was first identified in 2019 and has since expanded to 26 minerals in 2022 with the addition of high-purity alumina and silicon.

Mineral	Antimony	Beryllium	Bismuth	Chromium
<b>Australian resources (EDR 2020)</b>	125.2 kt Sb	n/a	n/a	n/a
<b>World ranking for resources</b>	5	n/a	n/a	n/a
<b>Share of world production</b>	1%	n/a	n/a	0%

Mineral	Cobalt	Gallium	Germanium	Graphite
<b>Australian resources (EDR 2020)</b>	1,495 kt Co	n/a	n/a	7.97 Mt
<b>World ranking for resources</b>	2	n/a	n/a	8
<b>Share of world production</b>	4%	n/a	n/a	0%

Mineral	Hafnium	Helium	High-purity Alumina	Indium	Lithium
<b>Australian resources (EDR 2020)</b>	14.5 kt	n/a	n/a	n/a	6,174 kt Li
<b>World ranking for resources</b>	n/a	n/a	n/a	n/a	2
<b>Share of world production</b>	n/a	3%	n/a	n/a	49%

Mineral	Magnesium	Manganese	Niobium	Platinum group elements
<b>Australian resources (EDR 2020)</b>	286 Mt MgCO <sub>3</sub>	276 Mt (Mn ore)	216 kt Nb	107 t PGE metal
<b>World ranking for resources</b>	4	4	3*	minor
<b>Share of world production</b>	3%	12%	unknown	minor

Mineral	Rare earth elements	Rhenium	Scandium	Silicon	Tantalum
<b>Australian resources (EDR 2020)</b>	4.2 Mt REE oxide	n/a	30.34 kt Sc	n/a	99.4 kt Ta
<b>World ranking for resources</b>	6	n/a	unknown	n/a	1*
<b>Share of world production</b>	8%	n/a	0%	n/a	4%



Mineral	Titanium	Tungsten	Vanadium	Zirconium
<b>Australian resources (EDR 2020)</b>	Ilmenite 274 Mt Rutile 35.3 Mt	577 kt W	7,408 kt V	Zircon 79.3 Mt
<b>World ranking for resources</b>	Ilmenite 2 Rutile 1	2	2	1
<b>Share of world production</b>	Ilmenite 9% Rutile 26%	minor	0%	21%

Rare Earth Elements (REE) include yttrium (Y), lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu). Platinum Group Elements (PGE) include ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), and platinum (Pt).

n/a not available

Sources: Australia's Identified Mineral Resources 2021. Geoscience Australia and Mineral commodity summaries 2021: U.S. Geological Survey. Figures as at 31 December 2020.

\*Note niobium and tantalum are based on published estimates of economic resources and therefore do not consider the large but undocumented resources of the Congo









# Australia – a trusted partner in the global critical minerals supply chain



Australia is considered the **most attractive region in the world** for mining investment based on supportive government policies and mineral potential\*



Australia has among the **world's largest recoverable resources of critical minerals**\*\*



Australia has one of the world's **most efficient regulatory environments**\*\*\*

\* Jairo, Y. & Aliakbari, E. 2022. Fraser Institute Annual Survey of Mining Companies 2021. Fraser Institute, Vancouver)

\*\* Geoscience Australia. 2021. World Rankings. Geoscience Australia, Canberra)

\*\*\* Kaufamnn, D. Kraay, A. 2022. Worldwide Governance Indicators. World Bank, Washington, D.C.)

## A resilient economy backed by strong exports, services and leading institutions

Amid global uncertainty, Australia continues to be one of the safest places to do business, scoring significantly higher than other OECD countries for governance effectiveness, regulatory quality and rule of law.<sup>2</sup> Despite lingering challenges posed by the COVID-19 pandemic, Australian GDP growth projections for 2022 exceed forecasts for advanced economies and the global average.<sup>3</sup> Within the Australian economy, the resources sector has fared particularly well against the challenges of the pandemic. It continues to set records for production and exports of high-quality minerals that satisfy global demand. Furthermore, Australia continues to be a locus of economic dynamism as the world's 12th largest economy yet home to only 0.3% of the world's population. These underlying economic conditions support the long-term viability of resources investment in Australia.

## Supportive government policies

The Australian Government supports the development of the Australian critical minerals sector. Government initiatives are complemented by a range of other strategic and policy initiatives at the state and territory level. Australian Government policy programs are designed to:

1. **foster sector-wide development** through trade and investment facilitation, research and development, standards and accreditation, and hubs and precincts.
2. **forge strategic partnerships** with major trading partners such as the United Kingdom, the United States, the EU and its member countries, Japan, South Korea and India.
3. drive the development of critical minerals projects through **supportive debt-finance and other funding mechanisms**.

2. Kaufamnn, D., Kraay, A. (2022). Worldwide Governance Indicators. World Bank, Washington.

3. International Monetary Fund, (2022). World Economic Outlook: Countering the Cost of Living Crisis. IMF, Washington D.C.

**4. unlock the mid-stream** through industry development, research and development, science, technology, and infrastructure support.

In October 2022, the Australian Government announced new initiatives to drive the development of Australia's critical minerals sector. These measures form part of Australia's commitment to achieve net zero by 2050. They include the Critical Minerals Development Program; the Australian Critical Minerals Research and Development Hub (R&D Hub); the Value Adding in Resources Fund; and a refreshed National Critical Minerals Strategy slated for early 2023.

**The Critical Minerals Development Program (CMDP) will provide A\$50 million in competitive grants** over three years to support early and mid-stage critical minerals projects. The program builds on the A\$49.7 million already committed to six projects under the CMDP in mid-2022.

**The A\$50.5 million R&D Hub will build on Australia's world-leading research capabilities** by drawing together critical minerals expertise in the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian Nuclear Science and Technology Organisation (ANSTO), and Geoscience Australia.

The R&D Hub will also coordinate and align critical minerals research efforts. This will enable the development of Australian intellectual property in critical minerals processing and progress international science and R&D collaboration.

The Australian Government is committed to building resilient supply chains for the critical minerals needed to produce clean energy technologies. **The Value-Adding in Resources Fund, part of the National Reconstruction Fund, will deliver A\$1 billion in investment** through loans, equity and guarantees for businesses in resources value-adding and mining science.

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*The Australian Government supports critical minerals projects through a A\$2 billion finance facility*

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## Financial support

The Australian Government also supports advanced critical minerals projects through the A\$2 billion Critical Minerals Facility, managed by Export Finance Australia — Australia's national credit agency. To date, the Australian Government has approved three loans under the Facility. The loan recipients are:

- **Iluka Resources:** a A\$1.25 billion loan for the development of its Eneabba Rare Earths Refinery Project.
- **Renascor Resources:** a A\$185 million loan for its Siviour Graphite Project.
- **EcoGraf:** a US\$40 million loan for its Battery Anode Material Facility.

Eligible projects are also able to access finance from other Commonwealth financing bodies, including the Northern Australia Infrastructure Facility (NAIF) and Clean Energy Finance Corporation (CEFC). NAIF recently approved loans for critical minerals projects. These include A\$150 million for the development of the Coburn Heavy Mineral Sands Project and A\$140 million for the construction of Hastings Technology Metals' Yangibana Rare Earths Project. The CEFC has invested directly in critical minerals projects such as Pilbara Minerals' Pilgangoora Project, as well as investing in efforts to make mining operations greener.

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*Australia is world-recognised for governance effectiveness, regulatory quality and rule of law*

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## A world-leading approach to ESG policies

A secure supply of minerals for industrial end-users requires the effective management of all environmental, social and governance (ESG) considerations related to mining and minerals processing. Consumers are increasingly conscious of the origins of traded goods and the social impact of their choices.





Australia is well-positioned to meet the growing demand for responsibly produced minerals. The Australian resources sector has a reputation for extracting minerals safely, responsibly and with robust environmental, social, and labour protections. As an active participant in the International Organization for Standardization (ISO), Australia is also working to ensure that production standards are equitable and environmentally sustainable.

Australian critical minerals companies, for their part, increasingly view ESG reporting as an opportunity to create value for customers and investors. Australian critical minerals companies are recognised for their focus on workplace, community, and labour relations in sustainability reports, in addition to management of water and greenhouse gas emissions.<sup>4</sup>

### **A highly skilled workforce and a globally recognised METS sector**

The Australian resources sector benefits from a highly skilled and talented workforce. Australia's top-ranking education system, coupled with a national focus on maintaining in-demand skills,

supports the longevity of a work-ready local talent pool. With research institutions that rank in the world's top 1% across 15 different fields, Australia's workforce includes a variety of skills needed in the resources industry.<sup>5</sup>

The international competitiveness of Australia's resources sector is underpinned by an advanced mining equipment, technology, and services (METS) industry, which directly employs more than 300,000 people.<sup>6</sup> Australia is an established services hub, with professional and technical services growing at a compound annual growth rate of 4.8% for the past three decades.<sup>7</sup> Our equipment and technology producers have long embraced robotics, automation and big data, meaning that Australia resources projects are efficient and productive.

*Australian research institutions rank in the top 1% across 15 different fields*



4. Smith, D., Upcorft, M., Claassen, M. Reynolds, C., O'Donoghue, J., McKenna, S., Meadows, R., Pope, C., McKinley, S., Haynes, L., Mulherin, C., Vangou, D., Harris, C., Jamieson, M., Frayre, F., Whittaker, L., Torres, J.D., Sharma, M., Mehta, J., Robb, K., Loughridge, J. 2022. Aussie Mine 2022 Mission Critical. PricewaterhouseCoopers, Melbourne.

5. Austrade. (2022). Why Australia: Benchmark Report 2022, Austrade, Canberra, pg. 29

6. METS Ignited. (2021). METS in Australia, Brisbane.

7. Austrade. (2022). Why Australia: Benchmark Report 2022, Austrade, Canberra, pg. 13

# Australian Government support of the critical minerals sector

## Australian Trade and Investment Commission

The Australian Trade and Investment Commission (Austrade) is the Australian Government's lead trade and investment facilitation agency. It contributes to Australian critical minerals strategy by developing commercial partnerships that connect Australian companies with targeted sources of offtake and investment. In doing so, Austrade works closely with the Critical Minerals Office, Department of Foreign Affairs and Trade, and state and territory investment agencies, as well as counterpart trade and investment facilitation agencies in other countries.

Austrade's three principal focus areas are:

1. offtake agreements for (and investment and potential equity in) Australian critical minerals projects to accelerate their development
2. foreign investment in downstream processing and value-chain creation
3. foreign investment in greenfields critical minerals opportunities.

Austrade delivers this capability through specialised services to Australian critical minerals companies, including bespoke client engagement programs and targeted trade missions. These initiatives build on the agency's understanding of the specific needs of global critical mineral end-users and their tiered suppliers. Austrade also facilitates commercial partnerships with targeted global partners. Interested investors, project proponents and offtake partners can contact Austrade via [www.austrade.gov.au](http://www.austrade.gov.au) or email [criticalminerals@austrade.gov.au](mailto:criticalminerals@austrade.gov.au).

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## Policy coordination

### Critical Minerals Office

The Critical Minerals Office (CMO) was established within Australia's Department of Industry, Science and Resources as the policy lead and coordinator for critical minerals. It leads the delivery of a National Critical Minerals Roadmap with state and territory governments. A priority work stream under the National Roadmap is the delivery of an ethical certification scheme that includes provenance and blockchain technology pilots, as well as the establishment of critical minerals processing precincts to unlock government regulatory and infrastructure support.

### Department of Foreign Affairs and Trade

The Department of Foreign Affairs and Trade, and Australia's diplomatic missions overseas, are deepening international partnerships to showcase Australia's strengths in the critical minerals sector, creating the right government-to-government settings to enable further commercial linkages and the sector's development.

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## Financing bodies

### Clean Energy Finance Corporation

The Clean Energy Finance Corporation (CEFC) is a specialist investor at the centre of efforts to help deliver on Australia's ambitions for a thriving, low emissions future. CEFC investments in the resources sector seek to capitalise on Australia's world-leading access to many of the minerals critical to the low emissions economy of the future, including those that are essential to the development of renewable energy, energy storage and electrification. With a strong investment track record, the CEFC invests to fill market gaps by collaborating with investors, innovators and industry leaders to spur substantial new investment where it will have the greatest impact.



The CEFC invests on behalf of the Australian Government, with a strong commitment to deliver a positive return for taxpayers across its portfolio.

### **Northern Australia Infrastructure Facility**

The Northern Australia Infrastructure Facility (NAIF) is a A\$5 billion lending facility providing loans to infrastructure projects in northern Australia. An extra A\$2 billion was allocated to the lending facility in the 2022-23 Australian Budget. NAIF investments can be used to develop new or materially-enhance existing infrastructure. NAIF can lend up to 100% of the debt, provided there is appropriate risk-sharing. Loans can be on concessional terms, relative to private sector financing arrangements– if the infrastructure generates public benefit and there is an ability to repay or refinance. Access to dual funding through Export Finance Australia as well as NAIF may be available to eligible projects.

### **Export Finance Australia**

Export Finance Australia (EFA) supports Australia's trade and infrastructure agenda by providing commercial finance for exporting businesses and Indo-Pacific infrastructure development. EFA supports critical minerals projects and related infrastructure, and Australian businesses involved with the critical minerals export supply chain.

EFA administers the Australian Government's National Interest Account. This includes the A\$2 billion Critical Minerals Facility, the Defence Export Facility and lending for the Australian Infrastructure Financing Facility for the Pacific.

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## **Scientific & Research Institutions**

### **Geoscience Australia**

Geoscience Australia is a trusted source of information on Australia's geology and geography. It provides technical capability, geoscience information, innovation and advice on critical minerals. The organisation, working with its state and territory partners, delivers programs of continental-scale data acquisition, and develops tools for mapping, prediction and decision-making.

Geoscience Australia's critical minerals activities aim to underpin new exploration technologies, stimulate mineral exploration investment, drive new discoveries and open up new, producing critical minerals provinces.

To find out more about Geoscience Australia's critical minerals activities, publications and data, visit: <https://www.ga.gov.au/scientific-topics/minerals/critical-minerals>

### **The Future Battery Industries Cooperative Research Centre**

The Future Battery Industries Cooperative Research Centre (FBI-CRC) is jointly funded by a variety of participants across industry, government, and the research community. The FBI-CRC has a six-year research and development program targeting each stage of the battery value chain. It has a mandate to expand Australia's capacity to produce battery minerals.

### **Australian Nuclear Science and Technology Organisation**

The Australian Nuclear Science and Technology Organisation (ANSTO) is contributing to the development of sustainable alternative supply chains for the Australian critical minerals industry. ANSTO's minerals business unit has world-leading expertise in critical minerals particularly rare earth processing (including scandium), lithium processing (brines and hard rock), zirconium/niobium/hafnium processing and other speciality metal processing. The minerals' group also has expertise in uranium and base metals processing, and radioactivity control and management in the mining and minerals processing industries.

### **The Commonwealth Scientific and Industrial Research Organisation**

CSIRO has considerable strengths in critical minerals processing. It generates ideas for innovation and process improvements that help Australian mining companies to operate competitively and sustainably. It is developing technologies to help Australian critical minerals companies to improve extraction from difficult and low-grade ores. CSIRO is also developing practical technologies that will help Australian companies upgrade and refine critical minerals to speciality grades, and to manufacture the minerals into intermediate components.







# Abundant opportunities for new Australian mineral discoveries

Australia is a leading mining jurisdiction with some of the world's largest recoverable mineral resources in the ground and many opportunities for more discoveries.

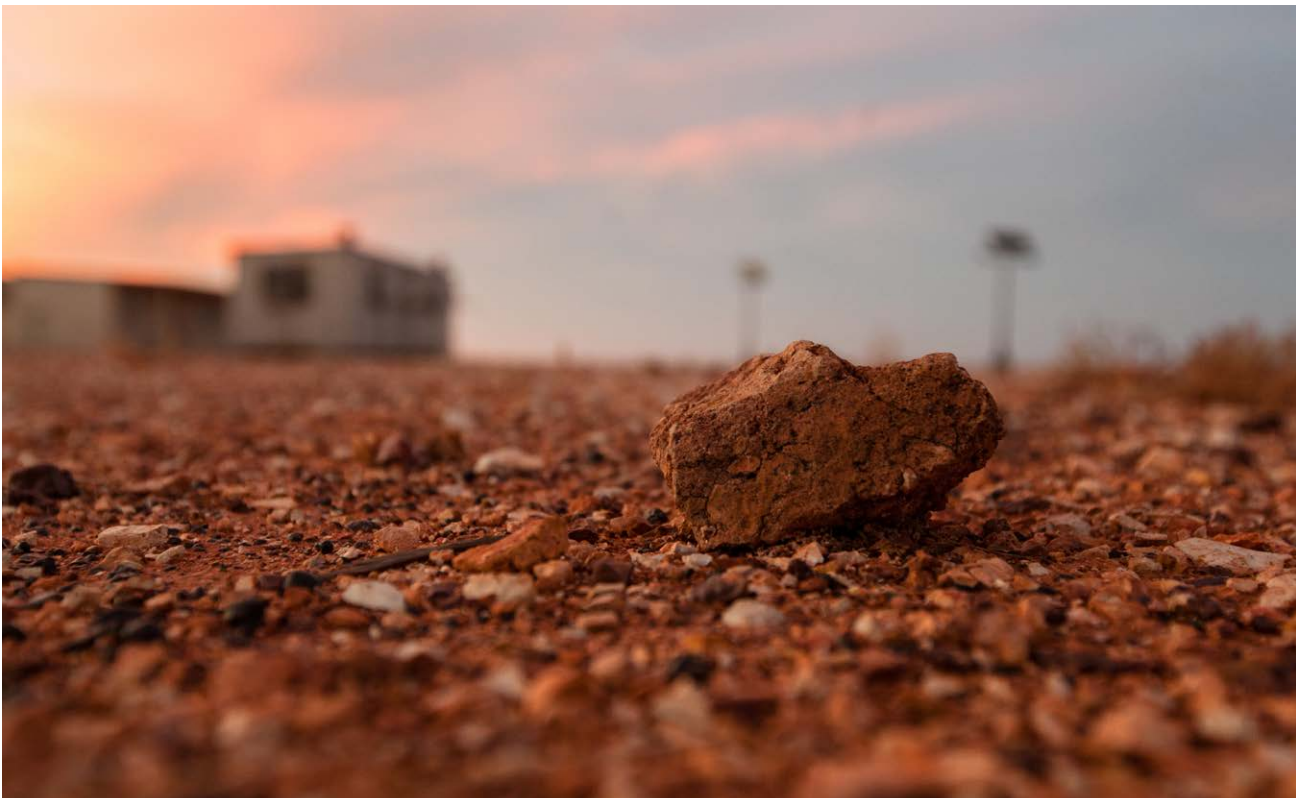
Until quite recently, most Australian mineral discoveries were either exposed at the surface or had some form of surface expression that could be easily detected by geological, geochemical or geophysical exploration methods. There is no reason to suppose that resources will only be found near the surface. **With most of the Australian continent underexplored, many potential resources remain undiscovered.** The challenge is where to look.

## Geoscience Australia: the gateway to Australia's untapped resources

Geoscience Australia is reducing exploration risk by collecting and analysing geological and geophysical data and providing this precompetitive data publicly. This helps to

inform new mineral discoveries in Australia's underexplored areas. **The Australian Government's A\$225 million Exploring for the Future program** is using proven as well as new and innovative technologies and techniques to provide communities and industry with the information they need to confidently plan, make informed decisions and invest in new developments.

One of the current projects is assessing the mineral potential undercover in the Curnamona Province and Delamerian Orogen. The Curnamona Province is the birthplace of Broken Hill Proprietary Company Limited, now BHP, one of the world's largest mining companies. The Broken Hill lead-zinc-silver mine in western New South Wales, named after the hill that prompted the discovery and the mine, is the largest single source of silver, lead and zinc in the world.



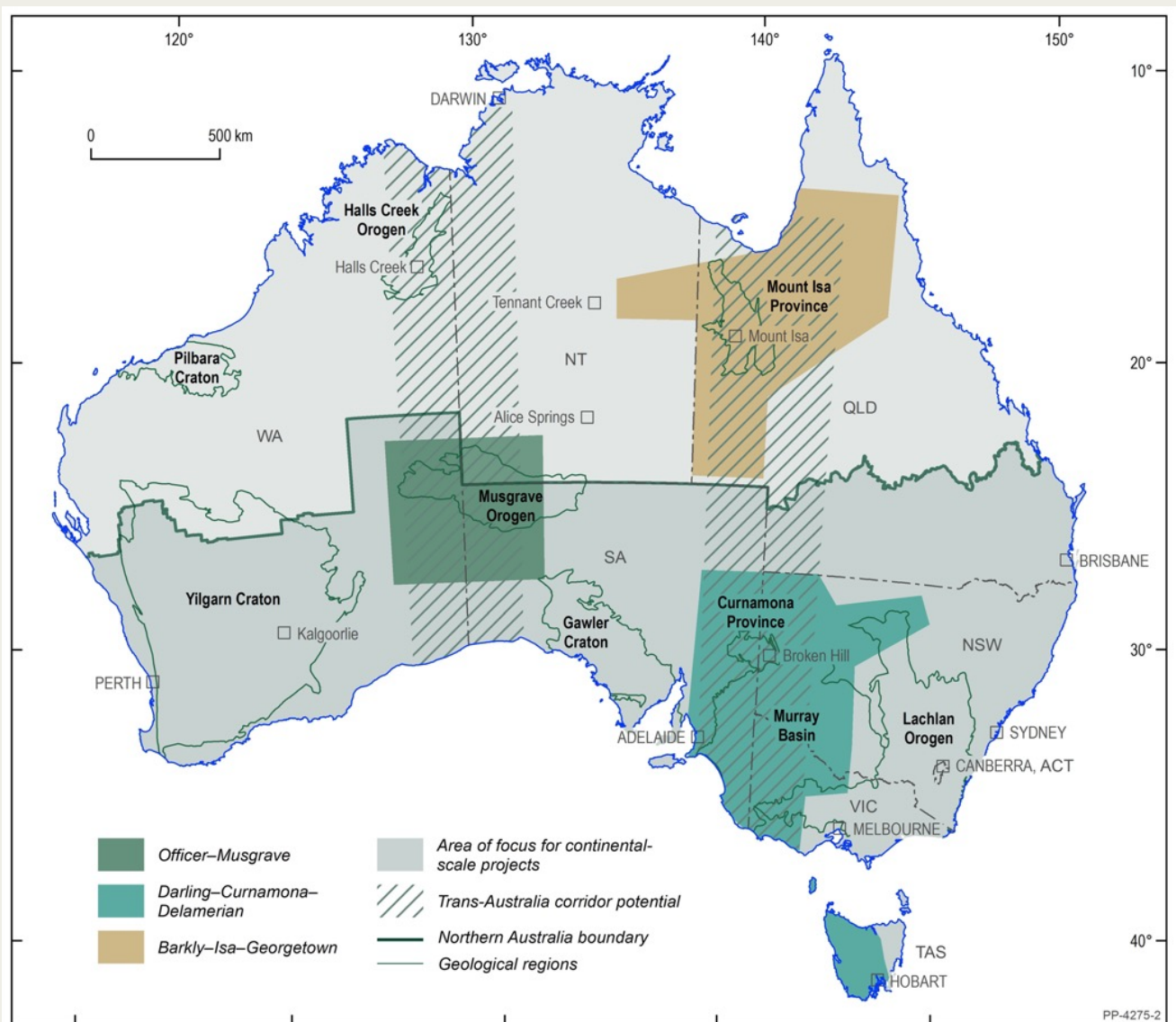
The ancient rocks that host this mine extend beyond Broken Hill and beneath the cover of the vast plains, where potential for high-quality mineral discoveries remains. The Delamerian Orogen wraps around the Curnamona Province in New South Wales and South Australia and extends through Victoria into Tasmania. This is a slightly younger continental collision zone and region of mountain building and volcanism. It has the potential for discovery of high-quality mineral deposits, including copper, gold, lead, zinc, nickel and related critical minerals that now lie under the cover of younger sedimentary basins.

The Exploring for the Future Darling-Curnamona-Delamerian project aims to lift the veil of this cover and help industry find new mineral deposits.

Geoscience Australia’s precompetitive data, including the data from the Exploring for the Future program, is publicly available to support and reduce risk in resource decision-making and investment.

A wealth of data is available online through Geoscience Australia’s Exploring for the Future Data Discovery Portal. To access the Portal visit [www.eftf.ga.gov.au](http://www.eftf.ga.gov.au)

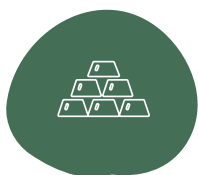
**Figure 1. Australian resource provinces**





## Critical minerals mapping initiative

Geoscience Australia developed the Critical Minerals Mapping Initiative Portal in collaboration with the Geological Survey of Canada and the United States Geological Survey. The portal allows users to interrogate the world's largest dataset of critical minerals in ores. In time it will also include assessments of critical mineral potential. The portal can be accessed at: [www.criticalminerals.org](http://www.criticalminerals.org)



Australia has

### 24 commodities ranked in the top five

for world economic resources, including cobalt, lithium, manganese, tungsten and vanadium.



Australia spent

### \$3.9 billion on mineral exploration in 2021–22.

This was a 22% increase compared to 2020–21.

*Australian Bureau of Statistics (June 2022), Mineral and Petroleum Exploration, Australia. ABS Website, Canberra.*

## Australian mineral systems with critical mineral discovery potential

Felsic igneous-related **rare earth elements, lithium, tungsten, niobium, tantalum, beryllium** and **bismuth** occur in known deposits and are prospective in the under-cover extensions of mineral provinces.

Mafic-ultramafic-related **platinum group elements, chromium** and **cobalt** resources often occur together with nickel and copper, and are prospective where the host mafic-ultramafic igneous complexes could be concealed beneath regolith and sedimentary basins. Geoscience Australia's mineral potential mapper identifies these regions and has contributed to large discoveries such as the Julimar PGE-Ni-Cu-Au-Co deposit near Perth, Western Australia.

Australian sedimentary basins host critical and strategic minerals such as **magnesium, manganese, nickel** and **vanadium**. Of these, manganese, magnesium and nickel are currently mined in Australia, and advanced exploration projects have identified significant resources of magnesite (source of **magnesium**) and vanadium (plus nickel and molybdenum). Moreover, metamorphosed basins are also known to contain significant **graphite** resources. **Scandium** and rhenium resources are known in other geological environments. Australian salt lakes have low potential for **magnesium** and **lithium**, but they have high potential for potash, which is now being produced in Western Australia.

New discoveries of heavy mineral sand provinces in Australia, such as the Murray Basin, attest to the potential of the continent for further delineation of major resources, which host **zirconium, titanium** and **rare-earth elements**.

**High-purity alumina (HPA)** is aluminium oxide with very low levels of impurities, which can be produced primarily from kaolin clay or processed bauxite. **Silicon** for high-tech applications is produced from high purity quartz (HPQ) with a purity greater than 99% silica. HPQ occurs through a variety of natural processes and broad range of geological mineral systems such as hydrothermal veins, gravels and quartz-rich granites. Geoscience Australia assesses the geological potential for HPA and HPQ in Australia to be moderate to high, respectively, however further study is being undertaken.

**Antimony, indium, gallium** and **germanium** are primarily by-products of the refining of major commodities including gold, zinc, lead, copper, aluminium and nickel. Australia holds significant resources of these major commodities and there is potential for new or increased production of these minerals.

# Developing the midstream

With an abundance of raw critical minerals, Australia is an increasingly popular destination to host midstream processing activities. A variety of supportive government policies, in addition to a highly educated workforce, means that there are significant reasons to develop Australia's capability in midstream processing. From batteries, wine turbines and solar panels, to stronger and lighter jet engines, Australia's midstream products are needed in a variety of green technologies.

The projects profiled below are intended to exemplify critical minerals processing in Australia. It is not an exhaustive list, and there are many more critical minerals processing projects that are not featured below.

## Lithium processing is gaining momentum

### Tianqi Lithium Energy Australia (Tianqi Lithium Corporation & IGO Ltd Joint-Venture)

Australia's first battery-grade lithium hydroxide was produced in May 2022 in the Kwinana Industrial Area, using feedstock from the Talison Lithium Mine in Greenbushes. The plant, which is a joint venture between Tianqi and IGO, plans to supply global customers producing rechargeable batteries for the electric vehicle and energy storage industries.

- **Forecast production is 24,000 tpa of lithium hydroxide from each production train. The first train is constructed, and the second is underway**



### Covalent Lithium (SQM and Wesfarmers Joint-Venture)

Following a final investment decision in 2021, Covalent Lithium plans to produce battery-grade lithium hydroxide through an integrated operation, encompassing the Mount Holland Mine, and the Kwinana refinery.

- **Forecast production is 50 ktpa of battery-grade lithium hydroxide**



### MARBL (Albemarle & Mineral Resources Joint-Venture)

MARBL's Kemerton facility is a world-class 50,000 metric tonne battery grade lithium hydroxide processing plant - the largest of its type in Australia.

Trains 1 and 2 process high grade spodumene ore from the Greenbushes mine and a first production milestone was reached in June 2022. Expansion plans are progressing to double the output of the facility to a target of 100mtpa of battery grade lithium hydroxide.

- **Forecast production is 50 ktpa of battery grade lithium hydroxide**





## Production of other Li-ion battery materials is a growing focus

### EcoGraf: Battery Anode Material Facility

EcoGraf plans to produce purified spherical graphite (PSG), a battery anode material used in lithium-ion batteries at its processing facility in Kwinana. EcoGraf has developed a method of producing PSG without hydrofluoric acid, which will provide a supply of sustainably produced, high quality PSG for the lithium-ion market. EcoGraf was the recipient of a US\$40 million loan for its Battery Anode Material Facility.



- **Forecast production is 20 ktpa of PSG**
- 

### Renascor Resources: Mining and Battery Anode Material Manufacturing Plant

Renascor Resources is developing a vertically integrated Mining and Battery Anode Material (BAM) Manufacturing operation, leveraging the Siviour Graphite Deposit to produce Purified Spherical Graphite (PSG) for use in Li-ion battery anodes. Renascor is progressing an updated BAM Study with geotechnical, tailings, hydrogeological and infrastructure studies completed. Renascor has received a A\$185 million loan to develop the project.



- **Forecast Stage 1 production capacity considered 28,000 tpa of PSG**
- 

### Queensland Pacific Metals: Townsville Energy Chemicals Hub (TECH) Project

The TECH project plans to produce high-grade ore to produce nickel sulphate, cobalt sulphate, and high-purity alumina for the battery market. QPM completed a Pre-Feasibility Study in early 2020, and a Definitive Feasibility Study is underway. Binding offtake agreements are in place with General Motors, LG Energy Solution and POSCO for nickel and cobalt produced and refined at the TECH Project.



- **Forecast production of 16,000tpa of nickel sulphate, 1,800tpa of cobalt sulphate and 4,000 tpa of high-purity alumina**
- 

### Pure Battery Technologies: Coolgardie Cathode Active Material Refinery Hub

In October 2021 Pure Battery Technologies (PBT) announced plans to build a A\$460 million precursor cathode active material (pCAM) Hub refinery in Kalgoorlie, Western Australia. The WA pCAM Hub will be an integrated Nickel Manganese Cobalt battery material refinery. In March 2022, PBT, in collaboration with Poseidon Nickel, secured an A\$119.6 million grant from the Australian Government for the proposed Hub.



- **Forecast production of 50 ktpa of precursor Cathode Active Material (pCAM) expandable to 100 ktpa within 5 years**

## Australia is also developing rare earths processing capability

### Lynas Rare Earths: Mt Weld Concentration Plant

Lynas is investing more than A\$1 billion in capital to expand its Mt Weld mine and concentrator plant near Laverton and construct a Rare Earths Processing Facility in Kalgoorlie. The Facility will process concentrate produced at Mt Weld before being shipped to the Lynas advanced materials plant in Malaysia. The Kalgoorlie Facility has also been designed to feed Lynas' planned U.S. Processing Facility which is expected to be located on the Gulf Coast of Texas.



- **Mt Weld expansion project to deliver concentrate feedstock to produce 12,000 tpa NdPr products in 2024**

### Iluka Resources: Eneabba Rare Earths Refinery

Iluka is building a fully integrated rare earths refinery at Eneabba in Western Australia, following a final investment decision in 2022. Iluka is the recipient of an A\$1.25 billion loan delivered through the Australian Government's Critical Minerals Facility. Iluka is set to become a globally material supplier of rare earth oxides, with first production scheduled for 2025.<sup>8</sup>



- **Forecast production is up to 23 ktpa of rare earth oxides**

## Alloy and non-lithium energy storage systems are also increasing across Australia

### TNG Ltd: Mount Peake

TNG has developed a patented innovative TIVAN® technology to extract maximum value from Mount Peake ore, enabling production of three high-purity products: vanadium pentoxide, titanium dioxide pigment and iron oxide fines. TNG is progressing plans for a Vanadium Redox Flow Battery business to capitalise on its planned production of high-quality vanadium pentoxide and vanadium electrolyte.<sup>9</sup> TNG is at advanced stage of engineering and approvals ahead of a Final Investment Decision.



- **Forecast production of 6 ktpa of vanadium pentoxide, 100 ktpa of titanium dioxide pigment, and 500 ktpa of iron oxide fines**

### LIBERTY Bell Bay: Manganese Alloy Smelter

LIBERTY Bell Bay has four submerged electric arc furnaces and a sinter plant. These are used to produce ferro-manganese and silico-manganese alloys, which are key ingredients in the production of steel. LIBERTY Bell Bay services both domestic and export markets and is an important part of steelmaker LIBERTY's integrated Australian and global operations.



- **The smelter has a flexible flowsheet with a combined capacity to produce approximately 250 ktpa of high carbon ferro-manganese and silico-manganese, which are used in steel production**

8. Please see the Eneabba Refinery investment summary on page 52 for more information

9. Please see the Mount Peake investment summary on page 69 for more information.





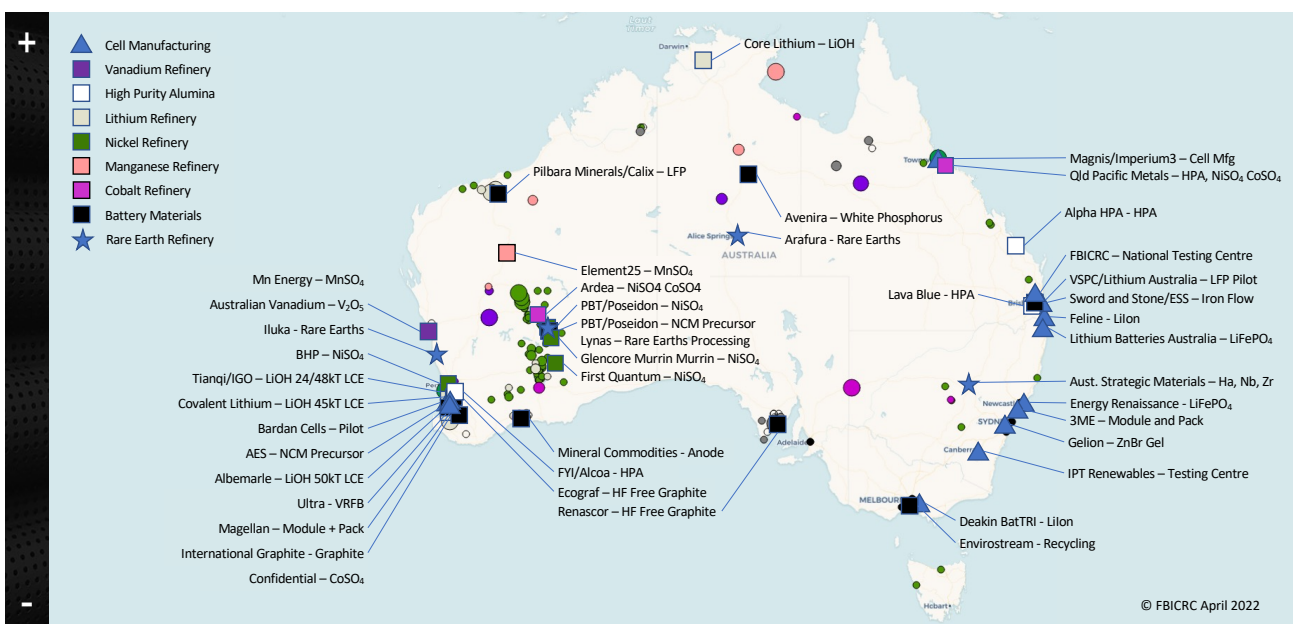
Tianqi's Kwinana lithium hydroxide plant. CREDIT: Image courtesy of Tianqi.

### Across Australia, regional hubs are bolstering processing capability

Australia is home to several developing critical minerals hubs, including the **Kwinana Strategic Industrial Area** in Western Australia, which is a specialist centre for resource-based processing. It hosts both cathode and anode material facilities, with two lithium hydroxide plants and a purified spherical graphite plant.

The **Townsville State Development Area** in Queensland is a dedicated industrial zone with an established history in minerals processing and plans to accelerate vanadium processing capability. New South Wales is host to nascent processing hubs, with the **Critical Minerals Hub** and the **Parkes Special Activation Precinct** strategically placed in proximity to several critical minerals projects.

### Refining, materials and cell manufacturing facilities map includes Planned and Operating Sites



Map courtesy of FBICRC, April 2022

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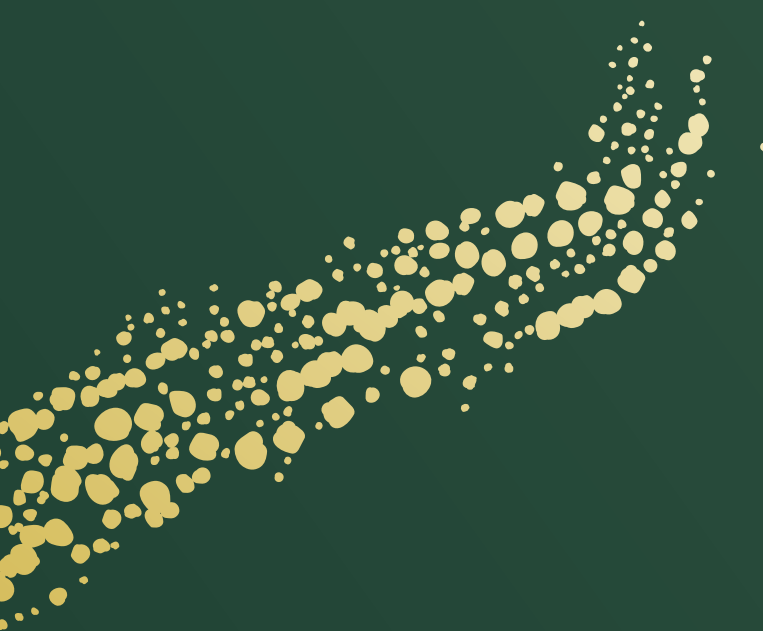
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The prospectus is not exhaustive. Austrade is able to facilitate introductions to other projects according to your specific needs. For further information, please contact your local Austrade representative or email [criticalminerals@austrade.gov.au](mailto:criticalminerals@austrade.gov.au)

## Broken Hill Cobalt

Cobalt Blue Holdings Ltd

ASX-listed (COB) • [www.cobaltblueholdings.com](http://www.cobaltblueholdings.com)



*Cobalt Blue is looking for project partners, with a formal process being managed by our corporate advisors Cutfield Freeman (London). Opportunities for equity and offtake partners exist. Advanced discussions are expected to continue in 2023 following final operations of the Demonstration Plant and as the Definitive Feasibility Study nears completion.*

The Broken Hill Cobalt Project includes the development of an open cut mining operation, ore processing to produce an intermediate mixed cobalt-nickel hydroxide and elemental sulphur, and a refinery to produce high purity cobalt sulphate (feedstock for battery cathode precursor production). It is expected that the life span of the mine and processing operations will be at least 20 years. A pilot plant was commissioned in March 2021, and a larger scale demonstration plant commenced operations in Q2 2022. In 2022 the Federal Government granted Major Project Status to the Broken Hill Cobalt Project, recognising its strategic importance. Cobalt Blue was awarded a \$15m grant through the Critical Minerals Accelerator Initiative to accelerate the development of the project by expanding the scope of Feasibility Studies, bringing forward infrastructure and services work packages, and decreasing start-up commissioning risks. Cobalt Blue has confirmed that the cobalt is locked inside the pyrite mineral, and subsequently developed and patented a metallurgical process that liberates cobalt at low pressure and low temperature with the following characteristics: high cobalt recoveries; no sulphur dioxide emissions; produces high quality cobalt sulphate and high purity elemental sulphur; and relatively low capital and operational costs compared to other processing methods. The company's ESG credentials are being assessed in accordance with the Cobalt Institute's Responsible Assessment Framework.

### Mineral inventory

Commodity(ies):	Cobalt (Sulphur, Iron)				
<b>Mineral Resources as at September 21 at a 275 ppm CoEq cut-off</b>	Resource Category	Tonnes (Mt)	Co (ppm)	S (%)	CoEq (ppm)
	Measured	18	1,030	10.9	1,276
	Indicated	59	631	6.9	788
	Inferred	41	619	7.2	781
	<b>Total</b>	<b>118</b>	<b>687</b>	<b>7.6</b>	<b>859</b>
	<b>Contained (kt)</b>	<b>81.1</b>			
<b>Ore Reserves as at July 20</b>	Reserve Category	Tonnes (Mt)	Co (ppm)	S (%)	
	Probable	71.8	710	7.6	
	<b>Total</b>	<b>71.8</b>	<b>710</b>	<b>7.6</b>	
	<b>Contained (kt)</b>	<b>51</b>			



#### Project Status

Pre-Feasibility Study



#### Post-tax IRR:

18.9%



#### Product & Annual Production Rate

- **Cobalt Sulphate sulphate heptahydrate:** ~16,700 tpa Co metal in sulphate: ~3,500 tpa
- **Sulphur:** ~300,000 tpa



#### Offtake Available

Yes

#### Capital Cost:

A\$560m



#### Min Mine Life (Yrs)

20

#### Post-tax NPV<sub>7.5%</sub>:

A\$554m



## Kalgoorlie Nickel Project Goongarrie Hub

Ardea Resources Ltd (ARL)

ASX-listed (ARL) • [www.ardearesources.com.au](http://www.ardearesources.com.au)



In 2018, ARL completed a pre-feasibility study (PFS) and an Expansion Study at a scale of 2.25Mtpa ore mined and processed to produce 10,000tpa battery grade Cobalt Sulphate and 81,000tpa battery grade Nickel Sulphate from its Goongarrie Hub Project. These studies confirmed the project's status as one of the world's largest, lowest cost sustainable and ethical sources of battery materials from the premier operating jurisdiction of Kalgoorlie, Western Australia. The flow sheet has since been enhanced and the Project scale increased to 3.5Mtpa with an updated PFS currently underway and due for completion in Q1, 2023. ARL is currently undertaking a Strategic Partner process to identify a development partner wanting to secure sustainable and ethical mineral supply with 100% offtake available.

The Goongarrie Hub is the developed world's premier nickel-cobalt-scandium project with world-class supporting infrastructure in the well-established and community supportive Kalgoorlie mining district. Conventional open-pit mine with low strip ratio and in excess of 25 year mine life (2.25Mtpa Expansion Study case) feeding high quality goethite dominated cobalt-nickel ore into a fifth generation High Pressure Acid Leach (HPAL) hydrometallurgical process plant. The Project will initially produce Mixed Hydroxide Precipitate and following attainment of steady production, may produce Precursor Cathode-Active Material. Goongarrie is part of ARL's larger Kalgoorlie Nickel Project (KNP), which is the largest nickel-cobalt project in the developed world (830Mt at 0.71% Ni and 0.046% Co containing 5.9mt Ni and 384kt Co). The KNP provides optionality to develop multiple processing hubs and substantially expand Goongarrie production.

### Mineral inventory

Commodity(ies):	Nickel, Cobalt, Scandium, Rare Earth Elements			
<b>Mineral Resources as at 16 June 21 (0.8% Ni cut-off)</b>	<b>Resource Category</b>	<b>Tonnes (Mt)</b>	<b>Co (%)</b>	<b>Ni (%)</b>
	Measured	11.0	0.106	1.13
	Indicated	56.5	0.066	0.98
	Inferred	10.8	0.051	0.95
	<b>Total</b>	<b>78.3</b>	<b>0.069</b>	<b>1.00</b>
	<b>Contained (kt)</b>		<b>54.3</b>	<b>784</b>
<b>Ore Reserves as at 28 March 18 (to be updated as part of the Q1, 2023 PFS)</b>	<b>Reserve Category</b>	<b>Tonnes (Mt)</b>	<b>Co (%)</b>	<b>Ni (%)</b>
	Proved	9.0	0.10	0.96
	Probable	31.2	0.09	0.78
	<b>Total</b>	<b>40.1</b>	<b>0.09</b>	<b>0.82</b>
	<b>Contained (kt)</b>		<b>36</b>	<b>329</b>



**Project Status**

Pre-Feasibility Study (2018)



**Post-tax IRR:**

27%



**Product & Annual Production Rate**

- **Cobalt Sulphate:** (battery grade, high purity): 10,000 tpa
- **Nickel Sulphate :** (battery grade, high purity): 81,000 tpa



**Offtake Available**

Yes

**Capital Cost:**

US\$918m



**Min Mine Life (Yrs)**

25

**Post-tax NPV<sub>8%</sub>:**

US\$1.805b

## Kalkaroo

Havilah Resources Limited

ASX-listed (HAV) • www.havilah-resources.com.au



Kalkaroo is one of the largest undeveloped open pit copper-gold deposits in Australia on a CuEq Ore Reserve basis, containing approximately 1.1 million tonnes of copper, 3.1 million ounces of gold and 23 thousand tonnes of cobalt in JORC resources (see table below). The project is expected to produce material by-product quantities of the REE and cobalt critical minerals.

In July 2022, Havilah entered into agreements that provide OZ Minerals Limited with an 18 month option period to complete a study program leading to an updated Pre-Feasibility Study for the Kalkaroo project. During the option period OZ Minerals will also fund a regional exploration drilling program with the objective of discovering new copper deposits that could potentially enhance the development prospects for Kalkaroo. The Kalkaroo project is favoured by its proximity to the regional mining centre of Broken Hill with its skilled workforce and the main east-west railway line and highway. It is an area that is endowed with abundant solar and wind energy opportunities and substantial saline groundwater resources. Mining is likely to be by conventional open pit methods. The ore is amenable to standard flotation that produces a high grade, low impurity copper concentrate and also a cobalt-rich pyrite concentrate. Production of a bastnasite concentrate, high in the more valuable REE's (Nd, Pr, Tb, Yb), is also under study.

### Mineral inventory

Commodity(ies):	Cobalt, Copper, Gold, Rare Earth Elements, Molybdenum					
<b>JORC Mineral Resources 31 July 22 (0.4% CuEq cut-off)</b>  <i>Havilah's total cobalt metal inventory stands at 43.4 Kt, including the nearby 100% owned Mutooroo copper-cobalt-gold project (12.53 Mt of 1.53% Cu, 0.16% Co and 0.20 g/t Au in sulphide JORC resources).</i>	<b>Resource Category</b>	<b>Tonnes (Mt)</b>	<b>Cobalt (%)</b>	<b>Copper (%)</b>	<b>Gold (g/t)</b>	
	<b>Cobalt (note: Cobalt resource is not added to the total tonnage)</b>					
	Inferred	193.3	0.012			
	<b>Total</b>	<b>193.3</b>	<b>0.012</b>			
	<b>Copper-Gold (Oxide Gold Cap + Sulphide Copper-Gold)</b>					
	Measured	97.6		0.50	0.47	
	Indicated	34.9		0.39	0.41	
	Inferred	113.0		0.42	0.33	
	<b>Total</b>	<b>245.5</b>		<b>0.45</b>	<b>0.40</b>	
	<b>Contained (Kt Co and Cu, K Oz Au)</b>			<b>23.2</b>	<b>1,097</b>	<b>3,105</b>
<b>JORC Ore Reserves 31 July 22</b>	<b>Reserve Category</b>	<b>Tonnes (Mt)</b>	<b>Copper (%)</b>	<b>Gold (g/t)</b>		
	Proved	90.2	0.48	0.44		
	Probable	9.9	0.45	0.39		
	<b>Total</b>	<b>100.1</b>	<b>0.47</b>	<b>0.44</b>		
	<b>Contained (Kt Cu, K Oz Au)</b>		<b>474</b>	<b>1,407</b>		



#### Project Status

Pre-Feasibility Study (2019)  
Note: PFS will be updated by OZ Minerals study program



**Pre-tax IRR:**  
26%



#### Product & Annual Production Rate

- **Copper (metal and in concentrate):** 30,000 tpa
- **Gold (metal and in concentrate):** 72,000 tpa
- **Cobalt (in pyrite concentrates):** ~500 tpa
- **REE (in bastnasite concentrate):** under study



#### Offtake Available

Dependent on whether OZ Minerals exercises the option to purchase the project

#### Capital Cost:

Pre-production  
A\$332M

**Pre-tax NPV<sub>7.5%</sub>:**  
A\$564m



#### Min Mine Life (Yrs)

15+



## Mt Thirsty

Greenstone Resources Ltd (50%), Conico Ltd (50%)  
ASX-listed (GSR, CNJ) JV -50/50  
www.greenstoneresources.com.au; www.conico.com.au



The Mt Thirsty Joint Venture (50% Greenstone Resources, 50% Conico Limited) is currently assessing options to simplify the ownership structure to support the next development phase of project development, including a standalone initial public offering on the Australian Securities Exchange (“ASX”). The principal objective of which is to advance the Project to a final construction decision, and includes the opportunity for strategic cornerstone shareholder to join the register. Please refer to ASX:GSR 22/03/2022 announcement for a more detailed project update and sensitivities.

The Mt Thirsty Cobalt-Nickel Project is an advanced, high-grade, low capital expenditure, sustainable source of cobalt and nickel located in the mining friendly jurisdiction of Western Australia. Mining will be by conventional open-pit over a 12-year initial mine life. Extensive test work has demonstrated that the metal can be leached at atmospheric pressure using sulphur dioxide as the main reagent, which is a key competitive advantage to higher capital expenditure, high-pressure acid leaching projects. An onsite processing plant will produce an intermediary mixed sulphide product (MSP), which will be dried, loaded into bulka bags and trucked in shipping containers to Australian end users or exported via one of several container ports in Western Australia. The Joint Venture is currently also assessing the option of producing sulphate or precursor cathode active material (P-CAM) products on site.

### Mineral inventory

Commodity(ies):	Cobalt, Nickel				
<b>Mineral Resources (as at 30 June 20)</b>	DryTonnes (Mt)	Co (%)	Ni (%)	Mn (ppm)	
	Indicated (main)	22.8	0.121	0.53	0.79
	Inferred (main)	2.5	0.103	0.45	0.66
	Inferred (north)	1.5	0.092	0.55	0.48
	<b>Total</b>	<b>26.9</b>	<b>0.117</b>	<b>0.52</b>	<b>0.76</b>
	<b>Contained (kt)</b>		<b>31.5</b>	<b>140</b>	<b>204</b>
<b>Ore Reserves (as at 30 June 20)</b>	DryTonnes (Mt)	Co (%)	Ni (%)	Mn (ppm)	
	Probable	18.8	0.126	0.54	0.80
	<b>Total</b>	<b>18.8</b>	<b>0.126</b>	<b>0.54</b>	<b>0.80</b>
	<b>Contained (kt)</b>		<b>23.7</b>	<b>102</b>	<b>150</b>



#### Project Status

Pre-Feasibility Study  
Study completed  
March 2020



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

12



#### Post-tax IRR:

Not available

#### Capital Cost:

A\$371m

#### Post-tax NPV<sub>8%</sub>:

A\$44m



#### Product & Annual Production Rate

##### Mixed sulphide product (MSP)

- Contained cobalt: 1.6 ktpa
- Contained nickel: 2.1 ktpa

## NiWest

GME Resources Ltd

ASX-listed (GME) • [www.gmeresources.com.au](http://www.gmeresources.com.au)



GME is looking for project partners, with a formal process underway being managed by its corporate advisors. Opportunities for new equity and/or offtake partners exist. Advanced discussions are expected in 2023, as the Definitive Feasibility Study (DFS) underway nears completion and offtake samples are produced through the completion of further metallurgical testwork during the DFS.

The NiWest Project is located adjacent to Glencore's Murrin Murrin Nickel operations in the North Eastern Goldfields of Western Australia. The project is situated in a semi-arid region that is well serviced with existing infrastructure including rail, established mining towns, arterial bitumen roads and communications. The Project will be a low strip ratio (2.0:1) shallow conventional open pit mining operation, with approximately 2.4Mtpa ROM ore mined at average head grades of 1.05% Ni and 0.07% Co for the first 15 years. There is an opportunity to extend high-grade profile through potential conversion of Inferred Resources. ROM ore will be heap leached on an on/off heap leach pad with sulphuric acid used to leach the nickel and cobalt from the ore. Pregnant Leach Solution (PLS) will be recovered from leaching and neutralised prior to recovery of nickel and cobalt via highly efficient Direct Solvent Extraction (DSX) and crystallization to produce high purity (+99.95%) nickel and cobalt sulphate products for the battery market. Process recoveries of 79% for nickel and 85% for cobalt are expected. The Project has a construction period of around 18 months from Final Investment Decision (FID).

### Mineral inventory

Commodity(ies):	Nickel, Cobalt				
<b>Mineral Resources as at 2018 (0.8% Ni cut-off)</b>		<b>Tonnes</b>	<b>Ni</b>	<b>Co</b>	
	<b>Resource Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>	
	Measured	15.2	1.08	0.064	
	Indicated	50.4	1.04	0.078	
	Inferred	19.5	0.96	0.057	
	<b>Total</b>	<b>85.2</b>	<b>1.03</b>	<b>0.065</b>	
	<b>Contained (kt)</b>		<b>878</b>	<b>55</b>	
<b>Ore Reserves as at 2018 (0.5% Ni cut-off)</b>		<b>Orebody</b>	<b>Tonnes</b>	<b>Ni</b>	<b>Co</b>
	<b>Reserve Category</b>		<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>
	Probable	Eucalyptus	32.2	0.87	0.05
	Probable	Hepi	4.7	0.91	0.06
	Probable	Mt Kilkenny	27.9	0.96	0.06
	<b>Total</b>	<b>Total</b>	<b>64.9</b>	<b>0.91</b>	<b>0.06</b>
	<b>Contained (kt)</b>		<b>592</b>	<b>38</b>	



#### Project Status

Pre-Feasibility Study (completed July 2022)



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

20 years mining  
27 years processing



#### Post-tax IRR:

19.9%<sup>1</sup>

#### Capital Cost:

A\$1,261<sup>1</sup>

#### Post-tax NPV<sub>8%</sub>:

A\$1,587 (ungeared, real)<sup>1</sup>

1. Economics as per 21 July 2022 Updated PFS Outcomes announcement – mid case.



#### Product & Annual Production Rate

- Nickel sulphate (hexahydrate 99.95% purity) and Cobalt sulphate (heptahydrate >99.9% purity): approx. 90 ktpa
- Contained Nickel (ave): 20 ktpa
- Contained Cobalt (ave): 1.4 ktpa



## Rover 1

Castile Resources Ltd

ASX-listed (CST) • [www.castile.com.au](http://www.castile.com.au)



Castile is developing the Rover 1 Project in the historically prolific gold copper mining province of Tennant Creek in the Northern Territory of Australia. Rover 1 is a polymetallic, high grade Iron Oxide Copper Gold (IOCG) underground deposit that will produce a gold doré, pure copper metal, pure cobalt metal and a high grade industrial mineral magnetite. The processing plant will produce end-user products available for direct sale to EV manufacturers (pure copper) and battery manufacturers (pure cobalt). The gold doré and the magnetite provide further diversity to the suite of metals produced giving Castile four different revenue streams. Castile is seeking a combination of debt, equity and metal stream providers to finance the development of the project.

The proposed underground mining technique for the Rover 1 project is long-hole open stoping with the ore trucked to surface then crushed and ground. The magnetite product will be separated and the sulphides floated and oxidised with the solids treated using conventional Carbon-in-leach. The liquor will be passed first through copper Solvent Extraction and Electrowinning (SXEW) then cobalt SXEW processes. All downstream processing operations will be carried out onsite in accordance with the Castile strategy of extracting “every dollar of value from every tonne that we mine”. The Rover 1 deposit remains open at depth and there are similar orebodies nearby owned on a 100% basis by Castile.

### Mineral inventory

Commodity(ies):	Gold, Copper, Cobalt, Magnetite					
<b>Mineral Resources as at 16 September 22 (2g/t AuEq Cut-off)</b>	Tonnes (Mt)	Gold g/t	Copper (%)	Cobalt (%)	Magnetite (%)	
	Indicated	3.97	1.83	1.59	0.07	23.6
	Inferred	1.61	1.57	1.25	0.07	22.1
	<b>Total</b>	<b>5.58</b>	<b>1.76</b>	<b>1.49</b>	<b>0.07</b>	<b>23.2</b>
	<b>Contained (koz/kt)</b>		<b>315.2koz</b>	<b>83.2kt</b>	<b>4.0kt</b>	<b>1295kt</b>
<b>Ore Reserves as at November 22</b>	Tonnes (Mt)	Gold g/t	Copper (%)	Cobalt (%)	Magnetite (%)	
	Probable	3.11	2.02	1.52	0.07	22.92
	<b>Total</b>	<b>3.11</b>	<b>2.02</b>	<b>1.52</b>	<b>0.07</b>	<b>22.92</b>
	<b>Contained (koz/kt)</b>		<b>201.8koz</b>	<b>47.4kt</b>	<b>2.2 kt</b>	<b>713.3kt</b>



#### Project Status

Pre-Feasibility Study Completed November 2022



#### Offtake Available

Offtake Available in 2025



#### Min Mine Life (Yrs)

8



#### Pre-tax IRR:

45.7%

#### Post-tax IRR:

34.5%

#### Pre-Production Capital Cost:

\$280.2m

#### Pre-tax NPV<sub>6.5%</sub>:

\$451.7m

#### Post-tax NPV<sub>6.5%</sub>:

\$302.6m



#### Product & Annual Production Rate

- **NCu Metal (99%):** 6.9 ktpa
- **Au Doré:** 28.7 ktpa
- **Co Metal (99%):** 0.3 ktpa
- **Fe<sub>3</sub>O<sub>4</sub> (96.5% magnetite):** 75.3 ktpa

## Sconi

Australian Mines Limited

ASX-listed (AUZ) • [www.sconi.com.au](http://www.sconi.com.au); [www.australianmines.com.au](http://www.australianmines.com.au)



In August 2021, Australian Mines Ltd signed a binding offtake agreement for its 100% owned Sconi Project with LG Energy Solution (LGES), a subsidiary of LG Chem, the world's largest producer of advanced batteries for electric vehicles. The Sconi Project offtake agreement details the supply 71,000 dry metric tonnes of nickel and 7,000 dry metric tonnes of cobalt over the initial 6 years of production to LGES. The company has extended the offtake agreement to 31 December 2022 and is now progressing project financing (including both debt and equity capital) for the Sconi Project.

The Sconi Nickel-Cobalt-Scandium project is a world class, Tier 1, lowest cost quartile and ethical source of battery minerals, as well as high purity scandium oxide. The existing Sconi ore reserves are forecast to support an open pit mine life in excess of 30 years, with further mineral exploration potential within the project tenements. According to an independent study by CRU International, Sconi is expected to be one of the lowest cost, cobalt-producing nickel projects in the world. The project will include a high pressure acid leach processing plant producing mixed nickel-cobalt hydroxide precipitate (MHP). The Sconi MHP flowsheet is a proven process used at various MHP operations globally. Australian Mines is the only mineral resources company certified Carbon Neutral under the Australian Government's Climate Active program and the Sconi Project will follow the internationally recognised ISO 14001 Standard for an effective Environmental Management System.

### Mineral inventory

Commodity(ies):	Nickel, Cobalt, Scandium				
<b>Mineral Resources as at 30 September 2021 (0.40-0.55% NiEq cut-off)</b>	Resource Category	Tonnes (Mt)	Nickel (%)	Cobalt (%)	
	Measured	8.3	0.75	0.09	
	Indicated	49.2	0.60	0.08	
	Inferred	18.2	0.54	0.05	
	<b>Total</b>	<b>75.7</b>	<b>0.60</b>	<b>0.08</b>	
	<b>Contained (kt)</b>		<b>456</b>	<b>57</b>	
<b>Ore Reserves as at 30 September 2021 (0.45% NiEq cut-off)</b>	Reserve Category	Tonnes (Mt)	Nickel (%)	Cobalt (%)	Scandium (ppm)
	Proved	8.1	0.72	0.09	44
	Probable	49.2	0.55	0.08	33
	<b>Total</b>	<b>57.3</b>	<b>0.58</b>	<b>0.08</b>	<b>35</b>
	<b>Contained (kt)</b>		<b>332</b>	<b>46</b>	<b>2</b>



#### Project Status

Pre-Construction



#### Post-tax IRR:

15%\*



#### Product & Annual Production Rate

- **Mixed nickel-cobalt hydroxide precipitate (MHP)**, containing:
    - Nickel:** 11,833 tpa metal<sup>1</sup>
    - Cobalt:** 1,167 tpa metal<sup>1</sup>
  - **Scandium oxide:** 48 tpa (separate product)<sup>1</sup>
1. Yrs 1-6; LGES Offtake Agreement



#### Offtake Available

Yes – Nickel-Cobalt MHP offtake committed to LG Energy Solution for first 6 years

#### Capital Cost:

US\$974m\*



#### Min Mine Life (Yrs)

>30

#### Post-tax NPV<sub>8%</sub>:

A\$817m\*

\*Based on updated 2019 BFS



## Sunrise Battery Materials Complex

Sunrise Energy Metals Ltd

ASX-listed (ASX:SRL) • www.sunriseem.com



Sunrise Energy Metals completed the Project Execution Plan (PEP) for the Sunrise Battery Materials Complex (the Project) in late 2020. The PEP confirmed the Project's status as one of the world's largest, lowest cost, development-ready sources of critical battery materials. The Company is targeting at least 50% of Sunrise's construction capital to be provided under a non-recourse project debt facility. Mandated Lead Arrangers have been appointed for the debt funding. The Company is in discussions for both investment and long-term offtake.

The Sunrise Battery Materials Complex will be a fully integrated supplier of high-purity battery-grade nickel and cobalt sulphate for the electric vehicle (EV) supply chain, as well as one of the world's largest producers of scandium oxide. The Project consists of a shallow open-cut mine, a hydrometallurgical processing plant to leach and separate metal and a refinery. Ore reserves will support up to 50 years of operation. Work is currently underway to assess cathode precursor production on-site, as well as construction of a battery recycling circuit to process black mass. With over A\$250 million invested to date, the Project is development-ready, with all key permits secured, lowest quartile operating costs and industry-leading emissions performance. A recently completed Renewable Energy Supply study confirms the Sunrise Project's external power needs can be fully supplied by renewable power sources.

### Mineral inventory

Commodity(ies):	Nickel, Cobalt, Scandium, PGMs				
<b>Mineral Resources as at 30 September 20</b>		<b>Tonnes</b>	<b>Ni</b>	<b>Co</b>	<b>Sc</b>
	<b>Resource Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>	<b>(ppm)</b>
	Measured	69	0.65	0.11	61
	Indicated	89	0.49	0.09	79
	Inferred	17	0.26	0.10	289
	<b>Total</b>	<b>177</b>			
	<b>Contained (kt)</b>		<b>935</b>	<b>168</b>	<b>16</b>
	(@ 0.35% nickel-equivalent cut-off)				
<b>Ore Reserves as at 30 September 20</b>		<b>Tonnes</b>	<b>Ni</b>	<b>Co</b>	<b>Sc</b>
	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>	<b>(ppm)</b>
	Proved	65.4	0.67	0.11	55
	Probable	77.9	0.52	0.09	41
	<b>Total</b>	<b>143.2</b>	<b>0.59</b>	<b>0.10</b>	<b>47</b>
		<b>Contained (kt)</b>		<b>845</b>	<b>143</b>



**Project Status**  
Pre-Construction



**Post-tax IRR:**  
15.4%



**Product & Annual Production Rate**

- **Nickel:** 21,293 tpa metal in sulphate
- **Cobalt:** 4,366 tpa metal in sulphate
- **Scandia:** 80 tpa (expandable)
- **Ammonium Sulphate:** 82,000 tpa



**Offtake Available**  
Yes

**Capital Cost:**  
US\$1.8b



**Min Mine Life (Yrs)**  
50

**Post-tax NPV<sub>8%</sub>:**  
US\$1.21b

# Wingellina Nickel-Cobalt Project

Nico Resources Ltd

ASX-Listed: NC1 • [www.nicoresources.com.au](http://www.nicoresources.com.au)








*Wingellina is a development-ready, long life nickel-cobalt-scandium project, with a demonstrated ability to produce nickel & cobalt sulphates, sulphides and hydroxides. Since acquiring Wingellina in 2022, NiCo has been actively advancing the project by commissioning an updated Pre-Feasibility Study and commencing a 10,000m RC drilling program targeting high-grade reserve definition which will provide inputs to a new Bankable Feasibility Study commencing in 2023. Wingellina offers several development options with the company welcoming discussions with strategic investors and offtake partners alike.*

The world-class Wingellina Nickel-Cobalt Project is the largest single asset undeveloped nickel-cobalt project in Australia and is part of NiCo Resources Central Musgrave Project (CMP) which straddles the WA, SA and NT borders. Wingellina nickel-cobalt ore will be mined by low cost, free dig open pit mining with a low strip ratio of (LOM average of 1:1). Wingellina is one of the largest nickeliferous ‘pure oxide’ limonite accumulations in the world. The mineralogy of the Wingellina ore is a major strength of the project as, unlike most Australian nickel laterite projects, has characteristics perfectly suited to High Pressure Acid Leaching (HPAL) with high iron and low magnesium grades. The Wingellina project is shovel ready with E.P.A approval granted in 2016 as well as a native title agreement for mining and access. Discussions are underway with government and infrastructure partners regarding the upgrade of existing infrastructure corridors to service the project including power and existing roads.

## Mineral inventory

Commodity(ies):	Nickel, Cobalt				
<b>Wingellina Mineral Resources as at 30 June 16</b>	Resource Category	Tonnes (Mt)	Ni (%)	Co (%)	Fe <sub>2</sub> O <sub>3</sub> (%)
	Measured	37.6	0.98	0.07	45.94
	Indicated	130.9	0.91	0.07	45.55
	Inferred	14.1	0.87	0.06	41.25
	<b>Total</b>	<b>182.6</b>	<b>0.92</b>	<b>0.07</b>	<b>45.30</b>
	<b>Contained (kt)</b>		<b>1,684</b>	<b>132</b>	
<i>The Wingellina mineral resource is part of the larger CMP which has a mineral resource inventory containing approximately 2 million tonnes of nickel and 154,000 tonnes of cobalt.</i>					
<b>Wingellina Ore Reserves as at 2016</b>	Reserve Category	Tonnes (Mt)	Ni (%)	Co (%)	
	Probable	168.4	0.93	0.07	
	<b>Total</b>	<b>168.4</b>	<b>0.93</b>	<b>0.07</b>	
	<b>Contained (kt)</b>		<b>1,561</b>	<b>122.6</b>	

 <p><b>Project Status</b> Feasibility Study completed in 2012 (+/- 25%)</p>	 <p><b>Post-tax IRR:</b> 17.3%</p>	 <p><b>Product &amp; Annual Production Rate</b></p> <ul style="list-style-type: none"> <li>• <b>Nickel:</b> ~40,000 tpa metal</li> <li>• <b>Cobalt:</b> ~3,000 tpa metal as mixed Hydroxides or Ni and Co sulphates.</li> </ul>
 <p><b>Offtake Available</b> Yes</p>	<p><b>Capital Cost:</b> A\$2.4b</p>	
 <p><b>Min Mine Life (Yrs)</b> 39+</p>	<p><b>Post-tax NPV<sub>8%</sub>:</b> A\$3.1b</p>	



# C

## Graphite

### Munglinup

Mineral Commodities Ltd

ASX-listed (MRC), JV – MRC (51%) & Gold Terrace Pty Ltd (49%)

www.mineralcommodities.com



*Mineral Commodities Ltd (ASX: MRC) is a global mining and development company focused on the development of high-grade mineral deposits within the industrial and critical minerals sectors. The Company owns and operates the Skaland Graphite Operation in Norway, the world's highest-grade flake graphite operation and the largest producer in Europe. Minerals Commodities welcomes discussion regarding financing or offtake and seeks a strategic partner for project equity, joint venture, or offtake arrangements in both the concentrate and downstream businesses.*

The Munglinup Graphite Project is free-dig, open pit mining of high-grade graphite mineralisation, located within a granted Mining Lease in WA. ROM ore is processed through a relatively conventional, multi-stage milling and flotation process to produce high-grade graphite concentrates across a range of flake sizes. The resource is open at depth and along strike. The recent EM survey identified 12 new targets and 3,000m resource drilling planned for 2023 to update resource and reserve. The environmental permits are the only remaining approvals required before commissioning and it is anticipated that the EPA approvals for the project will be completed in early 2023. MRC is working with partners, including CSIRO and Doral Fused Materials, and has completed a Cooperative Research Centres Project (CRC-P) to develop a non-hydrofluoric acid purification process to produce high purity value-added products from Munglinup concentrate, targeting production of battery anode materials. The project achieved battery grades (99.95% purity) for spherical graphite with typical recoveries to product of 90%. Pilot plant operations and optimised integrated ore-anode DFS planned.

#### Mineral inventory

Commodity(ies):	Graphite		
<b>Mineral Resources as at 8 January 20 (5% TGC cut-Off):</b>		<b>Tonnes</b>	<b>TGC</b>
		<b>(Mt)</b>	<b>(%)</b>
	Measured	–	–
	Indicated	4.5	13.1
	Inferred	3.5	11
	<b>Total</b>	<b>8.0</b>	<b>12.2</b>
	<b>Contained (kt)</b>		<b>975</b>
<b>Ore Reserves as at 8 January 20:</b>		<b>Tonnes</b>	<b>TGC</b>
		<b>(Mt)</b>	<b>(%)</b>
	Proved	–	–
	Probable	4.2	12.8
	<b>Total</b>		
	<b>Contained (kt)</b>		<b>543</b>



#### Project Status

Feasibility Study



#### Post-tax IRR:

30%



#### Product & Annual Production Rate

• **Flake graphite concentrate:**  
(>95% TGC): 52 ktpa



#### Offtake Available

Yes

#### Capital Cost:

US\$61m



#### Min Mine Life (Yrs)

14

#### Post-tax NPV<sub>7%</sub>:

US\$111m

## Siviour Battery Anode Material Project

Renascor Resources Ltd

ASX-listed (RNU) • [www.renascor.com.au](http://www.renascor.com.au)



Renascor aims to become one of the world's largest producers of Purified Spherical Graphite for use in lithium-ion batteries through its Siviour Battery Anode Material Project in South Australia. Renascor is currently updating its 2019 DFS for the Siviour Graphite Mine and a 2020 integrated study for its Battery Anode Material Operation that confirms the project's status as one of the world's largest, lowest cost and development-ready sources of battery anode material. The revised study is considering expanded production of Purified Spherical Graphite following Renascor having secured non-binding commitments for up to 200% of the previously announced stage one production capacity. The Siviour Project has received conditional approval received for a A\$185m Loan Facility from Export Finance Australia via the Federal Governments' A\$2 billion Critical Minerals facility. The Siviour Project has also been granted Major Project Status by the Federal Government. Renascor is considering both additional offtake and investment in the project.

Renascor's Siviour Project will produce 100% Australian-made Purified Spherical Graphite through a vertically integrated operation that will combine:

- The Siviour Graphite Mine – the world's second largest Proven Reserve of Graphite and the largest Graphite Reserve outside of Africa which will produce graphite concentrate via a conventional flotation process from a low cost, low strip ratio open pit mine on the Eyre Peninsula and
- a Purified Spherical Graphite Manufacturing Facility – where Graphite concentrate will be converted to Purified Spherical Graphite using an eco-friendly processing method before being exported to lithium-ion battery anode manufacturers.

South Australia's Minister for Energy and Mining granted a Mineral Lease for Siviour in April 2019, the first step in the South Australian government's two-stage assessment and approval process. The second-stage approval was submitted in September 2021.

### Mineral inventory

Commodity(ies):	Graphite, Purified Spherical Graphite					
Mineral Resources as at August 22 (2.3% TGC cut-off)	<b>Resource Category</b>	<b>Tonnes (Mt)</b>	<b>TGC (%)</b>	<b>Reserve Category</b>	<b>Tonnes (Mt)</b>	<b>TGC (%)</b>
	Measured	16.8	8.6%	Proven	15.8	8.4
	Indicated	46.0	7.1%	Probable	35.8	6.9
	Inferred	30.7	7.0%	<b>Total</b>	<b>51.5</b>	<b>7.4</b>
Ore Reserves as at July 22	<b>Total</b>	<b>93.5</b>	<b>7.3%</b>	<b>Contained (kt)</b>	<b>3,800</b>	
	<b>Contained (kt)</b>	<b>6,860</b>				



**Project Status**  
Feasibility Study



**Post-tax IRR:**  
33%



**Product & Annual Production Rate**

- **Graphite Concentrate (94 to 96% TGC):** Stage 1 – 80 ktpa, Stage 2 – 115 ktpa
- **Battery Anode Material facility Purified Spherical Graphite (Stage 1):** 28 ktpa



**Offtake Available**  
Yes

**Capital Cost:**  
A\$204m



**Min Mine Life (Yrs)**  
40

**Post-tax NPV<sub>10%</sub>:**  
A\$713m



## Uley 2 (Stage 1)

Quantum Graphite Ltd

ASX-listed (QGL) • [www.quantumgraphite.com](http://www.quantumgraphite.com)



Quantum Graphite's century old Uley graphite mine is part of the broader Mikkira Deposit located in South Australia's Eyre Peninsula, one of the world's largest natural coarse flake graphite deposits. Uley 2 (Stage 1) is the only coarse graphite project which:

- Is fully permitted and development ready.
- Has decades long history of supplying global manufacturers and historical prequalification of its products.
- Has an exclusive arrangement with Sunlands Co., a leading thermal energy storage technology company, for the manufacture of thermal energy storage media for the Sunlands Co.'s long duration energy storage cells.

In May 2022, QGL signed an offtake agreement with Swiss global metals and minerals trading group MRI Trading AG (MRI) for 100% of the first 5 years Uley 2 production.

Quantum's 2020 Definitive Feasibility Study (DFS) reconfirmed superior returns achievable from production of high purity large to extra-large coarse flake products from the historical Uley mines. The Project will process run-of-mine ore via floatation, proprietary sequential polishing sections and thermal heat treatment. Our proprietary process enhances flake graphite recoveries, maximises coarse flake size and achieves very high purities. The DFS covers flake production operations only (Stage 1) and does not include revenues from the Quantum Sunlands Partnership, the Company's joint venture with Sunlands Co. for the manufacture of energy storage media. Testwork is being concluded by Sunlands Co. to determine the commercial scalability of Sunlands Co.'s natural flake thermal purification technology. This technology represents one of few available technologies that does not require hydrofluoric acid for production of purified flake for battery anode production.

### Mineral inventory

Commodity(ies):	Graphite		
<b>Mineral Resources as at 18 November 21 (at 3.5% graphitic carbon cut-off)</b>		<b>Tonnes</b>	<b>TGC</b>
		<b>(Mt)</b>	<b>(%)</b>
	Measured	0.8	15.6
	Indicated	4.2	10.4
	Inferred	2.2	8.9
	<b>Total</b>	<b>7.2</b>	<b>10.5</b>
	<b>Contained (kt)</b>	<b>757</b>	
<b>Ore Reserves as at December 19</b>		<b>Tonnes</b>	<b>TGC</b>
		<b>(Mt)</b>	<b>(%)</b>
	Proved	0.8	11.66
	Probable	3.2	11.95
	<b>Total</b>	<b>4.0</b>	<b>11.89</b>
		<b>Contained (kt)</b>	<b>476</b>



#### Project Status

Pre-Construction



#### Post-tax IRR:

28.5%



#### Product & Annual Production Rate

Graphite flake (Not thermally purified)  
(Extra Large Flake +300um, 98% Graphitic Carbon, Large Flake, -300+150um, 98% Graphitic Carbon, Medium Flake -150+75um, 96.6% Graphitic Carbon): 60 ktpa



#### Offtake Available

No

#### Capital Cost:

A\$120m



#### Min Mine Life (Yrs)

12 (Uley 2, Stage 1 only)

#### Post-tax NPV<sub>10%</sub>:

A\$362m

# HPA

High Purity  
Alumina

## Great White Kaolin Project

Andromeda Metals Ltd

ASX-Listed (ADN) • [www.andromet.com.au](http://www.andromet.com.au)



As a near-term kaolin producer, Andromeda focuses on progressing its flagship Great White Kaolin Project (GWKP). Andromeda's research and development activities seek to leverage the potential of this world-class kaolin/halloysite resource into additional product lines, including conversion to high-purity alumina (HPA) in future. Andromeda welcomes discussions with offtake partners and investors.

The GWKP, located on South Australia's Eyre Peninsula, will mine and refine kaolinite from a shallow conventional open pit mine, with the pit being progressively backfilled with overburden and rehabilitated as the pit advances. The kaolin will be processed in the onsite wet processing plant incorporating washing, size separation (hydrocyclones) filtering, drying and bagging stages producing a range of kaolin products, including for the ceramics and construction industries. Andromeda is committed to the sustainable extraction and supply of superior quality industrial minerals. Accordingly, the GWKP will be developed and follow strict ESG standards. The planned GWKP has a small footprint, uses conventional open-pit mining techniques, will be progressively rehabilitated, and aims to use local suppliers where possible. Andromeda further benefits from a large portfolio of nearby exploration tenements and is undertaking research and development (R&D) activities. A key focus of these R&D activities is aimed at producing HPA directly from its GWKP kaolin product. Kaolin is an aluminosilicate clay. There is a potential for chemically extracting HPA from the GWKP high-purity kaolin. Andromeda is undertaking research and test work to support its provisional patent application based on its novel process flowsheet to produce HPA from the kaolin feed material.

### Mineral inventory

Commodity(ies):	Kaolinite/Halloysite (aluminosilicate), with HPA to be determined.							
<b>GWKP Mineral Resources as at November 20 – Minus 45 Micron Fraction (75% ISO Brightness cut-off)<sup>1</sup></b>	Resource Category	Tonnes (Mt)	Kaolinite (%)	Halloysite (%)	Brightness (R457)	Al <sub>2</sub> O <sub>3</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)
	Measured	2.9	78.8	13.8	83.9	36.7	0.52	0.32
	Indicated	7.3	82.3	9.9	82.8	36.6	0.51	0.50
	Inferred	7.2	81.7	9.9	83.3	36.4	0.51	0.45
	<b>Total</b>	<b>17.4</b>	<b>81.5</b>	<b>10.5</b>	<b>83.2</b>	<b>36.5</b>	<b>0.51</b>	<b>0.45</b>
	<b>Contained (kt)</b>		<b>14,176</b>	<b>1,836</b>	<b>n/a</b>	<b>6,357</b>	<b>89</b>	<b>78</b>
<b>GWKP Ore Reserves as at April 22 (75% ISO Brightness cut-off)<sup>2</sup></b>	Reserve Category	Tonnes (Mt)	Total Yield (%)	Halloysite (% in -45 µm fraction)	Brightness(R457) (% in -45 µm fraction)			
	Proved	5.2	45	14	84			
	Probable	9.9	45	10	83			
	<b>Total</b>	<b>15.1</b>	<b>46</b>	<b>11</b>	<b>84</b>			
	<b>Contained (kt)</b>		<b>6,795</b>	<b>1,718</b>	<b>n/a</b>			

1. Mineral Resources are reported for minus 45-micron fraction only. The recovery factor from in-situ to the minus 45-micron fraction is approximately 50%. 2. Ore Reserves are reported on an in-situ basis with the estimated process recovery (Yield), and the estimated recovered contained product shown. Halloysite and Brightness values shown are % within the recovered fraction.



#### Project Status

Feasibility Study completed April 2022 (GWKP kaolin production only).



#### Offtake Available

Yes – Projected availability 2023/24



#### Min Mine Life (Yrs)

28



#### Post-tax IRR:

Refer to ASX announcements

#### Capital Cost:

Refer to ASX announcements

#### Post-tax NPV:

Refer to ASX announcements



#### Product & Annual Production Rate

Refer to ASX announcements



# HPA

High Purity  
Alumina

## High Purity Alumina Project

King River Resources Limited

ASX-Listed (KRR) • [www.kingriverresources.com.au](http://www.kingriverresources.com.au)



King River Resources (KRR) is seeking a suitable investment partner to fund the development of its High Purity Alumina (HPA) project in Kwinana. The Pre-Feasibility Study for the HPA Project was completed in June 2021. With limited high quality supply, combined with rising demand for 4N+ HPA, KRR's HPA project is an attractive opportunity for the right development partner to advance Australia's HPA production for the growing LED and Lithium ion battery global markets.

KRR's HPA Project plans to produce HPA by a processing plant using locally produced aluminium chemical feedstock. KRR's ARC HPA process flowsheet uses conventional crystallisation purification and calcination technologies and unit components, and readily sourced reagents. The unique flowsheet has been demonstrated through laboratory scale testwork to produce high recoveries of alumina into a high purity HPA product. KRR is currently working on flowsheet modifications to improve the project economics and environmental, social and governance (ESG) benefits, including reducing water and energy consumption and reagent related wastes. These process changes are still under development.

### Mineral inventory

The High Purity Alumina Project uses an aluminum industrial chemical feedstock so mineral resource and mining operation not required. Details of the aluminum chemical feedstock, reagents used, by product and process conditions and steps are a trade secret and are commercial in confidence.



#### Project Status

Pre-Feasibility Study



#### Pre-tax IRR:

50.8% pre-tax



#### Product & Annual Production Rate

• High purity alumina (HPA) at 99.99%  
(4N) purity: 9,000 tpa



#### Offtake Available

Yes

#### Capital Cost:

A\$203.4 million



#### Min Mine Life (Yrs)

>25 years

#### Pre-tax NPV<sub>10%</sub>:

A\$1,047 million pre-tax

# HPA

High Purity  
Alumina

## HPA First Project (Gladstone)

Alpha HPA Ltd

ASX-Listed (A4N) • [www.alphahpa.com.au](http://www.alphahpa.com.au)



Stage 1 of the HPA First Project located in Gladstone, will enter commercial production in the March quarter 2023, with production of:

- High Purity Alumina powders, and pellets;
- High purity Boehmite (alumina – hydroxide);
- High Purity Aluminium Precursors (Al-Nitrates and Al-Sulphates);

Stage 2 production is planned for early 2025, representing a large scale production centre of the products above. Alpha HPA is actively seeking customers for its best in class quality materials manufactured with its low-carbon production process. The Company will consider strategic Project investment if mutually beneficial.

Alpha HPA's premium products are based on the Company's unique Smart SX purification process, which represents the world's first application of solvent extraction purification technology for aluminium. The process is disruptive at a number of levels, including:

**Low carbon:** By using a common industrial feedstock, recycling all reagents and using 100% renewable energy, Alpha HPA is able to reduce the carbon footprint of high purity alumina production by ~70% when compared to the incumbent production process.

**Low cost:** The front end of our purification process is 100% wet-chemical and operates at atmospheric temperatures and pressures whilst realising a 100% reagent recycle. This allows Alpha HPA to produce its materials at a very disruptive cost base, incentivising its target markets to the adoption of these critical decarbonising materials.

**Flexibility:** By being able to produce a full range of high purity aluminium materials from a single process, Alpha can readily meet end-user product requirements, whilst also representing a single-source 'one-stop-shop' for the full range of high-purity aluminium materials for large, vertically-integrated customers.

### Mineral inventory





<b>Commodity(ies):</b>	High Purity Alumina
------------------------	---------------------

### Feed Stock

Alpha HPA's unique Smart SX purification process can deliver high-purity, low-cost, low-carbon materials by leveraging the existing industrial infrastructure in the Gladstone region:

- **Feedstock:** Common industrial feedstock sourced directly from Rio Tinto's alumina refinery in Yarwun (2.5km away)
- **Reagents:** Sourced directly from Orica Yarwun (adjacent) with binding 10 + 10 year agreements in place
- **By-Products:** Reagents are recycled on a 100% basis and returned to Orica for further processing

Our process can match or exceed best-in-class purity across our entire product range.

 <b>Project Status</b> Stage 1: Construction completed & now commissioning Stage 2: Feasibility Study completed March 2020. Financial Investment Decision expected early 2023	 <b>Post-tax IRR:</b> N/A <b>Capital Cost:</b> Stage 1: A\$50m (fully funded) Stage 2: est \$A400m <b>Post-tax NPV:</b> Stage 2: Annual free-cash flow between A\$130-\$280m	 <b>Product &amp; Annual Production Rate</b> <b>Stage 1</b> <ul style="list-style-type: none"><li>• Al-Nitrates+ Al-Sulphate: +300 tpa</li><li>• High Purity Alumina + Boehmites: 10-15 tpa</li></ul> <b>Stage 2</b> <ul style="list-style-type: none"><li>• Combination of Al-Nitrates, Al-Sulphate, High Purity Alumina and High Purity Boehmites: ~13,000 tpa</li></ul>
 <b>Offtake Available</b> Yes		

# HPA

High Purity  
Alumina

## Malaysian High Purity Alumina Project (Meckering Kaolin)

Altech Chemicals Limited

ASX-Listed (ATC) • [www.altechchemicals.com](http://www.altechchemicals.com)



Stage 1 and stage 2 early works construction of the HPA project in Malaysia has been completed. The site is currently on care and maintenance pending finalisation of financial close. Altech has secured a US\$190m senior loan facility from German government-owned KfW IPEX-Bank. To reach financial close, the company is currently pursuing secondary project finance initiatives – a US\$144m green bond offer and US\$100m project level equity funding. Altech has an exclusive arrangement with Mitsubishi Corporation of Japan, which will distribute 100% of the Company's final product. The company welcomes discussion regarding project loan finance, equity investment at either company or project levels to progress the development of the project.

Altech is aiming to become one of the world's leading suppliers of 99.99% (4N) high purity alumina ( $Al_2O_3$ ) through the construction and operation of a 4,500tpa high purity alumina (HPA) processing plant at Johor, Malaysia. The feedstock for the plant will be supplied from Altech's open-cut, low striping ratio (0.64:1 LOM average), kaolin mine at Meckering, WA. The deposit contains high-quality primary kaolin that is extremely low in impurities (sodium and iron). Run-of-mine kaolin ore will be trucked in sea containers to Fremantle Port, WA, before being shipped to Malaysia at a rate of ~43,500tpa. The Meckering kaolin deposit has sufficient Ore Reserves to support the proposed HPA processing operation for the initial mine-life of 30 years. The HPA plant in Malaysia will process the Meckering kaolin ore via calcination, acid leach and crystallisation to produce  $AlCl_3$  followed by further roasting, cooling and pelletising to produce 99.99% purity HPA ( $Al_2O_3$ ) beads.

### Mineral inventory

Commodity(ies):	Kaolin (Alumina)		
<b>Mineral Resources – Meckering kaolin (aluminous clay) deposit as at 30 June 22</b>	Resource Category & Deposit	Tonnes (Mt)	$Al_2O_3$ (%)
	Measured	1.5	30.0
	Indicated	3.3	30.0
	Inferred	7.9	29.1
	<b>Total</b>	<b>12.7</b>	<b>29.7</b>
	<b>Contained (kt)</b>		<b>3,739</b>
<b>Ore Reserves – Meckering kaolin (aluminous clay) deposit as at 30 June 22</b>	Reserve Category	Tonnes (Mt)	$Al_2O_3$ (%)
	Proved	0.454	30.1
	Probable	0.770	30.0
	<b>Total</b>	<b>1.224</b>	<b>30.0</b>
	<b>Contained (kt)</b>		<b>367.2</b>



**Project Status**  
Pre-Construction



**Pre-tax IRR:**  
21.9%



**Product & Annual Production Rate**  
• High Purity Alumina ( $Al_2O_3$ ) powder: 99.99% purity (4N): 4,500 tpa



**Offtake Available**  
No

**Capital Cost:**  
US\$298m



**Min Mine Life (Yrs)**  
250

**Pre-tax NPV<sub>7.5%</sub>:**  
US\$505.6m



# HPA

High Purity  
Alumina

## Premium HPA

FYI Resources Ltd / Alcoa

NYSX-listed (AA) / ASX-listed (FYI) OTC (FYIRF)

www.alcoa.com;www.fyiresources.com.au



FYI Resources is an emerging critical minerals producer. Following completion of an updated definitive feasibility study (DFS) in April 2021, FYI signed a Term Sheet with Alcoa of Australia to partner and majority fund the development of the HPA project. FYI and Alcoa have the objective to become a dominant producer of HPA. Under Alcoa's management, the joint development team are working towards project completion to address the production shortfall in traditional supply with the joint ventures low carbon HPA material.

FYI has developed an innovative, low capex / low opex and reduced carbon emission process for the production of ultra-high quality HPA from the joint feedstock supply. Our fully integrated business model, from mine to market, provides full traceability and provenance of the HPA material that the FYI/Alcoa JV will produce – thus guaranteeing quality and exceptional ESG certification to the customer. The FYI HPA process operates at a fraction of current HPA production costs and our production strategy is ideally timed to address the growing high-tech applications such as sapphire glass, LED substrates, ceramic coated separators for use in Lithium-ion batteries, semi-conductors and bio-ceramics. Under a proposed joint venture, partners FYI and Alcoa are progressing a defined 3-stage development pathway to commercialise the HPA project at a production rate of 10,000 tpa. The joint venture three HPA development stages that have been achieved are categorised as: 1. Technology Development; 2. Commercialisation of the project; 3. HPA Market insight and knowledge. The current HPA market is approximately 30,000 tpa of demand and is forecast to increase to over 120,000 tpa in 2028 surpassing US\$6.5b in sales.

### Mineral inventory

Commodity(ies):	High-purity alumina		
<b>Cadoux Kaolin Mineral Resources as at April 22 (20% Al<sub>2</sub>O<sub>3</sub> cut-off grade):</b>	<b>Resource Category</b>	<b>Tonnes (Mt)</b>	<b>Al<sub>2</sub>O<sub>3</sub> (%)</b>
	Measured	0.481	23.56
	Indicated	5.743	23.56
	Inferred	5.046	21.45
	<b>Total</b>	<b>11.269</b>	<b>22.51</b>
	<b>Contained (kt)</b>		<b>2,537</b>
<b>Cadoux Kaolin Ore Reserves as at April 22</b>	<b>Reserve Category</b>	<b>Tonnes (Mt)</b>	<b>Al<sub>2</sub>O<sub>3</sub> (%)</b>
	Proved	0.290	24.9
	Probable	2.914	24.8
	<b>Total</b>	<b>3.205</b>	<b>24.8</b>
	<b>Contained (kt)</b>		<b>795</b>



#### Project Status

Feasibility Study  
(completed in 2021)



#### Post-tax IRR:

55%



#### Product & Annual Production Rate

• Premium quality HPA (>99.995% Al<sub>2</sub>O<sub>3</sub>): 10,000 tpa



#### Offtake Available

NO – currently finalising  
offtake commitments

#### Capital Cost:

US\$203m

#### Post-tax NPV<sub>8%</sub>:

US\$1.014b



#### Min Mine Life (Yrs)

>50 years

## Finniss Lithium Project

Core Lithium

ASX Listed (ASX: CXO) • [www.corelithium.com.au](http://www.corelithium.com.au)



Core is on the cusp of becoming Australia's next lithium producer. Since the first drill hole at the project in 2016, Core has identified a Mineral Resource for a 12+ year mine life producing high-quality 5.5%  $\text{Li}_2\text{O}$  spodumene concentrate, targeting first DSO sales in Q4 CY22 and maiden spodumene concentrate production in H1 CY23. Core has binding offtakes with Ganfeng Lithium and Sichuan Yahua, each for 300kt over four years, and a binding term sheet with Tesla for up to 110kt over four years. Core is well funded to complete construction of the spodumene concentrator. Studies are underway for a Stage 2 expansion as well as lithium hydroxide production.

Finniss is a low capital-intensive, conventional hard-rock mining project that will use simple dense media separation (DMS) to produce up to 197 ktpa of spodumene concentrate in Stage 1. Ore will be mined from the Grants open pit (initially) and BP33 underground mine (subject to final approvals) to deliver crusher feed prior to introduction into primary and secondary DMS lines. Stage 1 construction commenced in October 2021. Mining of lithium ore from Grants commenced in September 2022 ahead of DSO sales in Q4 CY22 and commissioning of the spodumene concentrator in Q1 CY23. Lithium products will be trucked 88km to Darwin Port for export. In parallel, near-mine exploration continues at BP33 and Carlton to further increase the project Mineral Resource and mine life. The BP33 approvals process, for Australia's first underground lithium mine, is on track for first ore in H1 2024.

### Mineral inventory

Commodity(ies):	Lithium		
<b>Mineral Resources as at 30 June 22 (0.50% <math>\text{Li}_2\text{O}</math> cut-off)</b>		<b>Tonnes</b>	<b><math>\text{Li}_2\text{O}</math></b>
	<b>Resource Category</b>	<b>(Mt)</b>	<b>(%)</b>
	Measured	5.60	1.46
	Indicated	7.69	1.35
	Inferred	5.57	1.12
	<b>Total</b>	<b>18.86</b>	<b>1.32</b>
	<b>Contained (kt)</b>		<b>248.2</b>
<b>Ore Reserves as at 30 June 22</b>		<b>Tonnes</b>	<b><math>\text{Li}_2\text{O}</math></b>
	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>
	Proved	5.5	1.4
	Probable	5.1	1.3
	<b>Total</b>	<b>10.6</b>	<b>1.3</b>
		<b>Contained (kt)</b>	



#### Project Status

- Mining of lithium-bearing ore for DSO shipments/stockpiling: **Operating**
- Final stages of construction of spodumene concentration plant: **Construction**



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

12



#### Post-tax IRR:

Not Applicable

#### Capital Cost:

Under construction

#### Post-tax NPV:

Not Applicable



#### Product & Annual Production Rate

- **Stage 1 – Spodumene Concentrate (5.8%  $\text{Li}_2\text{O}$ ):** 160 ktpa to 197 ktpa

## Kathleen Valley

Liontown Resources Ltd

ASX-listed: LTR • www.ltresources.com.au



*Kathleen Valley is a hard-rock lithium project with world-class scale and economics, located in a Tier-1 mining district. The project is funded to first production of approximately 500,000tpa of 6% lithium oxide concentrate from mid-2024, with planned expansion to approximately 700 ktpa. Liontown is also progressing studies into downstream processing options to convert spodumene concentrate into higher grade outputs. The company is ideally positioned to be a fully integrated lithium producer to capture long-term value from mine to end-use in the electric vehicle market. Kathleen Valley will also produce tantalum pentoxide, a valuable critical mineral used in electronic components, high-strength alloys and optics manufacturing.*

Kathleen Valley is a Tier-1 hard-rock lithium deposit with an initial mine life of over 23 years. The deposit is open at depth with the potential to further increase the resource and mine life. Mining will be predominately underground before undergoing on-site crushing, grinding and whole-of-ore flotation to produce a 6% lithium oxide concentrate. The project will be powered by more than 60% renewable energy generation from start-up and is expected to have the largest off-grid wind-solar-battery storage capacity of any mining project in Australia. The underground mining approach allowing direct access to higher grade mineralisation while minimising waste rock movement and environmental footprint is a further example of the real action being taken by Liontown to deliver on its ESG objectives. The project is also being delivered in meaningful partnership with the Tjiwarl Traditional Owners.

### Mineral inventory

Commodity(ies):	Lithium, Tantalum			
<b>Mineral Resources as at April 21 (0.55% Li<sub>2</sub>O cut-off)</b>		<b>Tonnes (Mt)</b>	<b>Li<sub>2</sub>O (%)</b>	<b>Ta<sub>2</sub>O<sub>5</sub> (%)</b>
	Measured	20	1.3	145
	Indicated	109	1.4	130
	Inferred	27	1.3	113
	<b>Total</b>	<b>156</b>	<b>1.4</b>	<b>130</b>
<b>Ore Reserves as at November 21 (Open Pit: 0.50% Li<sub>2</sub>O cut-off, Underground; 0.17 – 1.2% cut-off)</b>		<b>Total Mt</b>	<b>Li<sub>2</sub>O Mt</b>	<b>Ta<sub>2</sub>O<sub>5</sub> Mt</b>
	Probable	65.4	1.34	119
	<b>Total – Underground</b>	<b>65.4</b>	<b>1.34</b>	<b>119</b>
	Proved	2.7	1.30	141
	Probable	0.5	0.93	148
	<b>Total – Open Pit</b>	<b>3.2</b>	<b>1.21</b>	<b>142</b>
	<b>Total</b>	<b>68.5</b>	<b>1.34</b>	<b>120</b>
<b>Contained (kt)</b>		<b>918</b>	<b>8</b>	



#### Project Status

Construction



#### Post-tax IRR:

57%\*



#### Product & Annual Production Rate

- Initial Production from mid-2024 Lithium spodumene concentrate (6% Li<sub>2</sub>O): ~500 ktpa
- Lithium spodumene concentrate (6% Li<sub>2</sub>O): ~700 ktpa



#### Offtake Available

Majority contracted, ~10% of spodumene available for spot sale

#### Capital Cost:

A\$545 million<sup>1</sup>



#### Min Mine Life (Yrs)

23 years

#### Post-tax NPV<sub>8%</sub>:

A\$4.2B<sup>2</sup>

1. 11 November 2021 DFS post-tax IRR presented which assumes US\$1,392/t SC6 concentrate price and US\$84/lb 30% tantalum price. Note not updated for FID capital cost estimate.
2. 29 June 2022 FID updated capital cost estimate



# Mn

Manganese

## Butcherbird High Purity Manganese Project

Element 25 Limited

ASX-listed (E25) • [www.element25.com.au](http://www.element25.com.au)



Element 25 Limited is the operator of the Butcherbird Manganese Mine which hosts the Australia's largest onshore manganese resource. E25's goal is to become an industry leading, world class, low-carbon battery materials manufacturer, producing high quality manganese concentrate and battery grade High Purity Manganese Sulphate Monohydrate (HPMSM) products for traditional and new EV battery markets. E25's export business continues to demonstrate the company's reliability as a trusted supplier of manganese concentrate to global markets, at a time when commodity producers are facing extensive disruptions from a complex array of factors.

E25 Butcherbird mine currently produces ~365 ktpa high-quality manganese concentrate for use in manganese alloy production (Stage 1). Engineering optimisation underway will increase manganese concentrate production from Butcherbird to ~1.0Mtpa in 2023 as Stage 2 of the Project. A Scoping Study completed in January 2022 confirmed the attractiveness of developing a HPMSM manufacturing facility within southeast Asia for downstream processing of Butcherbird Manganese Concentrate. The HPMSM manufacturing facility is expected to consist of up to three processing trains each capable of producing a total of 66,650tpa of manganese sulphate with 75% or 50,000tpa at a battery grade (HPMSM) and 25% or 16,650tpa at a fertiliser grade (FGMSM) via a leaching, purification and crystallisation process. The HPMSM manufacturing facility (Stages 3 & 4 of the Project) represents a long life, low operating cost opportunity to expand into the down-stream processing to produce HPMSM. E25's HPMSM plants are being designed with a focus on ESG principles including carbon minimisation, social engagement and good corporate stewardship. Energy will be sourced from renewable where available in-line with the Company's net-zero carbon strategy.

### Mineral inventory

Commodity(ies):	Manganese					
<b>Mineral Resources as at 17 April 19 (7% Mn cut-off)</b>		<b>Tonnes</b>	<b>Mn</b>	<b>Si</b>	<b>Fe</b>	<b>Al</b>
		<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>	<b>(%)</b>	<b>(%)</b>
	Measured	16	11.6	20.6	11.7	5.7
	Indicated	41	10.0	20.9	11.0	5.8
	Inferred	206	9.8	20.8	11.4	5.9
	<b>Total</b>	<b>263</b>	<b>10.0</b>	<b>20.8</b>	<b>11.4</b>	<b>5.9</b>
	<b>Contained Mn (kt)</b>	<b>26,300</b>				
<b>Ore Reserves (as at 30 June 21)</b>		<b>Tonnes</b>	<b>Mn</b>			
		<b>(Mt)</b>	<b>(%)</b>			
	Proved	14.4	11.5			
	Probable	36.2	9.8			
	<b>Total</b>	<b>50.6</b>	<b>10.3</b>			
	<b>Contained (kt)</b>	<b>5,210</b>				



### Project Status

#### Stage 1 (365 ktpa):

Operating

#### Stage 2 (Expansion to 1Mtpa):

Pre-construction

#### Stage 3 (First 50 ktpa Battery Grade MnSO<sub>4</sub> module):

Scoping Study completed and Feasibility Study underway

#### Stage 4 (Expansion to 3\* 50 ktpa Battery Grade MnSO<sub>4</sub> modules):

Scoping Study Completed and Feasibility Study underway



### Offtake Available

Yes (Manganese Concentrate and Battery Grade HPMSM)



### Min Mine Life (Yrs)

Stage 1: 42+

Stage 2: 15+

Stage 3: 20

Stage 4: 20

Note: based on only 20% of global resource



### Post-tax IRR:

Stage 1: Operating

Stage 2: Pre-tax IRR: 359%<sup>1</sup>

Stage 3: Pre-tax IRR: 40%<sup>2</sup>

Stage 4: Pre-tax IRR: 47%<sup>2</sup>

### Capital Cost:

Stage 1: Operating

Stage 2: ~A\$30m (estimated)

Stage 3: US\$150m<sup>2</sup>

Stage 4: US\$172m<sup>2</sup>

### Post-tax NPV:

Stage 1: Operating

Stage 2: Post-tax NPV<sub>5%</sub>: A\$798m<sup>1</sup>

Stage 3: Post-tax NPV<sub>8%</sub>: US\$395m<sup>2</sup>

Stage 4: Post-tax NPV<sub>8%</sub>: US\$1,142m<sup>2</sup>

1. HPMSM Scoping Study, 18 January 2022

2. Updated PFS and Expansion Studies, 3 December 2020



### Product & Annual Production Rate

#### • Stage 1

Manganese concentrate (30-35% Mn): 365 ktpa

#### • Stage 2

Manganese concentrate (30-35% Mn): 1 mtpa

#### • Stage 3 (First HPMSM module)

Battery Grade HPMSM (99.99% purity): 50 ktpa  
Mn concentrate (30-35% Mn): 900 ktpa

#### • Stage 4

(HPMSM Expansion to 3 modules)

Battery Grade HPMSM (99.99% purity): 150 ktpa  
Mn concentrate (30-35% Mn): 750 ktpa



Image courtesy of Element 25 Ltd



# Mg

Magnesium

## Latrobe Valley Project

Latrobe Magnesium Limited

ASX-listed (LMG) • [www.latrobemagnesium.com](http://www.latrobemagnesium.com)



Latrobe Magnesium Limited (LMG) is constructing its 1,000tpa magnesium production demonstration plant which should be completed by 30 June 2023. LMG then plans to expand the demonstration plant to a minimum of 10,000tpa magnesium production. LMG has funding available for these two plants. LMG is now investigating the establishment of a 100,000tpa magnesium production plant using a renewable energy source. It is looking for a joint venture partner to invest \$150 million for a 50% interest in this project. Offtake is also available for the 100,000tpa plant.

LMG has developed a unique hydrometallurgical process to process fly ash and ferro nickel slag into magnesium and other valuable products. The process will recycle 100% of these wastes. LMG owns its own 11 hectare site in the Latrobe Valley where it will build the demonstration and expanded plants using Yallourn power station brown coal fly ash. The power station will produce enough fly ash before it closes in 2028 to supply a 10,000tpa plant for 20 years. The LMG project is at the forefront of environmental benefit – by recycling plant waste, avoiding landfill and producing 50% lower CO<sub>2</sub> emissions than the industry average.

### Mineral inventory

Based upon initial estimates from Yallourn of both the fly ash in landfill and the fly ash produced before closure, there is approximately 7 million tonnes of fly ash at a 10% magnesium content would allow LMG to produce up to 700,000 tonnes of magnesium and operate a plant with a capacity of 10,000 tpa for 70 years.

For its 100,000tpa plant LMG has secured a supply agreement for 600,000tpa for 20 years (total of 12 million tonnes) of ferro nickel slag (33% MgO, 9% Fe<sub>2</sub>O<sub>3</sub> and 55% SiO<sub>2</sub>) to be supplied from New Caledonia Island on an FOB basis by Societe Le Nickel, one of the world's largest ferro nickel producers. There is in excess of 28 million tonnes of ferro nickel slag on the island and in excess of 20 smelters in the South East Asian region that produce similar slag.



#### Project Status

Construction (demonstration plant)  
Pre-Feasibility Study underway for 100,000 tpa plant



#### Post-tax IRR:

Not publicly available for the demonstration plant, as demonstration plant does not give an appropriate indication of value.



#### Product & Annual Production Rate

- **Demonstration plant:** 1,000tpa Magnesium
- **Expanded plant:** 10,000 tpa
- **Magnesium Large plant:** 100,000 tpa Magnesium (Magnesium quality is in excess of 99.9% purity)



#### Offtake Available

Yes for the 100,000 tpa plant

#### Capital Cost:

Demonstration plant A\$39M  
10,000 tpa plant A\$102M  
100,000 tpa plant A\$1B



#### Min Mine Life (Yrs)

In excess of 20 years

#### Post-tax NPV<sub>5%</sub>:

Not publicly available for the demonstration plant, as demonstration plant does not give an appropriate indication of value.



# Mg

Magnesium

## Winchester

Korab Resources Ltd

ASX-listed (KOR) • www.korabresources.com.au



In March 2022 Korab announced results of its Scoping Study into production of 50,000 tpa magnesium metal which showed a pre-tax NPV<sub>12%</sub> of approximately A\$1 billion. In May 2022, Korab received a Letter of Intent from Speira GmbH for purchase of magnesium metal from Winchester. No commercial terms have yet been agreed. Other offtake and financing discussions are also underway. No agreements have yet been reached. Korab is looking for additional potential offtake discussions, partnerships or financing.

As per its 2018 Feasibility Study, in the initial stage of development, Korab plans to develop the Winchester project as a quarry producing magnesium carbonate rock to be crushed, screened, and sorted on-site, prior to transport to the Darwin Port for export. As Stage 2 of development, part of the production is planned to be sold as un-processed magnesium carbonate rock, and part is planned to be processed off-site into magnesium oxide in the form of caustic calcined magnesia (CCM), and dead burned magnesia (DBM). Off-site processing is expected to be undertaken by means of toll-treatment in kilns owned by third parties, which would not require additional capital investment. As Stage 3, Korab plans to build a magnesium metal production plant to produce 50,000 tpa of high purity magnesium metal using silicothermic method which has been successfully tested in a pilot plant. Korab is also assessing alternative magnesium production methods. Most of the energy needs can be supplied by two solar farms (10MW and 12.5MW) located within 1km of the project.

### Mineral inventory

Commodity(ies):	Magnesium			
Mineral Resources as at 30 September 2021 (at 40% MgO cutoff grade)	Resource Category	Tonnes (Mt)	MgO Grade (%)	Contained Mg Metal (kt)
	Indicated	12.2	43.1	3,172
	Inferred	4.4	43.6	1,157
	<b>Total</b>	<b>16.6</b>	<b>43.2</b>	<b>4,329</b>

Notes: All of Mg is contained within MgO.



#### Project Status

Feasibility Study: Production of DSO magnesium carbonate and magnesium oxides  
Scoping study: Production of magnesium metal



#### Post-tax IRR:

**Stage 1:** (Magnesium carbonate ore only) – Post-tax IRR: 160%  
**Stage 2:** (CCM, DBM & Magnesium Carbonate Ore) – Post-tax IRR: N/A  
**Stage 3:** (Magnesium metal) – Post-tax IRR: N/A



#### Product & Annual Production Rate

**Stage 1**  
Magnesium carbonate ore: 600,000-1,000,000 tpa  
**Stage 2**  
DBM: 75,000-150,000 tpa  
CCM: 150,000-300,000 tpa  
Magnesium Carbonate ore: 300,000-600,000 tpa  
**Stage 3**  
Magnesium: 50,000 tpa  
DBM: 75,000-100,000 tpa  
CCM: 50,000-75,000 tpa  
Magnesium Carbonate ore: 150,000-300,000 tpa



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

15 (can be extended)

#### Capital Cost:

**Stage 1:** (Magnesium carbonate ore only) - A\$2.4m-A\$2.5m  
**Stage 2:** (CCM, DBM & Magnesium Carbonate Ore): NIL (processing by third party)  
**Stage 3:** (Magnesium metal): A\$410m

#### Post-tax NPV:

**Stage 1:** (Magnesium carbonate ore only) – Post-tax NPV 12%: A\$184m  
**Stage 2:** (CCM, DBM & Magnesium Carbonate Ore) – Post-tax NPV 12%: N/A  
**Stage 3:** (Magnesium metal) – Pre-tax NPV12%: A\$1,000m

# PGE

Platinum-  
group  
elements

## Panton

Future Metals NL

ASX-listed (FME) • [www.future-metals.com.au](http://www.future-metals.com.au)



Future Metal's strategy and portfolio will deliver commodities that help make the transition to cleaner energy and improved living standards. Panton is a long life, expandable project on granted mining leases. The deposit hosts a resource mix that supports the growing demand for catalytic convertors, hydrogen electrolyzers and fuel cells, and batteries. Located in the top tier jurisdiction of Western Australia the project offers a significant opportunity for diversification of PGM supply away from Russia and South Africa. Future Metals is open to discussions with funding partners who can assist in the financing and development of the project.

Panton is located in close proximity to a sealed highway which enables easy access to the regional centres of Kununurra and Halls Creek with their skilled workforces, nearby public airports and the port of Wyndham. The project has been substantially de-risked with 20+ years of drilling and test work programs and can now benefit from abundant locally available renewable solar, hydro and wind energy. A Bankable Feasibility Study was completed on the project in 2003 and updated in 2011 based on a high grade, low capital and long mine life operation. Future Metals acquired the project in 2021 and is expeditiously progressing Panton towards production. Future Metals has optimized flotation to produce a high-grade saleable concentrate, drilled a further 6,000m and remodelled the resource. FME's new Scoping Study is currently underway and is focused on an initial high grade underground project producing a saleable concentrate. Further on-site hydrometallurgical processing options are being explored. A new Pre-Feasibility Study will be commenced in 2023 H1 focused on delivering commercial and sustainable project development outcomes for our shareholders and community.

### Mineral inventory

Commodity(ies):	Platinum, Palladium, Gold, Nickel, Copper, Cobalt						
Mineral Resources as at June 2022 (Reef mineralisation: No cut-off, Bulk mineralisation: 0.90 g/t PdEq cut-off)	Resource Category	Tonnes (Mt)	Palladium (g/t)	Platinum (g/t)	Gold (g/t)	Nickel (%)	Copper (%)
	<b>Reef</b>						
	Indicated	7.9	1.99	1.87	0.31	0.24	0.07
	Inferred	17.6	1.59	1.49	0.22	0.23	0.07
	<b>Total – Reef</b>	<b>25.4</b>	<b>1.71</b>	<b>1.61</b>	<b>0.24</b>	<b>0.24</b>	<b>0.07</b>
<b>Bulk</b>							
	Inferred	103.4	0.31	0.25	0.07	0.17	0.03
	<b>Total – Bulk</b>	<b>103.4</b>	<b>0.31</b>	<b>0.25</b>	<b>0.07</b>	<b>0.17</b>	<b>0.03</b>
	<b>Grand Total</b>	<b>128.8</b>	<b>0.58</b>	<b>0.52</b>	<b>0.10</b>	<b>0.19</b>	<b>0.04</b>
	<b>Contained Total</b>		<b>2,423 Koz</b>	<b>2,143 Koz</b>	<b>425 Koz</b>	<b>238.8kt</b>	<b>48.4kt</b>



#### Project Status

Feasibility Study (2011)



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

~10



#### Post-tax IRR:<sup>1</sup>

#### Capital Cost:<sup>1</sup>

#### Post-tax NPV:<sup>1</sup>

1. Previous 2011 Feasibility Study results are no longer representative of the expected project results which will be updated in the new Scoping Study underway and new Pre-Feasibility Study to be completed in 1H 2023.



#### Product & Annual Production Rate

Bulk PGE-Ni concentrate containing up to 100koz PGE and 1,500t Ni per annum for initial underground only project<sup>2</sup>

2. Preliminary estimate ahead of scoping and pre-feasibility study work

# REE

Rare Earth Elements

## Browns Range – Wolverine Rare Earth Project

Northern Minerals Limited

ASX-listed (NTU) • [www.northernminerals.com.au](http://www.northernminerals.com.au)



Northern Minerals is focused on becoming a principal supplier of ethically produced dysprosium and terbium from the one of the Australia's largest heavy rare earth inventories. Northern Minerals has entered into a supply agreement with Iluka Resources to supply Iluka with rare earth concentrate from its Wolverine Project at Browns Range. This supply agreement covers the initial 8+ year mine life of 30,500 tonnes of contained TREO in concentrate. Iluka is also providing a funding package through a series of investments in Northern Minerals. The Company is fully funded up to FID and welcomes discussions regarding further financing for the commercial scale mine and process plant.

The Wolverine Rare Earth Project is set to be the first significant dysprosium and terbium producer outside of China. A Definitive Feasibility Study (DFS) is underway on the Wolverine Project based on underground mining of the Wolverine xenotime deposit delivering ore to a beneficiation plant to be constructed at Browns Range to produce a dysprosium and terbium rich xenotime concentrate containing 25% TREO for supply to Iluka. Completion of the DFS is targeted in Q3 2023 prior to a Final Investment Decision (FID) anticipated in Q1 2024, and first production targeted in early 2026. A 10% scale Pilot Plant was operated at Browns Range for ~3 years until April 2022 to test the technical and economic viability of the process, to provide large quantities of product for downstream third-party qualification and provide data for the DFS on the full-scale project. Significant exploration scope exists to expand Browns Range system Mineral Resource in the future.

### Mineral inventory

**Commodity(ies):** Rare Earth Elements – Dysprosium and Terbium

Wolverine Deposit Mineral Resources as at 10 October 22 (0.15% TREO cut-off)	Resource Category	Tonnes (Mt)	TREO (%)	Dy <sub>2</sub> O <sub>3</sub> (kg/t)	Y <sub>2</sub> O <sub>3</sub> (kg/t)	Tb <sub>4</sub> O <sub>7</sub> (kg/t)	HREO (%)
	Measured	0.14	0.70	0.61	3.99	0.09	88%
Indicated	3.24	0.95	0.83	5.53	0.12	89%	
Inferred	3.05	0.98	0.84	5.68	0.13	89%	
<b>Total</b>	<b>6.44</b>	<b>0.96</b>	<b>0.83</b>	<b>5.57</b>	<b>0.12</b>	<b>89%</b>	
<b>Contained (kt)</b>			<b>61</b>	<b>5</b>	<b>36</b>	<b>1</b>	<b>55</b>

Browns Range Total Mineral Resources as at 10 October 22 (0.15% TREO cut-off)	Resource Category	Tonnes (Mt)	TREO (%)	Dy <sub>2</sub> O <sub>3</sub> (kg/t)	Y <sub>2</sub> O <sub>3</sub> (kg/t)	Tb <sub>4</sub> O <sub>7</sub> (kg/t)	HREO (%)
	Measured	0.14	0.7	0.61	3.99	0.09	89
Indicated	4.9	0.78	0.67	4.46	0.1	87	
Inferred	5.76	0.73	0.62	4.22	0.09	89	
<b>Total</b>	<b>10.81</b>	<b>0.76</b>	<b>0.64</b>	<b>4.33</b>	<b>0.09</b>	<b>88</b>	
<b>Contained (kt)</b>			<b>82</b>	<b>7</b>	<b>47</b>	<b>1</b>	<b>72</b>

Note: The Wolverine Deposit Mineral Resource is a sub-set of the Browns Range Total Mineral Resource stated above. These figures are not additive.



#### Project Status

Feasibility Study completed in 2015. Wolverine Project DFS targeting completion in Q3 2023.



#### Offtake Available

No – Supply agreement in place with ILU for 30.5k tonnes of TREO in concentrate.



#### Min Mine Life (Yrs)

Approximately 8+ years, to be confirmed by DFS.



#### Post-tax IRR:

N/A. Available on completion of DFS

#### Capital Cost:

N/A. Available on completion of DFS

#### Post-tax NPV:

N/A. Available on completion of DFS



#### Product & Annual Production Rate

- **RE Concentrate:** Approximately 16,000 tpa
- **Contained TREO:** Approximately 4,000 tpa
- **Contained Dy<sub>2</sub>O<sub>3</sub>:** Approximately 400 tpa



# REE

Rare Earth Elements

## Dubbo Project

Australian Strategic Materials (Holdings) Ltd

ASX-listed (ASM) • www.asm-au.com



The Dubbo Project funding strategy anticipates a mixture of debt, equity, and export credit finance. Strategic joint venture partner(s) are intended to provide required equity and potentially offtake, commercial banks will provide debt. Korean Export Credit Agencies are anticipated to be part of a debt consortium. In 2021, ASM received a non-binding letter of support from Export Finance Australia, an Australian Government-owned agency, to secure A\$200 million of debt funding. ASM intends to continue discussions with potential strategic investors, offtake partners and financial institutions with a view to financing the Dubbo Project.

Australian Strategic Materials (ASM) is a rare earths and critical mineral company. Our ‘mine to metals’ strategy is to extract, refine and manufacture high-purity metals and alloys, supplying direct to global customers. ASM’s cornerstone project is its Dubbo Project, located 25kms from Dubbo, in NSW, Australia. This rare earths and critical minerals project resource includes neodymium, praseodymium, dysprosium, terbium, zirconium, niobium and hafnium. The Dubbo Project is construction ready, with all major permits received. In 2022 ASM entered a conditional agreement with Hyundai Engineering to undertake engineering, construction, and procurement design work upon issuance of a notice to proceed by ASM. ASM intends to develop the Dubbo Project to produce a range of metal oxides and mixed chlorides. In partnership with the Australian Nuclear Science and Technology Organisation (ANSTO), ASM has completed significant successful test work to maximise recoveries.

### Mineral inventory

Commodity(ies):	Neodymium, Praseodymium, Dysprosium, Terbium, Zirconium, Niobium and Hafnium						
Mineral Resources as at 30 June 17	Resource Category	Tonnes (Mt)	ZrO <sub>2</sub> (%)	HfO <sub>2</sub> (%)	Nb <sub>2</sub> O <sub>5</sub> (%)	Ta <sub>2</sub> O <sub>5</sub> (%)	TREO (%)
	Measured	42.8	1.89	0.04	0.45	0.03	0.88
	Indicated						
	Inferred	32.4	1.90	0.04	0.44	0.03	0.88
	<b>Total</b>	<b>75.2</b>	<b>1.89</b>	<b>0.04</b>	<b>0.44</b>	<b>0.03</b>	<b>0.88</b>
	<b>Contained (kt)</b>		<b>1,421</b>	<b>30</b>	<b>331</b>	<b>23</b>	<b>662</b>
Ore Reserves as at 30 June 17	Reserve Category	Tonnes (Mt)	ZrO <sub>2</sub> (%)	HfO <sub>2</sub> (%)	Nb <sub>2</sub> O <sub>5</sub> (%)	Ta <sub>2</sub> O <sub>5</sub> (%)	TREO (%)
	Proved	18.9	1.85	0.04	0.44	0.03	0.87
	<b>Total</b>	<b>18.9</b>	<b>1.85</b>	<b>0.04</b>	<b>0.44</b>	<b>0.03</b>	<b>0.87</b>
	<b>Contained (kt)</b>		<b>350</b>	<b>8</b>	<b>83</b>	<b>5</b>	<b>165</b>



#### Project Status

Pre-Construction



#### Pre-tax IRR:

23.5%

#### Capital Cost:

A\$1,678m

#### Pre-tax NPV<sub>8%</sub>:

A\$2,361m

#### Post-tax NPV<sub>8%</sub>:

A\$1,581m

(assumes 0.75 AUD:USD exchange rate, 30% tax rate, real basis)



#### Product & Annual Production Rate

- **Zirconium:** 16,374 tpa
- **Niobium:** 1,967 tpa
- **Hafnium:** 200 tpa
- **Rare earths:** 6,664 tpa (containing 237 tpa – Pr<sub>6</sub>O<sub>11</sub>, 921 tpa Nd<sub>2</sub>O<sub>3</sub> as well as Tb & Dy)



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

20

# REE

Rare Earth Elements

## Donald Rare Earth & Mineral Sands Project

Astron Corporation Limited

ASX-listed (ATR) • [www.astronlimited.com.au](http://www.astronlimited.com.au)



The Donald project is a tier-1 rare earth and mineral sands resource located in regional Victoria. The resource of over 2.4B tonnes of heavy mineral has the potential to represent a globally significant, long-life supply of critical minerals such as zirconium, titanium, and neodymium and praseodymium (rare earth elements). An updated Feasibility Study (FS) is planned for completion during Q1 2023. Astron plans to progress Phase 1 funding discussions with financiers following the conclusion of the FS and is advancing its offtake agreements.

The Donald Project will utilise conventional shallow, dry mining, accessing a single pit with excavators and haul trucks to supply an onsite conventional gravity separation and froth flotation processing plant. The processing plant will produce a rare earth element concentrate (REEC) containing monazite and xenotime and a heavy mineral concentrate (HMC) containing zircon and titanium feedstock. Phase 1 envisages ore throughput of 7.5 Mtpa. REEC produced on-site will be sold to downstream processors both domestically and abroad whilst HMC will be sold to offshore processors. Phase 2 involves doubling of ore throughput to 15.0 Mtpa and construction of a mineral separation plant to produce final zircon and titania products. An updated geological model, including a revised Mineral Resource Statement incorporating the rare earth element of xenotime, is planned for Q4 2022. The initial mining phase is planned on granted Mining Licence MIN5532 which contains 13% of total Mineral Resources and can support mining operations for 35 years at Phase 1 throughput. RL2002 & RL2003 have further upside, supporting a continuous multi-generational project. The project benefits from government approval of EES & EPBC and positive community support.

### Mineral inventory

Commodity(ies):	Rare Earth Elements, Titanium, Zirconium							
<b>Mineral Resources as at 7 April 16 (1% HM cut-off)</b>	Resource Category	Tonnes (Mt)	HM (%)	Ilmenite (%)	Leucoxene (%)	Rutile (%)	Zircon (%)	Monazite (%)
	Measured	448	5.4	31.1	20.9	8.0	19.6	1.8
	Indicated	1,171	4.6	32.1	18.4	8.4	18.1	1.7
	Inferred	807	4.7	33.1	16.8	8.7	18.9	1.9
	<b>Total</b>	<b>2,427</b>	<b>4.8</b>	<b>32.2</b>	<b>18.4</b>	<b>8.4</b>	<b>18.7</b>	<b>1.8</b>
	<b>Contained (kt)</b>	<b>116,496</b>	<b>37,279</b>	<b>20,969</b>	<b>9,320</b>	<b>22,134</b>	<b>2,330</b>	
<b>Ore Reserves as at 16 February 21</b>	Reserve Category	Tonnes (Mt)	HM (%)	Ilmenite (%)	Leucoxene (%)	Rutile (%)	Zircon (%)	Monazite (%)
	Proved	310.0	5.4	31.0	20.0	8.2	20.0	1.8
	Probable	292.0	4.1	32.0	20.0	7.4	17.0	1.6
	<b>Total</b>	<b>602.0</b>	<b>4.8</b>	<b>32.0</b>	<b>20.0</b>	<b>7.9</b>	<b>19.0</b>	<b>1.7</b>
		<b>Contained (kt)</b>	<b>28,896</b>	<b>9,160</b>	<b>5,808</b>	<b>2,282</b>	<b>5,432</b>	<b>491</b>



#### Project Status

Feasibility Study



#### Post-tax IRR:

N/A



#### Product & Annual Production Rate

- Rare Earth Elements Concentrate (~60% TREO, with Nd/Pr ~20% of TREO): ~9 ktpa
- Heavy Mineral Concentrate: ~285 ktpa



#### Offtake Available

Open to discussions – production expected to commence in 2025

#### Capital Cost:

~A\$350 million

#### Post-tax NPV:

N/A



#### Min Mine Life (Yrs)

Phase 1 operations – 35 years (equates to 13% of mineral resource)

# REE

Rare Earth Elements

## Fingerboards Mineral Sands Project

Kalbar Operations Pty Ltd

Kalbar Limited and Appian Capital Advisory LLP

www.kalbaroperations.com.au



Kalbar has a binding agreement in place with Appian Capital Advisory LLP (“Appian”), regarding a staged equity investment of up to A\$144 million in Kalbar Operations Pty Ltd by Appian to fund the Project. The Fingerboards Project, with its supportive shareholders, is in the position of having its equity component funded. The balance of funds required will be raised through debt markets. An initial sounding process undertaken in early 2021 was well received by approximately 15-20 potential finance providers.

The Fingerboards Mineral Sands Project is focused on a high-grade area of the 2.7Bt Glenaladale Mineral Resource, ~20km northwest of Bairnsdale. During the first full 10 years of production, the Project will produce heavy mineral concentrate averaging 110 ktpa of contained zircon – representing 10% of global supply, and 13.5 ktpa of contained rare earths – representing 5% of light (Nd-Pr) rare earths and 20% of heavy (Dy-Tb) rare earths global supply. The initial mine life is forecast to be 15 years during which approximately 165Mt of ore will be mined. The Project plans to produce a zircon-rich non-magnetic concentrate (“Non-Mags”), and ilmenite and rare earth-rich magnetic concentrate (“Mags”) via Reflux Classifier technology as the primary gravity separation units followed by WHIMS units. A Bankable Feasibility Study Update (BFSU) was completed in 2020. Kalbar is currently undertaking a Definitive Feasibility Study and going through the approvals and permitting process.

### Mineral inventory

Commodity(ies):	Zirconium, Rare Earth Elements, Titanium				
Mineral Resources as at 2022*:		<b>Tonnes (Mt)</b>	<b>TiO<sub>2</sub> (%)</b>	<b>Zircon (%)</b>	<b>TREO (%)</b>
	Measured	98.6	1.52	0.95	0.084
	Indicated	387	1.15	0.66	0.061
	Inferred	690	0.8	0.40	0.038
	<b>Total</b>	<b>1,170</b>	<b>1.0</b>	<b>0.5</b>	<b>0.049</b>
	<b>Contained (kt)</b>	<b>11,600</b>	<b>6,270</b>	<b>580</b>	
*The Fingerboards Resource has been revised by applying a new economic cut-off of \$5/t mine gate value to the 2018 resource estimate.					
Ore Reserves as at 2019		<b>Tonnes (Mt)</b>	<b>TiO<sub>2</sub> (%)</b>	<b>Zircon (%)</b>	<b>TREO (%)</b>
	Proved	73	1.8	1.2	0.11
	Probable	100	1.9	1.2	0.11
	<b>Total</b>	<b>173</b>	<b>1.9</b>	<b>1.2</b>	<b>0.11</b>
	<b>Contained (kt)</b>	<b>3,203</b>	<b>2,110</b>	<b>191</b>	



#### Project Status

Feasibility Study



#### Post-tax IRR<sup>1</sup>:

64%



#### Product & Annual Production Rate

- **Magnetic Concentrate (zircon rich):** 205-294 ktpa
- **Non-Magnetic Concentrate (illmenite and REE rich):** 223-324 ktpa
- **Contained Zircon:** 110-155 ktpa
- **Contained TREO:** 10-14 ktpa
- **Contained Titanium Oxide:** 135-191 ktpa



#### Offtake Available

No

#### Capital Cost<sup>1</sup>:

Stage 1: A\$231m,  
Stage 2: A\$126m



#### Min Mine Life (Yrs)

15

#### Post-tax NPV<sub>8%</sub><sup>1</sup>:

A\$1,056m<sup>1</sup>

1. Economics as per Bankable Feasibility Study Update completed in 2020



# REE

Rare Earth Elements

## Eneabba Refinery

Iluka Resources Ltd

ASX-listed (ILU) • [www.iluka.com.au](http://www.iluka.com.au)



Iluka is an international critical minerals company with more than 70 years industry experience. ASX-listed and headquartered in Perth, Iluka is a leading producer of zircon and high-grade titanium feedstocks (rutile and synthetic rutile). From 2025, Iluka is set to become a globally material supplier of separated rare earth oxides. In April 2022, Iluka approved the final investment decision for a fully integrated rare earths refinery at Eneabba in Western Australia – the first of its kind in Australia and one of few globally. This represents a game changing development for the diversification of global supply chains and for domestic value addition to Australia’s rare earth resources. The Eneabba refinery is fully funded via a strategic partnership between Iluka and the Australian Government, including a \$1.25 billion loan under the Critical Minerals Facility administered by Export Finance Australia.

The Eneabba refinery will be fully integrated, producing both light and heavy separated rare earth oxides and capable of processing feedstocks from Iluka’s portfolio and from a range of third party suppliers. This positions Eneabba and Australia as a strategic hub for the downstream processing of these critical minerals.

Production capacity for the refinery is 17.5-23 ktpa of rare earth oxides, subject to the feedstock used. Ground works will commence in Q4 2022, with first production scheduled for 2025. Fluor Australia has been awarded the Engineering, Procurement and Construction Management services contract for the project.

Building on the existing screening and concentrating infrastructure, the refinery will be a significant downstream infrastructure asset comprising roasting, leaching, purification, solvent extraction and product finishing capabilities to produce light and heavy rare earth oxides.

The refinery will be fed initially from Iluka’s unique rare earths stockpile at Eneabba. This stockpile consists of the rare earth bearing minerals monazite and xenotime, which are produced as co-products of Iluka’s mineral sands processing activities. It is very high grade, located at surface and requires no mining infrastructure, providing speed to market. A beneficiation plant was commissioned in June 2022. This will separate the monazite and the xenotime from the zircon in the stockpile to produce a direct feed for the Eneabba refinery.

Other potential future sources of feedstock for the refinery include Iluka’s Wimmera development; other deposits within Iluka’s portfolio; and a range of third parties, including both mineral sands and hard-rock rare earths deposits.

The Wimmera project involves the mining and beneficiation of a fine grained heavy mineral sands ore body in Western Victoria for the potential long term supply of zircon and rare earths. Wimmera’s rare earth bearing minerals are very similar to those contained in the Eneabba stockpile, though with more xenotime, which contains higher levels of dysprosium and terbium. A Pre-Feasibility Study for the Wimmera project is underway and is scheduled for completion in late 2022.

### Mineral inventory

**Commodity(ies):** Rare Earth Elements, Zircon and Ilmenite

Eneabba MSP By-Product Stockpile Mineral Resources as at 31 December 21	Resource	In Situ HM	Total HM	Ilmenite	Zircon	Monazite	Xenotime
	Category	Tonnes (Mt)	Tonnes Mt	Grade (%)	Grade (%)	Grade (%)	Grade (%)
	Measured	0.68	0.57	84.0	32.4	26.4	1.2
	Indicated	0.24	0.19	78.5	35.3	12.9	1.7
	Inferred	0.06	0.04	69.4	38.2	12.1	1.1
	<b>Total</b>	<b>0.98</b>	<b>0.80</b>	<b>81.8</b>	<b>33.4</b>	<b>28.0</b>	<b>1.3</b>
	<b>Contained (kt)</b>		<b>800</b>		<b>270</b>	<b>220</b>	<b>11</b>

Eneabba MSP By-Product Stockpile Ore Reserves as at 31 December 21:	Resource	In Situ HM	Total HM	Ilmenite	Zircon	Monazite	Xenotime
	Category	Tonnes (Mt)	Tonnes Mt	Grade (%)	Grade (%)	Grade (%)	Grade (%)
	Proved	0.69	0.58	84.7	32.2	20.4	1.2
	Probable	0.22	0.17	78.3	35.1	12.7	1.7
	Total	0.91	0.76	83.1	32.9	18.6	1.3
	<b>Contained (kt)</b>		<b>760</b>		<b>250</b>	<b>210</b>	<b>140</b>
					<b>10</b>		

Note: Please refer to Iluka's website [www.iluka.com](http://www.iluka.com) for further detail in Mineral Resource and Ore Reserve statements. The MSP By-products Stockpile has been adjusted for depletion and additions to 31 of December 2021.

**Project Status**  
Pre-Construction  
FID announced April 2022;  
EPCM contract awarded  
June 2022; groundworks  
to commence Q4 2022

**Offtake Available**  
Yes – detailed discussions are  
ongoing

**Min Mine Life (Yrs)**  
Initial refinery feedstock  
(Eneabba stockpile) has an  
indicative life of ~9 years,  
subject to feed rate

**Post-tax IRR:**  
Refer to Iluka's FID  
announcement on  
4 April 2022

**Capital Cost:**  
~A\$1,000m – A\$1,200m

**Product & Annual  
Production Rate**  
17.5 – 23 ktpa rare  
earth oxides subject to  
feedstock used

Product range will include  
neodymium (Nd) oxide;  
praesedymium (Pr) oxide,  
didymium (NdPr) oxide;  
dysprosium (Dy) oxide;  
terbium (Tb) oxide



Image courtesy of Iluka Resources Ltd

# REE

Rare Earth Elements

## Goschen Project

VHM Limited

Australian owned, unlisted, public company • [www.vhmltd.com.au](http://www.vhmltd.com.au)



The Goschen Rare Earth and Mineral Sands Project is located in a premier mining jurisdiction approximately 35km southwest of Swan Hill and 280km north-west of Melbourne. Goschen is a globally significant rare earth project with 413,107 tonnes of total rare earth oxides (TREO) contained within the total Mineral Resource. The Project will produce a rare earth mineral concentrate (REMC), mixed rare earth carbonate (MREC), and a zircon-titania heavy mineral concentrate (HMC) to be marketed to national and international consumers. The company welcomes discussion regarding project loan finance, equity and product offtake agreements.

The Definitive Feasibility Study (DFS) for the Goschen Project completed in 2022 is based on development of a 5Mtpa nameplate capacity mine and processing plant production rate over a >20 year mine life. The Project will utilise dry, strip mining by conventional ‘truck and shovel’ bulk earthmoving equipment, with pits maintained above the water table. The composition of economic mineral in fully liberated sand allows for low cost processing (no crushing or blasting required) via a simple process flowsheet consisting of a mining unit plant, wet concentrator plant, rare earth mineral flotation circuit and hydrometallurgical circuit to produce REMC, MREC and zircon-titania HMC. Additionally, the Company has recently discovered other large high-grade deposits of rare earth minerals and zircon across its large tenement position in Victoria covering 2,860km<sup>2</sup> that are analogous to Goschen. These will be the subject of targeted exploration programs.

### Mineral inventory

Commodity(ies):		Rare Earth, Zircon and Titanium							
Mineral Resources as at 30 June 21 (1.0% THM cut-off)	Resource Category	Tonnes (Mt)	THM (%)	Zircon (%)	Rutile (%)	Leucoxene (%)	Ilmenite (%)	Monazite (%)	Xenotime (%)
	Measured	30.7	5.72	29.9	10.8	9.0	24.7	4.3	0.8
	Indicated	310.3	3.19	20.5	10.1	8.6	24.9	3.4	0.7
	Inferred	287.7	2.32	17.2	8.7	7.5	22.7	2.9	0.5
	<b>Total</b>	<b>628.7</b>	<b>2.92</b>	<b>20.2</b>	<b>9.6</b>	<b>8.2</b>	<b>24.1</b>	<b>3.3</b>	<b>0.6</b>
	<b>Contained (kt)</b>		<b>18,329</b>	<b>3,698</b>	<b>1,765</b>	<b>1,509</b>	<b>4,418</b>	<b>601</b>	<b>118</b>
Company Ore Reserve as at 31 March 22	Reserve Category	Tonnes (Mt)	THM (%)	Zircon (%)	Rutile (%)	Leucoxene (%)	Ilmenite (%)	Monazite (%)	Xenotime (%)
	Proved	24.5	5.4	29.9	10.8	9.0	24.7	4.3	0.8
	Probable	174.2	3.5	21.0	9.6	8.2	25.8	3.5	0.6
	<b>Total</b>	<b>198.7</b>	<b>3.7</b>	<b>21.7</b>	<b>9.7</b>	<b>8.2</b>	<b>25.7</b>	<b>3.5</b>	<b>0.6</b>
	<b>Contained (kt)</b>		<b>7,352</b>	<b>1,595</b>	<b>713</b>	<b>603</b>	<b>1,889</b>	<b>257</b>	<b>44</b>



#### Project Status

Feasibility Study  
Front End Engineering and Design (FEED) commencing November 2022



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

>20 years



#### Post-tax IRR:

Not publicly available.  
Please contact the company for further information.

#### Capital Cost:

A\$478m

#### Post-tax NPV:

Not publicly available.  
Please contact the company for further information.



#### Product & Annual Production Rate

- Rare earth mineral concentrate (REMC): 9,000–11,000 tpa
- Mixed rare earth carbonate (MREC): 9,000–11,000 tpa
- Zircon/titania heavy mineral concentrate (HMC): 184,000 tpa



# REE

Rare Earth Elements

## Nolans

Arafura Resources Ltd

ASX-listed (ARU) • www.arultd.com



Arafura is in the final stages of front-end engineering design (FEED) and has engaged with potential construction contractors for the Nolans project hydrometallurgical plant. It will commence detailed design and construction tendering to target a Final Investment Decision in 2H 2022. Arafura has engaged Société Générale and National Australia Bank as its mandated lead arrangers to arrange and syndicate a finance facility. Letters of support have been received from Export Finance Australia and the Northern Australia Infrastructure Facility for senior debt facilities totalling A\$300 million. The strategic nature of NdPr and the alignment with clean energy applications make the project attractive to NdPr users not aligned with the Made in China 2025 strategy and is well-suited to some export credit agency mandates. Non-binding MoUs for NdPr offtake in place with Hyundai Motor Company and GE Renewable Energy with potential for strategic equity investment.

The Nolans Project is the only shovel ready fully integrated Neodymium and Praseodymium (NdPr) project that will mine from an open pit operation and process ore to oxide in Australia. All regulatory approvals are in place and the site is fully permitted for rare earths mining, extraction and separation including waste management. The long life Project has expansion potential and will deliver intergenerational benefits to the region and a Native Title Agreement has been executed. The metallurgical process developed by Arafura leverages the natural characteristics of the Nolans ore body to deliver low operating costs and has been comprehensively de-risked with an extensive 4 year pilot plant program to refine the process flowsheet.

### Mineral inventory

Commodity(ies):	Rare Earth Elements (Neodymium and Praseodymium (NdPr))				
<b>Mineral Resources as at 7 June 17 (1% TREO cut-off grade)</b>	Resource Category	Tonnes (Mt)	TREO (%)	P <sub>2</sub> O <sub>5</sub> (%)	NdPr (% of TREO)
	Measured	4.9	3.2	13	26.1
	Indicated	30	2.7	12	26.4
	Inferred	21	2.3	10	26.5
	<b>Total</b>	<b>56</b>	<b>2.6</b>	<b>11</b>	<b>26.4</b>
	<b>Contained (kt)</b>		<b>1,456</b>	<b>6,160</b>	<b>384</b>
<b>Ore Reserves as at 16 March 20</b>	Reserve Category	Tonnes (Mt)	TREO (%)	P <sub>2</sub> O <sub>5</sub> (%)	NdPr (% of TREO)
	Proved	5.0	3.0	13	26.2
	Probable	24.6	2.8	13	26.5
	<b>Total</b>	<b>29.5</b>	<b>2.9</b>	<b>13</b>	<b>26.4</b>
	<b>Contained (kt)</b>		<b>856</b>	<b>3,835</b>	<b>226</b>



#### Project Status

Pre-Construction



#### Post-tax IRR:

18.1%



#### Product & Annual Production Rate

- NdPr oxide: 4,440 tpa
- SEG/HRE carbonate: 474 tpa
- Phosphoric acid (fertilizer-grade, 54% P<sub>2</sub>O<sub>5</sub>): 144,393 tpa



#### Offtake Available

Yes

#### Capital Cost:

A\$1,150m



#### Min Mine Life (Yrs)

38

#### Post-tax NPV<sub>8%</sub>:

A\$1,402m

# REE

Rare Earth Elements

## Yangibana

Hastings Technology Metals Ltd

ASX-listed (HAS) • www.hastingstechmetals.com



Yangibana, a Rare Earths development project in WA has total funding requirements of A\$658 million until the end of the construction period. A\$110 million equity raising was completed in Q3 2022 to advance early works and equipment purchases. An acquisition of a key equity position in NEO Performance Materials, who specialise in downstream rare earths processing was also completed during Q3 2022. Debt financing of A\$140m was recently received from the Northern Australia Infrastructure Facility and further debt and equity may be required once final capital requirements are established. Project financing is underpinned by a 10 year binding offtake contract with thyssenkrupp AG representing 60% of production during the first 5 years. A master supply agreement with the German automotive supply company Schaeffler AG over 10 years has also been signed.

The Project involves the mining and beneficiation processing of ore at Yangibana as well as the downstream hydrometallurgical processing of concentrate at Onslow to produce 15,000tpa of Mixed Rare Earth Carbonate (“MREC”). Yangibana’s MREC boasts extremely high concentrations of the high value neodymium (Nd) and praseodymium (Pr) rare earth elements, with an NdPr: Total RE Oxides (“TREO”) ratio of up to 52% in some deposits. Early works have commenced including access roads, airstrips, 300-bed village, communications connections and water reticulation services. FEED design work continues ahead of processing plant construction in 2023. Mining will be via conventional open cut methods. Current Ore Reserves support a 15-year mine life, with substantial exploration potential. Primary Commonwealth and WA environment permits are in place. Yangibana is shovel ready.

### Mineral inventory

Commodity(ies):	Rare Earth Elements (Neodymium and Praseodymium (NdPr))				
<b>Mineral Resources (all 10 deposits) as at 5 May 21 (0.24% TREO cut-off)</b>	Resource Category	Tonnes (Mt)	TREO (%)	Nd <sub>2</sub> O <sub>3</sub> + Pr <sub>6</sub> O <sub>11</sub> (%)	
	Measured	4.90	1.01	0.38	
	Indicated	16.24	0.95	0.33	
	Inferred	6.27	0.99	0.31	
	<b>Total</b>	<b>27.42</b>	<b>0.97</b>	<b>0.33</b>	
	<b>Contained (kt)</b>		<b>266</b>	<b>90</b>	
<b>Ore Reserves as at 27 July 21</b>	Reserve Category	Tonnes (Mt)	TREO (%)	Nd <sub>2</sub> O <sub>3</sub> + Pr <sub>6</sub> O <sub>11</sub> (%)	Nd <sub>2</sub> O <sub>3</sub> + Pr <sub>6</sub> O <sub>11</sub> as % of TREO (%)
	Proved	4.69	0.99	0.38	39
	Probable	12.00	0.93	0.34	36
	Total	16.69	0.95	0.35	37
	<b>Contained (kt)</b>		<b>138</b>	<b>49</b>	<b>–</b>

The established Yangibana Mineral Resources are 86% within tenements held 100% by Hastings. The remaining 14% are within tenements controlled 70% by Hastings. Hasting’s 100% owned Brockman Project also hosts JORC resources totalling 41.4 Mt at 0.21% Total Rare Earths Oxides (TREO).

<p><b>Project Status</b> Pre-Construction (Feasibility Study competed in 2017. Updated economics completed in February 2022)</p>	<p><b>Pre-tax IRR:</b> 26%</p>	<p><b>Product &amp; Annual Production Rate</b></p> <ul style="list-style-type: none"> <li>• Concentrate (59% TREO): (35,000 tpa)</li> <li>• Mixed Rare Earth Carbonate: 15,000 tpa</li> <li>• Contained TREO: 8,500 tpa</li> <li>• Contained NdPr Oxide: 3,400 tpa</li> </ul>
<p><b>Offtake Available</b> Yes</p>	<p><b>Capital Cost:</b> A\$658m, including contingency.</p>	
<p><b>Min Mine Life (Yrs)</b> 15</p>	<p><b>Post-tax NPV<sub>5%</sub>:</b> A\$1,012m ASX release 21 February 2022</p>	

# Re

Rhenium

## Merlin

Chinova Resources

Unlisted Company • [www.chinovaresources.com](http://www.chinovaresources.com)



The Project is currently under care and maintenance. Chinova welcomes discussions with investors and offtake partners.

The Merlin Project is based on the world's highest-grade molybdenum and rhenium deposit. The Project is anticipated to mine and process a nominal 500,000 tpa ore at peak production via a combination of Long Hole Open Stopping (LHOS) and Drift and Fill (DAF) underground mining methods over a 13-year mine life. Ore will be treated by an on-site concentrator using a floatation process to produce a molybdenum-rhenium concentrate as well as a low-grade copper-gold flotation concentrate. The molybdenum-rhenium concentrate will then require refining using a specialised roaster to produce Ferro-molybdenum, as well as rhenium in the form of ammonium perrhenate. An exploration decline and cross-cut into the high-grade Little Wizard Zone was completed in 2012. The Merlin Molybdenum / Rhenium Feasibility Study was completed in November 2014 and although the viability of the project was considered promising, a subsequent downturn in the molybdenum prices caused the project to be placed into care and maintenance in 2015. Merlin is a construction ready Molybdenum/ Rhenium mining project ready to take advantage of an upturn in prices of these metals.

### Mineral inventory

Commodity(ies):	Rhenium, Molybdenum, Copper				
<b>Mineral Resources as at November 14</b>	Resource Category	Tonnes (Mt)	Mo (%)	Re (ppm)	Cu (%)
	Measured	0.8	2.30	34	0.3
	Indicated	4.2	1.50	26	0.2
	Inferred	1.4	1.10	24	0.5
	<b>Total</b>	<b>6.4</b>	<b>1.50</b>	<b>26</b>	<b>0.3</b>
	<b>Contained (kt)</b>		<b>96</b>	<b>0.17</b>	
<b>Ore Reserves as at November 14</b>	Reserve Category	Tonnes (Mt)	Mo (%)	Re (ppm)	Cu (%)
	Proved	-	-	-	-
	Probable	5.2	1.30	22	0.24
	<b>Total</b>	<b>5.2</b>	<b>1.30</b>	<b>22</b>	<b>0.24</b>
	<b>Contained (kt)</b>		<b>68</b>	<b>0.12</b>	<b>12.5</b>



#### Project Status

Care & Maintenance Feasibility Study completed in 2014



#### Offtake Available

N/A



#### Min Mine Life (Yrs)

13



#### Post-tax IRR:

35%<sup>1</sup>

#### Capital Cost:

A\$162m<sup>1</sup>

#### Post-tax NPV<sub>8%</sub>:

A\$509m<sup>1</sup>

1. Updated Economics (Oct 2022) Mine and Concentrator only, based on prices consisting of:

- Mo = US\$15.00/lb
- Re = US\$1,590/kg
- A\$1 = US\$0.65



#### Product & Annual Production Rate

- **Molybdenum-Rhenium Concentrate (54.5% Mo, 0.095% Re):** 12,600 tpa
- **Molybdenum in Concentrate:** 5,300 tpa
- **Rhenium in Concentrate:** 7 tpa
- **Low-grade copper-gold flotation concentrate (15% Cu, 0.07 ppm Au):** 600 tpa



**Sc**

Scandium

## Nyngan Scandium

Scandium International Mining Corp.

TSX-listed (SCY) • www.scandiummining.com



*As the world's first scandium only mining project, Scandium International Mining Corp., welcomes discussion regarding financing of the project construction or scandium product offtake agreements. The Company is actively progressing offtake agreements focusing on aluminium-scandium master alloy sales.*

The Nyngan Scandium Project based on a shallow and surface-mineable lateritic clay deposit with an attractive scandium enrichment, but relatively little other mineral enrichment. Commercial activity in the area is predominantly farming and mining (copper/gold/silver). Annual mining activity will be conducted in short campaigns lasting 4-6 weeks each. Mining and ore sizing will produce feedstock for a continuous high-pressure acid leach autoclave system (HPAL), followed by a solvent extraction (SX) concentration of scandium. Final oxide product is made through an oxalate stage, calcine finish, and packaging. All of this product recovery, refinement and packaging is planned as mine site activity, to produce a saleable oxide product ( $\text{Sc}_2\text{O}_3$ , or scandia). The process flowsheet resembles a conventional laterite recovery system, most comparable to nickel processes. Considerable bench scale and small pilot metallurgical test work has been conducted with third party laboratories to finalise the flowsheet and SX specifics. An independent Feasibility Study (NI 43-101) was completed in 2016 by Lycopodium (Brisbane). The Feasibility Study considered a 20-year project and utilised approximately 8.5% of the total established mineral resource (M&I), grading 409ppm Sc average over the phase 1 project period. A pilot testwork program completed in 2020 assessed production of aluminium-scandium master alloy (Al-Sc2%) from scandium oxide using SCY's proprietary process. A patent was awarded to SCY in 2021 for this process.

### Mineral inventory

Commodity(ies):	Scandium		
<b>Mineral Resources as at May 16</b>	<b>Resource Category</b>	<b>Tonnes (Mt)</b>	<b>Sc (ppm)</b>
	Measured	5.7	256
	Indicated	11.2	225
	Inferred	-	-
	<b>Total</b>	<b>16.9</b>	<b>235</b>
	<b>Contained (kt)</b>		<b>4.0</b>
<b>Ore Reserves as at May 16</b>	<b>Reserve Category</b>	<b>Tonnes (Mt)</b>	<b>Sc (ppm)</b>
	Proved	0.8	394
	Probable	0.6	428
	<b>Total</b>	<b>1.4</b>	<b>409</b>
	<b>Contained (kt)</b>		<b>0.6</b>

**Project Status**

Feasibility Study

**Post-tax IRR:**

33%

**Product & Annual Production Rate**

• **Scandium Oxide ( $\text{Sc}_2\text{O}_3$ ):** 38.3 tpa  
(Also potential to further refine scandium oxide to produce aluminum-scandium master alloys)

**Offtake Available**

Yes

**Capital Cost:**

US\$87m

**Min Mine Life (Yrs)**

20

**Post-tax NPV<sub>8%</sub>:**

US\$225m

# Si

Silicon

## Arrowsmith North Silica Sand

VRX Silica Limited

ASX-Listed (VRX) • [www.vrxsilica.com.au](http://www.vrxsilica.com.au)



VRX Silica (ASX: VRX) has four high-grade, low impurity silica sand projects in Western Australia boasting multi-decade scale contiguous sand deposits with a combined +1.1b tonne Mineral Resource of 99.6% to 99.7% SiO<sub>2</sub> grade silica sand. Arrowsmith North Project is the first project to be developed. Silica sand is the raw material required to produce critical silicon components to meet global decarbonisation commitments, including EV glass, fillers, resins, paints and high tensile fibreglass yarn. Global supplies of silica sand are dwindling rapidly, particularly in Asia. Offtake has been agreed for export to the South Korean foundry market subject to final approvals and pricing.

Arrowsmith North is located 270km north of Perth adjacent to highway and rail connections to Geraldton Port. It is the most advanced of VRX's projects, with purchasing of key equipment having commenced in May 2022 and production anticipated to commence in 2023. Mining Leases have been granted. Native Title Agreements are in place. Environmental and mining approvals are well advanced with completion expected early 2023. Exploration, metallurgical testwork, process circuit design and detailed engineering has been completed. Loose sand is mined from the surface to 8-12m deep with FEL's feeding a mobile trommel and progressive rehabilitation. Sand will be processed on site including; screening, attritioning, flotation and classification to produce a range of products including glassmaking sand and three foundry sand. By-product sand to be sold locally.

### Mineral inventory

Commodity(ies):	Silica Sand						
<b>Mineral Resources as at October 22: (no cut-off grade applied):</b>	Resource Category	Tonnes (Mt)	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)	LOI (%)
	Measured	10	95.9	1.9	0.7	0.3	0.7
	Indicated	237	97.7	1.00	0.40	0.20	0.50
	Inferred	521	98.2	0.80	0.30	0.20	0.40
	<b>Total</b>	<b>768</b>	<b>98.0</b>	<b>0.90</b>	<b>0.30</b>	<b>0.20</b>	<b>0.40</b>
<b>Ore Reserves (saleable product) as at October 22</b>	Reserve Category	Total Mt	AFS20 Mt	AFS35/NF500 Mt	AFS55 Mt	Local Mt	
	Proven	9.2	0.8	3.9	2.7	1.8	
	Probable	211.8	24.2	102.5	51.1	34.1	
	<b>Total</b>	<b>221.0</b>	<b>25.0</b>	<b>106.4</b>	<b>53.8</b>	<b>35.9</b>	

See tech data on Reserve products <https://vrxsilica.com.au/resources/tech-sheets/>



#### Project Status

Pre-Construction



#### Post-tax IRR:

79% (ungeared)



#### Product & Annual Production Rate

• Silica sand at 99.7% SiO<sub>2</sub> and 500ppm Fe<sub>2</sub>O<sub>3</sub> (foundry and glassmaking sand): 2 mtpa



#### Offtake Available

Yes, subject to final approvals  
From 2023 (anticipated)

#### Capital Cost:

Arrowsmith North  
A\$28.6m (2019 estimate)



#### Min Mine Life (Yrs)

25 years

#### Post-tax NPV<sub>10%</sub>:

A\$242m (ungeared)

**Beharra**

Perpetual Resources Ltd

ASX-Listed (PEC) • [www.perpetualresourceslimited.com.au](http://www.perpetualresourceslimited.com.au)

Beharra is the lowest known impurity silica sand project in the Mid West region of Western Australia. Perpetual completed a Pre-Feasibility Study in 2021 on the production of 1.5 mtpa high grade silica sand from the Beharra Project, delivering a 55% ungeared post-tax IRR. Perpetual has undertaken additional metallurgical test work while completing detailed discussions with potential offtake partners, prior to finalising funding and a Definitive Feasibility Study on the Project, expected around mid CY23. Perpetual is open to an investment in Company and/or Project Equity as well as a sensible level of debt funding to provide funding for project execution.

The Beharra project is located 96km south of the deep water port town of Geraldton, which is the point of export of Beharra silica sand. Beharra aims to ship +1.5 mtpa of >99.5% SiO<sub>2</sub> purity silica sand with low impurities, targeting the high-end float and cover glass markets in Asia. The Beharra orebody is free-flowing material and will be mined using dozers and front-end loaders. The silica sand will be processed using simple conventional gravity and magnetic separation techniques, with the end product trucked on sealed roads from mine to port. The environmental footprint is small as the orebody is progressively mined and rehabilitated and Perpetual has developed an exceptional relationship with the local indigenous group. All environmental impacts are considered low. The Beharra exploration license is only 40% explored with significant upside potential.

**Mineral inventory**

Commodity(ies):	Silica						
<b>Mineral Resources as at 9 March 21 (no cut-off grade applied)</b>	Resource Category	Tonnes (Mt)	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)	LOI (%)
	Measured	139.0	98.6	0.42	0.23	0.35	0.24
	<b>Total</b>	<b>139.0</b>	<b>98.6</b>	<b>0.42</b>	<b>0.23</b>	<b>0.35</b>	<b>0.24</b>
	<b>Contained (kt)</b>		<b>137,054</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>
<b>Ore Reserves as at 17 March 21 (no cut-off grade applied)</b>	Reserve Category	Tonnes (Mt)	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)	LOI (%)
	Probable – In-situ	64.1	98.6	0.42	0.20	0.35	0.24
	Probable – Saleable Product	47.6	99.6	0.18	0.028	0.035	0.1
	<b>Contained (kt)</b>		<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>

Note: The Saleable Products Ore Reserve shown above is the saleable product reserve recoverable from the in-situ ore reserve. The saleable product ore reserve is a subset of the in-situ reserve and they are not additive.

**Project Status**

Pre-Feasibility Study

**Post-tax IRR:**

55% (ungeared)

**Product & Annual Production Rate**

- High Grade Silica Sand (>99.5% SiO<sub>2</sub> with low impurities <200ppm Fe<sub>2</sub>O<sub>3</sub>): >1.5 million tpa

**Offtake Available**

Yes – available from 2HCY23

**Capital Cost:**

A\$39m

**Min Mine Life (Yrs)**

32 years

**Post-tax NPV<sub>10%</sub>:**

A\$231m (ungeared)



## Cape Flattery Silica Sand

Metallica Minerals Ltd

ASX-Listed (MLM) • [www.metallicaminerals.com.au](http://www.metallicaminerals.com.au)



Metallica Minerals (ASX: MLM) welcomes interest from potential offtake partners interested in securing a high-purity silica sand product from its highly prospective Cape Flattery Silica Project in Far North Queensland. The Company is also interested in discussing strategic investment opportunities to support the commercialisation of the Project. First Silica Sand production from the project is forecast to be in the first half of 2025.

Metallica's Cape Flattery Silica Sand Project (CFS) is being progressed in the world class silica sand region of Cape Flattery. The Pre-Feasibility Study, completed in 2022, confirms the CFS Project's potential as a long-life producer of high-quality silica sand for the burgeoning Asia-Pacific glass manufacturing markets supplying the solar panel industry. The project includes shallow open-cut sand extraction using wheel loaders. Approximately 1.85Mtpa sand will be slurry pumped to the processing plant which will reduce heavy mineral  $\text{Fe}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3$  contaminants via screening, gravity separation, attritioning and potentially magnetic separation, producing approximately 1.35Mtpa high purity silica sand product. Product will be trans-shipped to export markets via a barge loading facility to be constructed nearby to the CFS. The Queensland government has determined the CFS as a "Project of Regional Significance" under the Water Plan (Cape York) 2019 and MLM has signed a MOU with Ports North for establishing a jetty within the port precinct. The Company is currently undertaking a Definitive Feasibility Study and advancing numerous studies, approval processes and stakeholder engagement activities that are key components of the project's development.

### Mineral inventory

Commodity(ies):	Silica Sand					
<b>Mineral Resources as at 7 April 22 (98.5% <math>\text{SiO}_2</math> cut-off)</b>	Resource Category	Tonnes (Mt)	$\text{SiO}_3$ (%)	$\text{Fe}_2\text{O}_3$ (%)	$\text{Al}_2\text{O}_3$ (%)	LOI (%)
	Measured	16.7	99.29	0.10	0.08	0.18
	Indicated	35.2	99.15	0.13	0.13	0.19
	Inferred	0.3	99.26	0.14	0.16	0.18
	<b>Total</b>	<b>52.2</b>	<b>99.18</b>	<b>0.12</b>	<b>0.11</b>	<b>0.19</b>
	<b>Contained (kt)</b>		<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>
<b>Ore Reserves as at 21 March 22 (98.5% <math>\text{SiO}_2</math> cut-off)</b>	Reserve Category	Tonnes (Mt)	$\text{SiO}_3$ (%)	$\text{Fe}_2\text{O}_3$ (%)	$\text{Al}_2\text{O}_3$ (%)	LOI (%)
	Probable	46.0	99.18	0.12	0.11	0.19
	<b>Total</b>	<b>46.0</b>	<b>99.18</b>	<b>0.12</b>	<b>0.11</b>	<b>0.19</b>
	<b>Contained (kt)</b>		<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>

Note: Ore Reserves are on an In-Situ basis.



#### Project Status

Pre-Feasibility Study



**Pre-tax IRR:** 34.9%<sup>1</sup>

**Post-tax IRR:** 27.1%<sup>1</sup>



#### Product & Annual Production Rate

• **High Grade Silica Sand (99.19%  $\text{SiO}_2$ , 120ppm  $\text{Fe}_2\text{O}_3$ ):**  
Up to 1.35 mt



#### Min Mine Life (Yrs)

25

#### Capital Cost:

A\$79.4m<sup>1</sup>

#### Post-tax NPV<sub>8%</sub>:

A\$290.1m<sup>1</sup>

1. 21 March 2022 Pre-Feasibility Study

## Si

Silicon

## Galalar Silica Sand

Diatreme Resources Ltd

ASX-Listed (DRX) • www.diatreme.com.au



Diatreme is seeking suitable project partners, whether for investment or offtake, for its high-grade silica sand projects in Far North Queensland. This includes partners for potential downstream processing opportunities in Townsville, Qld.

The Galalar Silica Sand Project (GSSP) is a high-grade silica sand project located around 20km north of Cooktown, Qld. The project lies within the same sand dune system and in close proximity to the world's largest operating silica sand mine at Cape Flattery. The GSSP Pre-Feasibility Study completed in November 2021 showed the potential to develop a long-life, low capex and highly profitable operation with attractive economics. Significantly, the project is expected to contribute more than A\$800m to the local economy in wages, royalties and taxes, including substantial economic benefits for traditional owners. The GSSP's high-purity, low iron silica sand resource of 75Mt is part of a total resource of around 200Mt of high-grade silica sand across Diatreme's Galalar and adjacent Northern Silica Project. Approximately 1.59Mtpa sand will be mined in a shallow free-dig open pit with progressive rehabilitation. Sand will be mined by wheel-loader and fed through a screener, then pumped as a slurry to the processing plant for further screening, gravity separation, attritioning, classification, magnetic separation, washing and dewatering to produce a high purity silica sand suitable for photovoltaic glass manufacturing. The Galalar project's high grade product satisfies the required specifications for the booming solar PV and other specialty glass markets, supporting the global decarbonisation drive.

## Mineral inventory

Commodity(ies):	Silica sand				
<b>Mineral Resources as at 13 September 21 (98.5% SiO<sub>2</sub> cut-off)</b>	Resource Category	Silica Sand Tonnes (Mt)	SiO <sub>2</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)
	Measured	43.12	99.21	0.09	0.11
	Indicated	23.12	99.16	0.09	0.13
	Inferred	9.22	99.10	0.11	0.16
	<b>Total</b>	<b>75.46</b>	<b>99.18</b>	<b>0.09</b>	<b>0.12</b>
	<b>Contained (kt)</b>	<b>74,841</b>			
<b>Ore Reserves as at 9 November 21 (98.5% SiO<sub>2</sub> and 1200ppm Fe<sub>2</sub>O<sub>3</sub> cut-off's)</b>	Reserve Category	Silica Sand Tonnes (Mt)	SiO <sub>2</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)
	Probable	32.5	99.20	0.08	0.11
	<b>Total</b>	<b>32.5</b>	<b>99.20</b>	<b>0.08</b>	<b>0.11</b>
	<b>Contained (kt)</b>	<b>32,240</b>			

Note: Ore Reserves are on an In-Situ basis.

**Project Status**

Pre-Feasibility Study

**Pre-tax IRR:** 74%<sup>1</sup>**Post-tax IRR:** 66%<sup>1</sup>**Capital Cost:**Initial capex estimated at A\$60.1m<sup>1</sup>**Pre-tax NPV<sub>8%</sub>:** A\$495m<sup>1</sup>**Post-tax NPV<sub>8%</sub>:** A\$358m<sup>1</sup>A\$290.1m<sup>1</sup>**Product & Annual Production Rate**

- High-grade silica sand (99.9% SiO<sub>2</sub>, <110 ppm Fe<sub>2</sub>O<sub>3</sub>): 1.26 Mtpa

**Offtake Available**

Yes

**Min Mine Life (Yrs)**

23.5

1. November 2021 Pre-Feasibility Study

# Si

Silicon

## Muchea Silica Sand Project

VRX Silica Limited

ASX-Listed (VRX) • [www.vrxsilica.com.au](http://www.vrxsilica.com.au)



VRX Silica (ASX: VRX) has four high-grade, low impurity silica sand projects in Western Australia boasting multi-decade scale, contiguous sand deposits with a combined +1.1b tonne Mineral Resource of 99.6% to 99.9% SiO<sub>2</sub> grade silica sand. The high-grade Muchea Project is the second project to be developed. Silica sand is the raw material required to produce critical silicon components to meet global decarbonisation commitments, including silicon metal, gel and carbide, and ultra-clear solar panel glass. Further downstream processing can produce optical fibre, lamp tubing, laboratory glass, and pharmaceutical glass. Global supplies of silica sand are dwindling rapidly, particularly in Asia. Demand for Muchea offtake is substantial, with interest far exceeding current estimated production capacity.

Muchea is located 50km north of Perth, adjacent to highway and rail connections to Kwinana Port and adjacent energy infrastructure. It is one of a few world-class silica sand projects with an outstanding high-grade purity of 99.9% SiO<sub>2</sub> and <150ppm Fe<sub>2</sub>O<sub>3</sub>. This is essential to produce ultra-clear solar panel glass. Burgeoning uptake of solar panels is expected to drive exponential growth in demand for high quality silica sand. One Mining Lease has been granted with a second under application. Native Title Agreements are in place. Environmental studies have been completed. Exploration, metallurgy and process circuit design is complete and detailed engineering is underway. Loose sand is mined from the surface to 12-20m deep with FEL's feeding a mobile trommel and progressive rehabilitation. Sand will be processed on site including, screening, attritioning, flotation and classification to produce high-grade (99.9% SiO<sub>2</sub>) low iron sand.

### Mineral inventory

Commodity(ies):	Silica Sand						
Mineral Resources as at October 19 (no cut-off applied)	Resource Category	Tonnes (Mt)	SiO <sub>2</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	TiO <sub>2</sub> (%)	LOI (%)
	Indicated	29	99.6	0.09	0.03	0.07	0.22
	Inferred	172	99.6	0.05	0.02	0.10	0.23
	<b>Total</b>	<b>208</b>	<b>99.6</b>	<b>0.06</b>	<b>0.02</b>	<b>0.10</b>	<b>0.23</b>
Ore Reserves (saleable product) as at October 19	Reserve Category	Total Mt	F80 Mt	F80C Mt	F150 Mt		
	Probable	18.7	10.2	4.3	4.3		
	<b>Total</b>	<b>18.7</b>	<b>10.2</b>	<b>4.3</b>	<b>4.3</b>		

See tech data on Reserve products <https://vrxsilica.com.au/resources/tech-sheets/>



#### Project Status

Feasibility Study completed in 2019



#### Offtake Available

Yes – Muchea production 2024 (anticipated)



#### Min Mine Life (Yrs)

25 years



#### Post-tax IRR:

96% (ungeared)

#### Capital Cost:

A\$32.8m (2019 estimate)

#### Post-tax NPV<sub>10%</sub>:

A\$338m (ungeared)



#### Product & Annual Production Rate

• High grade silica sand at 99.9% SiO<sub>2</sub> with <150ppm Fe<sub>2</sub>O<sub>3</sub>: 2 Mtpa

## Balranald

Iluka Resources Ltd

ASX-listed (ILU) • [www.iluka.com](http://www.iluka.com)



Balranald is a rutile-rich deposit in the northern Murray Basin, New South Wales. Owing to the deposit's depth, Iluka is assessing the potential to develop Balranald via a novel, internally developed, underground mining technology. One potential benefit of this approach is lower expected environmental impacts.

Iluka is developing a novel underground mining method to access the Balranald deposits, which are located ~60 metres underground. A third trial of this technology was completed in late 2020, confirming the effectiveness of the underground mining method and validating key elements of the mining unit design. A Definitive Feasibility Study on the project was commenced by Iluka in August 2021 and is scheduled for completion in late 2022. If executed, the Balranald project will produce a heavy mineral concentrate, which Iluka plans to transport to its Narngulu mineral separation plant at Geraldton for processing. Rutile and zircon will be sold as final products. Ilmenite from Balranald will either be sold or transported for upgrading at Iluka's synthetic rutile kilns at Capel. The rare earth bearing minerals monazite and xenotime produced as a co-product of the mineral separation process at Narngulu has the potential to be transported for further value addition at Iluka's fully integrated rare earths refinery at Eneabba.

### Mineral inventory

Commodity(ies):	Zircon, Titanium feedstocks (rutile; ilmenite), Rare Earth Elements					
Resource Category	Tonnes (Mt)	Total HM (%)	Ilmenite Grade (%)	Zircon Grade (%)	Rutile Grade (%)	Monazite + Xenotime (%)
	<b>Nepean</b>					
Indicated	8.4	27.5	59.8	14.4	14.5	1.1
Inferred	0.8	11.2	57.3	14.6	14.0	1.2
<b>West Balranald</b>						
Measured	11.9	31.9	64.1	10.8	12.2	1.0
Indicated	19.9	35.1	64.3	11.3	12.2	0.9
Inferred	4.5	26.5	62.4	8.3	9.4	0.7
<b>Total</b>	<b>45.5</b>	<b>31.6</b>	<b>63.3</b>	<b>11.4</b>	<b>12.3</b>	<b>0.9</b>
<b>Contained (kt)</b>	<b>14,400</b>	<b>9,100</b>	<b>1,700</b>	<b>1,800</b>	<b>130</b>	

Please refer to Iluka's website [www.iluka.com](http://www.iluka.com) for further detail in Mineral Resource and Ore Reserve statements. The Balranald Project comprises the West Balranald and Nepean Deposits only.



#### Project Status

Pre-Feasibility Study



#### Post-tax IRR:

N/A



#### Product & Annual Production Rate

• **Per mining unit:** ~180 ktpa to ~200 ktpa concentrate<sup>1</sup>.

#### • Resource Assemblage:

Zircon ~11%

Rutile ~12%

Ilmenite ~63%

Monazite/Xenotime ~1%



#### Offtake Available

To be determined

#### Capital Cost:

N/A



#### Min Mine Life (Yrs)

Anticipated to be 8-14 years.<sup>1</sup>

#### Post-tax NPV:

N/A

1. HMC production subject to study outcomes, mine plan and HM grade. The number of units are scalable.



## Barrambie

Neometals Ltd

ASX-listed (NMT) • [www.neometals.com.au](http://www.neometals.com.au)



With one of the world's largest and highest grade hard-rock titanium and vanadium deposits, Neometals Ltd welcomes discussions regarding project equity ownership, joint venturing, project financing and offtake for the Barrambie project. The project is mine-ready with significant Mineral Resource, Pre-Feasibility Study and Ore Reserve completed in November 2022, granted mining lease, mining proposal and Ministerial Approval to construct a mine and processing plant. Further, Neometals has an offtake MoU with Chinese company, Jiuxing Titanium Materials (Liaoning) Co. Ltd for baseload offtake arrangements.

Barrambie is unique owing to its exceptionally high-grade titanium resource coupled with high vanadium content and the weathered nature of the orebody (low contaminants). A number of flow sheets and target markets have been evaluated to maximise potential viability. The Barrambie Pre-Feasibility Study is based on a conventional open pit mining of 2.14Mtpa (LOM ave) ore supplying an on-site Crush Mill Beneficiation (CMB) Plant producing a mixed titanium/vanadium/iron gravity concentrate. The mixed gravity concentrate will be transported to a Low Temperature Roast (LTR) and Magnetic Beneficiation Plant near Geraldton which will produce separate ilmenite and iron-vanadium concentrate via a low-temperature reductive roast step. Ilmenite and iron-vanadium concentrate will be exported via the port of Geraldton. Offtakers will likely utilise the ilmenite in the titanium pigment process, or target the ilmenite contained in the mixed gravity concentrate (an intermediate product contemplated in the PFS) in a smelting process to produce a chloride-grade titanium slag as well as an iron vanadium product. Titanium slag is an intermediate product used to feed the fast-growing demands of the Chinese pigment market.

### Mineral inventory

**Commodity(ies):** Titanium, Vanadium

Global Mineral Resources as at 17 April 18 (0.2% V <sub>2</sub> O <sub>5</sub> or 10% TiO <sub>2</sub> cut-off)				High-Grade TiO <sub>2</sub> Mineral Resources (14% TiO <sub>2</sub> cut-off)				Note: The High-Grade Titanium Mineral Resource is a sub-set of the total Global Mineral Resource stated above. These figures are not additive and are reporting the same block model volume but using different cut-off grades.
Resource Category	Tonnes (Mt)	TiO <sub>2</sub> (%)	V <sub>2</sub> O <sub>5</sub> (%)	Resource Category	Tonnes (Mt)	TiO <sub>2</sub> (%)	V <sub>2</sub> O <sub>5</sub> (%)	
Indicated	187.1	9.61	0.46	Indicated	39.3	21.18	0.65	Note: Cut-off is based on net value (revenue minus selling, processing, administration and incremental ore mining costs) > \$0/t on a diluted block-by-block basis from the parameters used in the pit optimisation. Ore Reserves reported are within the Mineral Resource estimates. This relates roughly to a 10% TiO <sub>2</sub> cut-off.
Inferred	93.0	8.31	0.40	Inferred	14.3	21.15	0.58	
<b>Total</b>	<b>280.1</b>	<b>9.18</b>	<b>0.44</b>	<b>Total</b>	<b>53.6</b>	<b>21.17</b>	<b>0.63</b>	
<b>Contained (kt)</b>	<b>25,713</b>	<b>1,232</b>		<b>Contained (kt)</b>	<b>11,347</b>	<b>338</b>		

Ore Reserves as at 17 November 22	Reserve Category	Tonnes (Mt)	TiO <sub>2</sub> (%)	V <sub>2</sub> O <sub>5</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)
		Probable	44.5	18.7	0.61
	Total	44.5	18.7	0.61	44.1
	<b>Contained (kt)</b>	<b>8,322</b>	<b>271</b>	<b>19,625</b>	



#### Project Status

Pre-Feasibility Study on ilmenite and iron-vanadium concentrate production.



#### Pre-tax IRR:

25%

#### Capital Cost:

A\$432.1m

#### Pre-tax NPV<sub>10%</sub>:

AS\$391m



#### Product & Annual Production Rate

##### • Ilmenite (52% TiO<sub>2</sub>):

416 ktpa LOM Ave (579 ktpa for first ten years).

##### • Iron-Vanadium Concentrate (58.9% FeT, 1.58% V<sub>2</sub>O<sub>5</sub>):

456 ktpa LOM Ave

(402 ktpa for first ten years)



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

21

## Coburn (Amy)

Strandline Resources Ltd

ASX-listed (STA) • www.strandline.com.au



Strandline's is currently developing its 100%-owned Coburn project in WA with commissioning now underway. The project is set to benefit from strong long term mineral sands commodity prices and is forecast to generate robust operating margins over its multi-decade mine life. Coburn is fully-funded through to production and cashflow with a favourable finance structure comprised of a combination of long-tenor debt provided by NAIF (A\$150m) and a US\$60 million Bond Issue, together with the Company's strong cash position. Strandline has secured 6 sales contracts covering 100% of production revenue for the first 5 years of operation. Investor and offtake discussions are welcome.

Coburn is a world-scale mineral sands project, with a high-value product suite, low cost operation and strong financial returns. Project features include:

- Located in WA, close to Geraldton's bulk export port.
- Conventional open pit shallow dry mining with progressive backfill and full rehabilitation.
- Proven mining and processing technology combined with modern renewable energy.
- A Wet Concentrate Plant (WCP) will produce high-grade (95%) saleable Heavy Minerals Concentrate (HMC) using high-capacity gravity separation & classification.
- The HMC will be processed in a Mineral Separation Plant (MSP), using electrostatic separation, gravity and magnetic fractionation to produce a high-value product suite comprising premium zircon, zircon concentrate, rutile and a chloride ilmenite product.
- Commissioning is underway, with first production forecast for December Quarter 2022.
- Coburn will generate significant socio-economic benefits, indigenous and enterprise opportunities over its long life.

### Mineral inventory

Commodity(ies):	Titanium, Zirconium, Monazite containing rare earths						
<b>Mineral Resources as at 14 November 18 (0.8% HM cut-off)</b>	Resource Category	Tonnes (Mt)	Total HM (%)	Ilmenite (%)	Zircon (%)	Rutile (%)	Leucoxene (%)
	Measured	119	1.3	45	24	5	6
	Indicated	607	1.3	48	22	7	5
	Inferred	880	1.2	49	21	7	4
	<b>Total</b>	<b>1,606</b>	<b>1.2</b>	<b>48</b>	<b>22</b>	<b>7</b>	<b>5</b>
	<b>Contained (kt)</b>	<b>19,604</b>	<b>9,468</b>	<b>4,239</b>	<b>1,342</b>	<b>891</b>	<b>4,418</b>
	<b>Ore Reserves as at 16 April 19</b>	Reserve Category	Tonnes (Mt)	Total HM (%)			
Proved		106	1.10				
Probable		417	1.12				
<b>Total</b>		<b>523</b>	<b>1.11</b>				
<b>Contained (kt)</b>		<b>5,828</b>					



**Project Status**  
Construction



**Post-tax IRR:**  
28%



**Product & Annual Production Rate**

- **Premium zircon:** (66% ZrO<sub>2</sub>) 34 ktpa
- **Zircon concentrate:** (28% ZrO<sub>2</sub>, 7% TiO<sub>2</sub> and monazite) 54 ktpa
- **Chloride grade Ilmenite:** (62% TiO<sub>2</sub>) 110 ktpa
- **Rutile-leucoxene:** (93% TiO<sub>2</sub>) 24 ktpa



**Offtake Available**  
Yes, after 5 years of production

**Capital Cost:**  
A\$260m + financing costs



**Min Mine Life (Yrs)**  
22.5

**Post-tax NPV<sub>8%</sub>:**  
A\$463m

## Copi

RZ Resources Ltd

Unlisted Private Company • [www.rzresources.com](http://www.rzresources.com)



*Copi is one of Australia's largest mineral sand projects which will produce finished products from the companies established Pinkenba Mineral Separation Plant in Queensland for export across the globe. The Company is nearing finalisation of most aspects of the project studies and operations readiness including environmental, land ownership, infrastructure, mining, processing, logistics, market offtake and construction funding. RZ Resources is a 100% privately owned Australian company, is well funded, has zero debt and welcomes discussions on investment in the company, project and/or offtake.*

The RZ Resources Copi Mine will produce Zircon, Rutile, Leucoxene, Ilmenite, Monazite and Xenotime from its operation ready process plant in Pinkenba Queensland which has a long history of producing the global benchmark on these products. Uses for the products include life critical minerals such as ceramics, pigments, energy, high-end aviation, automotive and medical markets.

The Project consists of an open-cut wet dredge mining and processing facility utilising the unpotable salt brine which removes the heavy minerals via gravity separation to produce heavy mineral concentrates. The heavy mineral concentrates will be transported via rail and road to the company's Pinkenba Mineral Separation Plant in Queensland for conversion into final products using electrostatic, gravity and magnetic fractionation to final product exported to the world via Brisbane port.

RZ Resources is currently preparing submission of its environmental approvals in 2022 followed by mining approvals. The Project will be development-ready pending approvals in 2023.

### Mineral inventory

Commodity(ies):		Titanium, Zirconium, Monazite and Xenotime							
Mineral Resources as at December 21	Resource Category	Tonnes (Mt)	Total HM (%)	Ilmenite (%)	Zircon (%)	Rutile (%)	Leucoxene (%)	Monazite (%)	Xenotime (%)
		Measured	-	-	-	-	-	-	-
	Indicated	549	2.0	40	13.2	9.6	22	0.84	0.11
	Inferred	646	0.7	41	13.3	9.2	22	0.84	0.13
	<b>Total</b>	<b>1,195</b>	<b>1.3</b>	<b>40</b>	<b>13.3</b>	<b>9.5</b>	<b>22</b>	<b>0.84</b>	<b>0.12</b>
	<b>Contained (kt)</b>		<b>15,535</b>	<b>6,214</b>	<b>2,066</b>	<b>1,476</b>	<b>3,418</b>	<b>130</b>	<b>18</b>



**Project Status**  
Feasibility Study



**Pre-tax IRR:**  
30%



**Product & Annual Production Rate**

- **Zircon:** ~50 ktpa
  - **Zircon in Concentrate:** ~45 ktpa
  - **Rutile and HiTi:** ~45 ktpa
  - **Ilmenite:** ~150 ktpa
  - **Monazite and Xenotime concentrate:** ~5 ktpa
- \*production profile subject to customer product specifications



**Offtake Available**  
Yes

**Capital Cost:**  
~A\$500m



**Min Mine Life (Yrs)**  
>20

**Pre-tax NPV<sub>7%</sub>:**  
~A\$1.0b

# W

## Tungsten

### Dolphin Tungsten Mine

Group 6 Metals Limited

ASX-listed (G6M) • www.g6m.com.au



The following funding has been secured for the Project:

	A\$ million
Debt with Warrants	29.0
Debt without Warrants	4.0
Tasmanian Government Loan	10.0
Leasing Facility	10.2
Equity Subscription – Sophisticated and Institutional Shareholders	14.3
Equity Subscription – Existing Major Shareholders	11.0
Shareholder Purchase Plan	5.7
<b>TOTAL</b>	<b>84.2</b>

Offtake agreements are in place with Wolfram Bergbau und Hutten AG and Traxys for 65% of the first 4 years of production. Circa 20% of the offtake remains available.

Between 1917 and 1990, the Dolphin Tungsten Mine (DTM), together with the adjacent Bold Head Mine, mined some 10Mt of tungsten ore at 0.67% WO<sub>3</sub>. Mining was conducted by both open-cut and underground methods. Under construction and targeting first concentrate production in March 2023, the redevelopment plan includes open-cut mining producing around 400,000tpa for the first 8 years, followed by underground mining expected to produce around 300,000tpa for a further 6 years, producing an average of 3,690tpa of Tungsten concentrate at >63% WO<sub>3</sub> for an initial 14 years. There is potential to extend the mine life at Bold Head as satellite mining operation. There is significant exploration upside via an exploration lease covering 67km<sup>2</sup> surrounding the DTM mining lease. Ore will be crushed and processed, primarily through a gravity circuit, supplemented by a simple flotation circuit to produce a tungsten concentrate for export through the Port of Grassy, less than one kilometre away. DTM hosts the highest grade known tungsten reserve outside of China. The Project is under construction and is expected to reach nameplate production in July 2023.

### Mineral inventory

Commodity(ies):	Tungsten		
Mineral Resources as at June 19 (0.20% WO <sub>3</sub> cut-off)		Tonnes	WO <sub>3</sub>
	Resource Category	(Mt)	(%)
	Indicated	9.6	0.90
	<b>Contained WO<sub>3</sub> tonnes</b>	<b>86,400</b>	
Ore Reserves as at December 20 (includes open pit reserve at 0.20% WO <sub>3</sub> cut-off and underground reserve at 0.70% WO <sub>3</sub> cut-off)		Tonnes	WO <sub>3</sub>
	Reserve Category	(Mt)	(%)
	Probable	4.4	0.92
	<b>Contained WO<sub>3</sub> tonnes</b>	<b>40,480</b>	



**Project Status**  
Construction



**Pre-tax IRR:**  
43%



**Product & Annual Production Rate**

- **Tungsten concentrate:** (>63% WO<sub>3</sub>): 3,690 tpa
- **Contained WO<sub>3</sub>:** 2,750 tpa (275,000 mtu pa)



**Offtake Available**  
Yes

**Capital Cost:**  
A\$73m – A\$80m



**Min Mine Life (Yrs)**  
14

**Pre-tax NPV<sub>8%</sub>:**  
A\$241m



# W

## Tungsten

### Molyhil

Thor Mining PLC

ASX & AIM listed (THR) • www.thormining.com



The Molyhil deposit is 100% owned by Thor Mining Plc. The project was awarded Major Project status by the Northern Territory Government in 2020. A Feasibility Study in 2018, confirmed the project is technically and economically viable, with strong financial returns and rapid capital payback. Thor Mining Plc is seeking project loan finance, along with equity investment in the company and/or joint venture participation, along with product offtake agreements to progress the development of the Molyhil project.

The Molyhil deposits occurs in two adjacent skarn bodies that contain outcropping scheelite, molybdenite and chalcopyrite mineralisation. A Feasibility Study in 2018 was based on an open pit design, with a mine life of 7 years. Beyond this period, Thor has identified portions of the resource below the pit shell which appear to allow profitable underground mining, thus extending the mine life. In addition the Bonya deposits, approximately 30km from Molyhil, with a JORC 2012 Mineral Resource of 0.74Mt @ 0.21% WO<sub>3</sub> and 0.09% Cu and 0.2Mt @ 2.0% Cu, have the potential to extend the operational life of Molyhil for several years. Mining and processing activities on site will produce tungsten, molybdenum, and copper concentrates for sale using industry standard ore sorting and flotation processing techniques. Recent 3D geological modelling has identified a large magnetic target which has the potential to be an offset extension to the Molyhil mineralisation. Diamond drilling in 2021 intersected a magnetite skarn with weakly disseminated tungsten-molybdenum-copper mineralisation down plunge. Additional magnetite targets to be followed up.

### Mineral inventory

Commodity(ies):	Tungsten, Molybdenum, Copper			
Resource Category	Tonnes	WO <sub>3</sub>	Mo	Cu
	(Mt)	(%)	(%)	(%)
Molyhill Mineral Resources as at 31 March 21 (0.07% WO <sub>3</sub> cut-off)				
Measured	0.46	0.28	0.13	0.06
Indicated	2.98	0.27	0.09	0.05
Inferred	0.99	0.26	0.12	0.03
<b>Total</b>	<b>4.39</b>	<b>0.27</b>	<b>0.10</b>	<b>0.05</b>
<b>Contained (kt)</b>		<b>11,800</b>	<b>4,400</b>	<b>2,190</b>



**Project Status**  
Feasibility Study



**Offtake Available**  
Yes



**Min Mine Life (Yrs)**  
7 plus Bonya



**Post-tax IRR:**  
59%

**Capital Cost:**  
A\$69m

**Post-tax NPV<sub>5%</sub>:**  
A\$101m



**Product & Annual Production Rate**

- **Tungsten Concentrate:** (65% WO<sub>3</sub>): 1,850 tpa
- **Molybdenum Concentrate:** (51.4% Mo):850 tpa
- **Copper concentrates:** minor

# W

## Tungsten

### Mount Lindsay

Venture Minerals Ltd

ASX-listed (VMS) • [www.ventureminerals.com.au](http://www.ventureminerals.com.au)



Venture Minerals completed a Feasibility Study in 2012 on the 100% owned Mount Lindsay tin-tungsten-magnetite project which is located within the world-class mineral province of North-West Tasmania and is one of the largest undeveloped tin-tungsten projects in the world. An updated Underground Mine Feasibility Study is underway, targeting Mount Lindsay to become a responsible producer of tin and tungsten by 2025, with access to renewable hydro and windpower, combined with the commitment to minimising the carbon and environmental footprint, through underground mining and simplified gravity-focused processing strategies. Venture welcomes discussion regarding financing of the project construction and/or offtake.

The 2012 Feasibility Study was based on extracting 1.75Mtpa of tin, tungsten, magnetite and copper bearing ore from a conventional open pit mine with minor underground development from the base of the pit to access some deeper mineralisation. Work completed includes; over 83,000m of diamond core drilling within the Projects two high-grade orebodies defining a significant resource, along with extensive engineering, environmental, hydrogeological and metallurgical studies. The process plant was designed to concentrate magnetite, copper sulfides, tin oxide and scheelite through flotation and/or gravity processing with the scheelite further upgraded to Ammonium Paratungstate, before being trucked to the Port of Burnie for export. The project has access to existing infrastructure. The updated Feasibility Study underway will optimise the higher-grade portions (0.7% SnEq Cut-off: 4.7Mt @ 0.3% WO<sub>3</sub> & 0.4% Sn) of the deposit using a cost effective, gravity-focused, processing flowsheet. Metallurgical drilling in 2021/22 collected over 10 tonnes of sample from the two zones for the metallurgical testing program currently underway.

### Mineral inventory

Commodity(ies):	Tin, Tungsten, Copper, Iron					
<b>Mineral Resources as at 17 October 12 at 0.2% SnEq Cut-off</b>		<b>Tonnes</b>	<b>WO<sub>3</sub></b>	<b>Sn</b>	<b>Cu</b>	<b>Mass Recovery of Magnetic Iron (Fe)</b>
	<b>Resource Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>	<b>(%)</b>	<b>Grade<sup>1</sup> (%)</b>
	Measured	8.1	0.1	0.2	0.1	17
	Indicated	17	0.1	0.2	0.1	15
	Inferred	20	0.1	0.2	0.1	17
	<b>Total</b>	<b>45</b>	<b>0.1</b>	<b>0.2</b>	<b>0.1</b>	<b>17</b>
<b>Contained (kt)</b>		<b>32</b>	<b>81</b>	<b>30</b>	<b>7,520</b>	
<b>Ore Reserves as at 7 November 12</b>		<b>Tonnes</b>	<b>WO<sub>3</sub></b>	<b>Sn</b>	<b>Cu</b>	<b>Mass Recovery of Magnetic Iron (Fe)</b>
	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>(%)</b>	<b>(%)</b>	<b>Grade<sup>1</sup> (%)</b>
	Proved	6.4	0.2	0.2	0.1	18
	Probable	7.3	0.1	0.2	0.1	13
	<b>Total</b>	<b>14.0</b>	<b>0.1</b>	<b>0.2</b>	<b>0.1</b>	<b>15</b>
	<b>Contained (kt)</b>		<b>16</b>	<b>30</b>	<b>14</b>	<b>2,150</b>

1. The mass recovery of the magnetic iron shown is determined mostly by Davis Tube Results. Pilot scale metallurgical testwork for the 2012 Feasibility Study resulted in a recovery for iron in the form of magnetite at 98%, as a saleable concentrate with a grade of 65% Fe.



**Project Status**  
Feasibility Study



**Post-tax IRR:**  
21% (2012 Study)



**Product & Annual Production Rate**

- **Tin concentrate (45-50% Sn):** 5,000 tpa (Tin in Concentrate: 2,350 tpa)
- **APT (Ammonium Paratungstate):** 1,500 tpa
- **Magnetite concentrate (65% Fe):** 240,000 tpa
- **Copper concentrate (~24% Cu):** 3,500 tpa (Cu in concentrate: 800 tpa)



**Offtake Available**  
Yes

**Capital Cost:**  
A\$198m (2012 Study)



**Min Mine Life (Yrs)**  
9 (2012 Study)

**Post-tax NPV<sub>8%</sub>:**  
A\$143m (2012 Study)

# W

## Tungsten

### Mt Mulgine

#### Tungsten Mining NL

ASX-listed (TGN) • [www.tungstenmining.com](http://www.tungstenmining.com)



Tungsten Mining NL (ASX: TGN) is an Australian based resources company whose prime focus is the exploration, acquisition and development of tungsten projects in Australia. The Mt Mulgine Tungsten Project is the cornerstone of the Company's strategic development plan, focused on demonstrating a pathway to long term sustainable mining activities. The immediate focus for the Mt Mulgine project is engaging with potential offtake and development partners to ensure Mt Mulgine fulfills its potential as a major tungsten producer for many years. The company welcomes discussions with strategic investors and offtake partners.

Tungsten Mining's flagship Mt Mulgine tungsten project sits on three granted mining leases, located approximately 350km NNE of Perth in the Murchison Region of Western Australia. The recently completed (January 2021) Pre Feasibility Study confirmed a large scale, long life, low cost mining and processing operation treating 6mtpa of run of mine (ROM) ore, producing 460,000 MTU's of WO<sub>3</sub> annually. In addition, the project will produce by-product concentrates of molybdenum and copper (containing gold and silver). The Mt Mulgine deposits are suitable for open pit mining and will be mined by conventional bulk drill and blast and load and haul methods. The ore will be processed and concentrate recovered using conventional processing methods including crushing, ore sorting, grinding, flotation and gravity. Tailings will be stored in a single wet tailings storage facility. Large diameter drilling to provide a bulk sample for ongoing metallurgical testwork has been completed. Environmental and groundwater studies are continuing. There is no native title, or native title claims over the project footprint.

#### Mineral inventory

Commodity(ies):	Tungsten, Molybdenum, Gold, Silver, Copper							
<b>Mineral Resources as at 4 May 20 (0.05% WO<sub>3</sub> cut-off)</b>	Resource Category	Tonnes (Mt)	WO <sub>3</sub> (%)	Mo ppm	Au g/t	Ag g/t	Cu (%)	
	Measured	-	-	-	-	-	-	
	Indicated	183	0.11	290	0.13	5	0.04	
	Inferred	76	0.11	240	0.09	5	0.03	
	<b>Total</b>	<b>259</b>	<b>0.11</b>	<b>270</b>	<b>0.12</b>	<b>5</b>	<b>0.03</b>	
<b>Contained (kt)</b>		<b>290 Kt</b>	<b>71 Kt</b>	<b>1,000 Koz</b>	<b>44 Moz</b>	<b>92 Kt</b>		
<b>Ore Reserves as at 29 January 21 (0.074% WO<sub>3</sub> cut-off)</b>	Reserve Category	Tonnes (Mt)	WO <sub>3</sub> (%)	Mo ppm	Au g/t	Ag g/t	Cu (%)	
	Probable	140	0.10	288	0.12	5.9	0.03	
	<b>Total</b>	<b>140</b>	<b>0.10</b>	<b>288</b>	<b>0.12</b>	<b>5.9</b>	<b>0.03</b>	
	<b>Contained (kt)</b>		<b>145 Kt</b>	<b>40 Kt</b>	<b>542 Koz</b>	<b>27 Moz</b>	<b>48 Kt</b>	



#### Project Status

Pre-Feasibility Study (Jan 2021)



#### Offtake Available

Yes



#### Min Mine Life (Yrs)

23.5



#### Post-tax IRR:

9.31%

#### Capital Cost:

A\$669m

#### Post-tax NPV<sub>5%</sub>:

A\$265m



#### Product & Annual Production Rate

- **Tungsten concentrate: 7.1 ktpa**  
Containing: 460,000 WO<sub>3</sub> MTU p.a
- **Molybdenum concentrate: 2.4 ktpa**  
Containing: 1,070 tpa Mo
- **Copper concentrate: 5.7 ktpa**  
Containing: 1,265 tpa Cu, 9,400 oz pa Au, 525,000 oz pa Ag

# W

## Tungsten

### Mount Carbine

EQ Resources Ltd

ASX-listed (EQR) In-Situ Material 100% EQR. LGS 50% EQR / 50% CRONIMET  
www.tungstenmining.com



*EQR's Mt Carbine tungsten project is Australia's only primary tungsten producer. Low-cost production, technology integration and a positive commodity outlook underpin Mt Carbine's strategic relevance as a responsible Western tungsten supply in the critical minerals sector. Recent bankable feasibility study update, enhanced by a 29% Open Pit Ore Reserves increase, drives NPV from \$131m to \$209.6m. With only 18% of the mineral resource currently defined as an open pit, significant upside opportunity remains with already strong project economics and fundamentals. With a strong ESG focus, proven consistent supply and sales, and Federal Government Critical Minerals Accelerator Initiative backing, EQR welcomes interest from investors and financiers.*

Mt Carbine is a fully permitted, established brownfields operation accelerating through a 2-phase, low-cost expansion. Mt Carbine is currently processing the 12Mt historic Low Grade Ore Stockpiles (LGS) and simultaneously working towards re-opening the historic open pit mine. Phase 1 upgrades (Early Works) are completed with the current production rate of LGS processed increased to 1Mtpa, producing up to 1,193tpa tungsten concentrate. Phase 2 expansion Pre-Construction is underway to further increase processing plant efficiency and capacity. Phase 2 open pit mining of the 3.5Mt in-situ ore reserves will commence in Q2 2023, supplying the upgraded processing plant for ~4yrs. EQR has identified a Western Extension of the deposit which will be drilled targeting extension of in-situ reserves and open pit mine life. A Scoping Study was completed in 2022 on future underground mining of approximately 5Mt ore. On track and credible, this project has achieved all major milestones within budget.

#### Mineral inventory

Commodity(ies):	Tungsten					
<b>Mineral Resources as at 4 August 22 (0.05% WO<sub>3</sub> cut-off for Southern Domain 1 and 0.15% WO<sub>3</sub> elsewhere)</b>	<b>Low Grade Stockpile</b>			<b>In-Situ</b>		
		<b>Tonnes</b>	<b>WO<sub>3</sub></b>		<b>Tonnes</b>	<b>WO<sub>3</sub></b>
	<b>Resource Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>Resource Category</b>	<b>(Mt)</b>	<b>(%)</b>
	Indicated	12.0	0.075	Indicated	12.04	0.27
	<b>Total</b>	<b>12.0</b>	<b>0.075</b>	<b>Inferred</b>	<b>8.28</b>	<b>0.40</b>
	<b>Contained (kt)</b>		<b>9.0</b>	<b>Total</b>	<b>20.32</b>	<b>0.32</b>
			<b>Contained (kt)</b>	<b>65.8</b>		
<b>Ore Reserves as at 16 September 22</b>	<b>Low Grade Stockpile</b>			<b>In-Situ</b>		
		<b>Tonnes</b>	<b>WO<sub>3</sub></b>		<b>Tonnes</b>	<b>WO<sub>3</sub></b>
	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>
	Probable	10.00	0.075	Probable	3.54	0.33
	<b>Total</b>	<b>10.00</b>	<b>0.075</b>	<b>Total</b>	<b>3.54</b>	<b>0.33</b>
	<b>Contained (kt)</b>		<b>7.5</b>	<b>Contained (kt)</b>	<b>11.6</b>	



#### Project Status

**Phase 1 Increased rate of processing of LGS:** Operating.  
**Phase 2 Expansion:** Feasibility Study Update completed November 2022, Pre-Construction underway.



#### Offtake Available

First 25,000t under offtake agreement with JV partner CRONIMET. Thereafter, concentrate offtake is available.



#### Min Mine Life (Yrs)

14+ (LGS and Open Pit)



#### Pre-tax Project IRR:

397%

#### Capital Cost:

A\$22.9m (BFS 2021)  
A\$16.4m (BFS Update 2022 – spend remaining)

#### Pre-tax Project NPV<sup>8% real</sup>:

A\$209.6<sup>1</sup>

1. \$209.6m NPV is Project NPV; NPV attributable to EQR as 50% portion of LGS Joint Venture and 100% of Open Pit results is \$172.5m



#### Product & Annual Production Rate

- Annual production during Open Pit Mining: 4,446tpa 50% WO<sub>3</sub> concentrate (4 years)
- LGS Annual Production for remainder of project: 1,193tpa 50% WO<sub>3</sub> concentrate



# W

## Tungsten

### O'Callaghans

Newcrest Mining Ltd

ASX & TSX-listed (NCM) • [www.newcrest.com.au](http://www.newcrest.com.au)



*O'Callaghans is one of Australia's largest undeveloped tungsten resources, with previous study work indicating that it could sustain significant production.*

O'Callaghans is a tungsten-lead-zinc-copper skarn deposit located approximately 10km south of Newcrest's Telfer Gold-Copper Mine in Western Australia, or 485km by road south-east of Port Hedland. The deposit has an extent of approximately 1.2km by 1.0km and commences 300m below surface. Mineralisation occurs at the contact between the Neoproterozoic Puntapunta Formation and the O'Callaghans Granite where it forms a flat, tabular orebody between 10m and 60m thick. The principal tungsten minerals are wolframite and scheelite, with associated sphalerite, galena and chalcopyrite, accompanied by an assemblage of elevated fluorine, bismuth, molybdenum and tin. The characteristics of O'Callaghans render it best suited to selective underground mining methods such as long hole open stoping or room and pillar. Indicatively, a saleable tungsten concentrate could be produced alongside separate zinc, lead and copper concentrates.

### Mineral inventory

Commodity(ies):	Tungsten, Zinc, Lead, Copper					
<b>JORC Mineral Resource as of June 30 22 (no cut-off grade applied)</b>	Resource Category & Deposit	Tonnes (Mt)	WO <sub>3</sub> (%)	Zn (%)	Pb (%)	Cu (%)
	Indicated	69	0.34	0.53	0.26	0.29
	Inferred	9	0.25	0.19	0.11	0.24
	<b>Total</b>	<b>78</b>	<b>0.33</b>	<b>0.50</b>	<b>0.25</b>	<b>0.29</b>
	<b>Contained (kt)</b>		<b>258</b>	<b>391</b>	<b>191</b>	<b>224</b>



#### Project Status

Pre-Feasibility Study (2014)



#### Offtake Available

No



#### Min Mine Life (Yrs)

Not available



#### Post-tax IRR:

Not available

#### Capital Cost:

Not available

#### Post-tax NPV:

Not available



#### Product & Annual Production Rate

• **Tungsten Concentrate (65% WO<sub>3</sub> based on laboratory testwork).**

Target annual production rates are currently under revision.

# V

## Vanadium

### Australian Vanadium Project

Australian Vanadium Ltd

ASX-listed (AVL) • www.australianvanadium.com.au



The Australian Vanadium Project is one of the most progressed, high-quality vanadium projects in the world. The Company has completed its feasibility studies and is aiming for Final Investment Decision by the end of 2022. AVL is seeking offtake, debt and equity for its project. Debt advisers HCF International and Grant Thornton Australia have been engaged.

The project is based on an open pit mine with on-site crushing, milling & beneficiation (CMB) and a processing plant located near Geraldton for final conversion to high-quality vanadium pentoxide (V<sub>2</sub>O<sub>5</sub>). The project has a high LOM vanadium ore grade to the CMB plant (1.03% V<sub>2</sub>O<sub>5</sub>), thereby realising a high concentrate mass yield; possibly the highest of all current vanadium operations worldwide. The CMB flowsheet is based on standard, industry proven processes and includes magnetic beneficiation producing a concentrate at a nominal 1.4% V<sub>2</sub>O<sub>5</sub> content. The processing plant flowsheet is based on an alkaline roast leach and ammonium metavanadate (AMV) extraction process producing 11,200 tonnes of high purity V<sub>2</sub>O<sub>5</sub> product and 900,000 tonnes of iron titanium co-product annually. The current mine life for the project is 25 years, with potential for extension. More than mining, AVL is pursuing downstream processing in addition to its vanadium mining operations. Vanadium products for steel and battery markets will be produced, with manufacturing of vanadium electrolyte and battery installations adding more value within Australia. AVL has strong ESG credentials, including its 100% owned vanadium redox flow battery subsidiary VSUN Energy. Engagement with local communities is strong and the project is well supported both locally and nationally.

#### Mineral inventory

Commodity(ies):	Vanadium, Titanium		
<b>Mineral Resources as at November 21</b>		<b>Tonnes</b>	<b>V<sub>2</sub>O<sub>5</sub></b>
	<b>Resource Category &amp; Deposit</b>	<b>(Mt)</b>	<b>(%)</b>
	Measured	11.3	1.14
	Indicated	82.4	0.70
	Inferred	145.3	0.71
	<b>Total</b>	<b>239</b>	<b>0.73</b>
	<b>Contained (kt)</b>	<b>1,745</b>	
<b>Ore Reserves as at April 22</b>		<b>Tonnes</b>	<b>V<sub>2</sub>O<sub>5</sub></b>
	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>
	Proved	10.5	1.11
	Probable	20.4	1.07
	<b>Total</b>	<b>30.9</b>	<b>1.09</b>
		<b>Contained (kt)</b>	<b>337</b>

Within the Total Mineral Resource, a Total High-Grade Portion of the Resource of 95.6Mt @ 1.07% V<sub>2</sub>O<sub>5</sub> was also defined in November 2021.

 <p><b>Project Status</b> Feasibility Study</p>	 <p><b>Pre-tax IRR:</b> 20.6%</p>	 <p><b>Product &amp; Annual Production Rate</b></p> <ul style="list-style-type: none"> <li>• V<sub>2</sub>O<sub>5</sub> as mix of flake or powder: 11,200 tpa</li> <li>• FeTi Co-product (54%Fe): 900 ktpa</li> </ul>
 <p><b>Offtake Available</b> Yes</p>	<p><b>Capital Cost:</b> US\$435m</p>	
 <p><b>Min Mine Life (Yrs)</b> 25</p>	<p><b>Pre-tax NPV<sub>7.5%</sub>:</b> US\$600m @ US\$10.5/lb V<sub>2</sub>O<sub>5</sub> and A\$: US\$ 0.72</p>	

# V

## Vanadium

### Mount Peake Vanadium-Titanium-Iron Project

TNG Limited

ASX-listed (ASX: TNG) • www.tngltd.com.au



The Mount Peake Project is an advanced critical minerals project that is progressing through final engineering optimisation, processing approvals and confirmation of capital requirements in support of a final investment decision. The Project will be an integrated mining and processing operation, with value-add downstream processing for final products undertaken in Australia. TNG has secured offtake agreements for 100% of production with an impressive group of global offtake partners. TNG is seeking debt and equity funding for development, supported by Germany's KfW IPEX-Bank and KPMG Corporate Finance. TNG has received a total of up to A\$800 million in conditional Letters of Support/Interest for Mount Peake from Australian, German and Korean Government backed funding sources. TNG is also progressing a number of potential strategic equity opportunities.

Mount Peake is a world-scale integrated critical minerals project that will produce high-purity vanadium pentoxide (V<sub>2</sub>O<sub>5</sub>), titanium pigment (TiO<sub>2</sub>) and iron fines for global markets. The Project is well advanced, with a FEED study completed, Mining Licences granted, Native Title agreement secured and mine development environmental approvals in place. Mount Peake hosts a JORC Compliant Resource of 160 million tonnes, making it one of the largest undeveloped vanadium-titanium-iron projects in the world. The project will operate a conventional open pit mine over a 37-year initial mine life, using TNG's 100% owned TIVAN<sup>®</sup> processing technology to convert magnetite concentrate into the three high purity final products. Mount Peake has Major Project Status with both the Federal and Northern Territory Governments.

#### Mineral inventory

Commodity(ies):	Vanadium, Titanium, Iron				
<b>Mineral Resources as at 26 March 13 (0.1% V<sub>2</sub>O<sub>5</sub> cut-off)</b>	Resource Category	Tonnes (Mt)	V <sub>2</sub> O <sub>5</sub> (%)	TiO <sub>2</sub> (%)	Fe (%)
	Measured	118	0.29	5.50	24.00
	Indicated	20	0.28	5.30	22.00
	Inferred	22	0.22	4.40	19.00
	<b>Total</b>	<b>160</b>	<b>0.28</b>	<b>5.30</b>	<b>23.00</b>
	<b>Contained (kt)</b>		<b>448</b>	<b>8,480</b>	<b>36,800</b>
<b>Ore Reserves as at 31 July 15 (15% Fe cut-off)</b>	Reserve Category	Tonnes (Mt)	V <sub>2</sub> O <sub>5</sub> (%)	TiO <sub>2</sub> (%)	Fe (%)
	Probable	41.1	0.42	7.99	28.00
	<b>Total</b>	<b>41.1</b>	<b>0.42</b>	<b>7.99</b>	<b>28.00</b>
	<b>Contained (kt)</b>		<b>173</b>	<b>3,284</b>	<b>11,508</b>



**Project Status**  
Pre-Construction



**Pre-tax IRR:**  
Currently being updated



**Product & Annual Production Rate**

- Vanadium Pentoxide: 6,000 tpa
- Titanium Dioxide Pigment: 100,000 tpa
- Iron Oxide: 500,000 tpa



**Offtake Available**  
No

**Capital Cost:**  
Currently being updated



**Min Mine Life (Yrs)**  
37

**Pre-tax NPV:**  
Currently being updated

## Murchison Technology Metals Project (MTMP)

Technology Metals Australia Ltd

ASX-listed (TMT) • [www.tmtlimited.com.au](http://www.tmtlimited.com.au)



The Company is developing one of the world's highest-grade primary vanadium projects, with feasibility work confirming that the Murchison Technology Metals Project (MTMP) will be a large scale, low-cost, high-quality vanadium producer. Cornerstone investment by Resource Capital Funds (RCF VII) endorses the asset quality and underpins establishment of a clear pathway to project funding, supported by end-user engagement in both the steel and battery industries. The company is progressing the development of the MTMP in line with recent increases in vanadium demand and growth in the Vanadium Redox Flow Battery market, and welcomes discussions with strategic investors and long term offtake partners.

The MTMP, comprising the Gabanintha and Yarrabubba deposits, is located in a Tier 1 mining jurisdiction serviced by excellent infrastructure and involves three open-cut mines feeding an on-site processing plant, incorporating beneficiation, salt roasting and leaching to produce high purity (>99%) vanadium pentoxide ( $V_2O_5$ ) and ilmenite ( $TiO_2$ ), with expected lowest quartile operating costs, over a mine life > 25 years. The Integration Study undertaken in 2022 combined the high grade Yarrabubba deposit into the MTMP mine plan. With high vanadium in concentrate grades (1.61%  $V_2O_5$ ), excellent recoveries and the addition of ilmenite product revenue, Yarrabubba is expected to materially enhance the economic metrics of the MTMP, lowering the development risk for the project. A bankable feasibility study is on track for completion towards the end of 2022. MTMP mining tenements are in place and environmental approvals are progressing in line with TMT's vision to be a strong, authentic and reliable corporate citizen.

### Mineral inventory

Commodity(ies):	Vanadium, Titanium				
Mineral Resources as at 10 November 21 (0.9% $V_2O_5$ Cut-Off Massive Magnetite Zone /0.4% $V_2O_5$ Cut-Off for remaining mineral resource):	Resource Category & Deposit	Tonnes (Mt)	$V_2O_5$ (%)	$TiO_2$ (%)	Fe (%)
	Measured	1.2	1.0	11.4	44.7
	Indicated	49	0.9	10.7	41.2
	Inferred	96	0.8	9.8	37.4
	<b>Total</b>	<b>146.2</b>	<b>0.8</b>	<b>10.1</b>	<b>38.7</b>
	<b>Contained (kt)</b>		<b>1,228</b>	<b>14,750</b>	<b>56,608</b>
Vanadium Ore Reserves as at 5 August 22	Reserve Category	Tonnes (Mt)	$V_2O_5$ (%)		
	Proved	1.12	0.95		
	Probable	43.36	0.89		
Titanium Ore Reserves as at 5 August 22	Reserve Category	Tonnes (Mt)	$TiO_2$ (%)		
	Proved	15.88	10.0		
	Probable	15.88	10.0		
<b>Total</b>	<b>44.48</b>	<b>0.89</b>			
<b>Contained (kt)</b>		<b>-</b>	<b>396</b>	<b>1,588</b>	

Note: Titanium Ore Reserve relates to the Yarrabubba ore body only; the tonnage of the Titanium Ore Reserve is included in the Vanadium Ore Reserve.



**Project Status**  
Feasibility Study



**Pre-tax IRR:**  
23%



**Product & Annual Production Rate**

- High-purity vanadium pentoxide ( $V_2O_5$ ) +99% purity: 12,500 tpa

- Ilmenite ( $TiO_2$ ): approximately 96,500 tpa in the first nine years



**Offtake Available**  
Yes

**Capital Cost:**  
A\$604m



**Min Mine Life (Yrs)**  
25

**Pre-tax NPV<sub>8%</sub>:**  
A\$942m



# V

## Vanadium

### Richmond – Julia Creek Vanadium

Richmond Vanadium Technology Pty Ltd (RVT)

RVT (100%) – expected to list on ASX in November 2022

www.richmondvanadium.com.au



One of the largest undeveloped oxide vanadium resources in the world which can produce globally significant supply for the steel and emerging energy storage markets. The project differentiator is its very large resource and reserve, minimal environmental impact, progressive rehabilitation, low capex, conventional processing, non-toxic waste, long mine life and first quartile operating costs. As the only critical minerals project to be declared a Coordinated Project by the Queensland Government, it is expected to deliver significant benefits to the regional and national economy. A common user vanadium facility in Townsville which the Queensland Government intends to build for refining of vanadium concentrate to vanadium pentoxide suitable for battery use is expected to further enhance the project. Bankable feasibility study is due for completion during 2023. RVT welcomes discussion regarding construction financing or offtake agreements.

The deposit commences from surface and is hosted in soft marine sediments making it amenable to low strip, open-cut, free-dig mining. The project is expected to have a 20-year initial mine life although the reserve can support a +100 year mine life, at a production rate of 4.2 Mtpa ore mined to produce 790,000 tpa vanadium concentrate (12,700 tpa contained  $V_2O_5$ ). Testwork shows that >90% of the contained metal lies in the –38µm size fraction which is amenable to low-cost removal via scrubbing, screening and flotation to produce a high-grade vanadium concentrate of 1.82%  $V_2O_5$  at 64% recovery. Pilot testwork has been undertaken and a provisional patent application lodged with IP Australia covering the method for the extraction of vanadium.

#### Mineral inventory

Commodity(ies):	Vanadium, Molybdenum, Nickel		
<b>Mineral Resources:</b> <b>Richmond-Julia Creek Vanadium Project Mineral Resource Estimate, December 19 (0.30% <math>V_2O_5</math> cut off):</b>		<b>Tonnes</b>	<b><math>V_2O_5</math></b>
	<b>Resource Category &amp; Deposit</b>	<b>(Mt)</b>	<b>(%)</b>
	Indicated – Lilyvale	430	0.50
	Inferred – Lilyvale	130	0.41
	Inferred – Rothbury	1,202	0.31
	Inferred – Manfred	76	0.35
	<b>Total</b>	<b>1,838</b>	<b>0.36</b>
<b>Contained (kt)</b>		<b>6,650</b>	
<b>Ore Reserves:</b> <b>Lilyvale Deposit Ore Reserve, January 20 (0.30% <math>V_2O_5</math> cut off)</b>		<b>Tonnes</b>	<b><math>V_2O_5</math></b>
	<b>Reserve Category</b>	<b>(Mt)</b>	<b>(%)</b>
	Probable	459.2	0.49
	<b>Total</b>	<b>459.2</b>	<b>0.49</b>

For Mineral Resources, Ore Reserves and metallurgical testwork results refer ASX:HRZ announcements entitled “Positive Metallurgical Testwork results from Richmond Vanadium project”, 8 May 2018, and “Positive Metallurgical Results Received as Drilling Commences at the Richmond Vanadium Project”, 26 November 2018, and “Richmond-Julia Creek Vanadium Project Update”, 16 June 2020, and “Pre-Feasibility Study Results and Maiden Ore Reserve for Richmond-Julia Creek Vanadium Project”, 27 October 2020

	<b>Project Status</b> Pre-Feasibility Study		<b>Post-tax IRR</b> <small>First 25 years*</small> 38% at US\$9.60/lb $V_2O_5$ price		<b>Product &amp; Annual Production Rate</b> • <b>Vanadium concentrate (1.82% <math>V_2O_5</math>):</b> 790,000 tpa concentrate, with potential to refine to 12,700tpa of vanadium pentoxide flake ( $V_2O_5$ )
	<b>Offtake Available</b> Yes		<b>Capital Cost:</b> US\$176.8M (A\$242.2M)		
	<b>Min Mine Life (Yrs)</b> 100+		<b>Post-tax NPV (over 25 years)<sub>10%</sub>*</b> US\$447.5M (A\$613M) US\$9.60/lb $V_2O_5$ price		

# V

## Vanadium

### Windimurra

Atlantic Vanadium Pty Ltd (AVPL)

Private company • [www.atlanticptyltd.com.au](http://www.atlanticptyltd.com.au)



AVPL owns 100% of the world class Windimurra vanadium project. AVPL is completing an Updated Definitive Feasibility Study for the Windimurra project development and expects to make a final investment decision for the project development mid-2023. AVPL is currently in advanced discussions with prospective project financiers and strategic offtake partners for the Windimurra project, however AVPL welcomes interest from prospective project financiers and offtake partners.

Windimurra will be the world’s next major primary vanadium producer leveraging significant existing infrastructure at the project site. In particular, Windimurra enjoys the following competitive advantages:

- Significant historic investment, making it the lowest capital intensity primary vanadium project development in the world.
- All development approvals in place.
- JORC 2012 compliant reserves deliver an initial 31 year mine life with upside through additional large JORC 2012 compliant resources.
- All critical infrastructure is already developed (roads, mine pit, gas pipeline, kiln, power station, village).
- Attractive economics based on low strip ratio, legacy investment and long mine life.
- Attractive vanadium market fundamentals with forecast strong vanadium demand growth driven by new Chinese rebar standards and vanadium flow battery demand.

The Windimurra project will produce a high purity  $V_2O_5$  flake product utilising proven open-cut mining and vanadium production processes including ore milling, magnetic separation, salt roasting, leaching and vanadium recovery to produce the final product.

### Mineral inventory

Commodity(ies):	Vanadium		
<b>Mineral Resources as at 30 June 22 at (0.28% <math>V_2O_5</math> cut-off)</b>	<b>Resource Category</b>	<b>Tonnes (Mt)</b>	<b><math>V_2O_5</math> (%)</b>
	Measured	34.6	0.49
	Indicated	123.5	0.50
	Inferred	51.6	0.50
	<b>Total</b>	<b>209.7</b>	<b>0.50</b>
	<b>Contained (kt)</b>		<b>1,048</b>
<b>Ore Reserves as at 30 June 22 at (0.28% <math>V_2O_5</math> cut-off)</b>	<b>Reserve Category</b>	<b>Tonnes (Mt)</b>	<b><math>V_2O_5</math> (%)</b>
	Proved	–	–
	Probable	87.5	0.49
	<b>Total</b>	<b>87.5</b>	<b>0.49</b>
	<b>Contained (kt)</b>		<b>429</b>



#### Project Status

Pre-Construction



#### Post-tax IRR:

Expected late 2022



#### Product & Annual Production Rate

• High purity  $V_2O_5$  flake:  
7,600 tpa



#### Offtake Available

Yes

#### Capital Cost:

Expected late 2022



#### Min Mine Life (Yrs)

31 years

#### Post-tax NPV:

Expected late 2022

**Zr**

Zirconium

**Avonbank**

WIM Resource Pty Ltd

Unlisted • [www.wimresource.com.au](http://www.wimresource.com.au)

Avonbank is world-class Zircon-rich Heavy Mineral Sands project, with Proved & Probable Reserves underpinning a 36 year operation. WIM Resource Pty Ltd welcomes discussions regarding the financing of Avonbank and interested parties are welcome to make contact for further information. WIM has completed the EES (environmental, socio economic studies), and no issues have been identified. WIM expects to have planning approvals in place in the first half of 2023, followed by final approvals. This will position WIM to make a FID, for construction to commence from 2024.

Avonbank is a world-class Zircon-rich Heavy Mineral Sands project. WIM will produce a high quality Heavy Mineral Concentrate (HMC) at site, for export overseas, where mainly Zircon & Titanium will be produced, with minor rare earth by-products. WIM has completed a Test Pit & Demonstration Scale Wet Concentration Plant at site – demonstrating successfully that the Avonbank ore is amenable to standard mineral sands gravity separation using spirals. Detailed downstream demonstration trials have also been successful, for mineral separation and other product quality assessment trials. The Avonbank orebody is a consistent ore body, and has a low strip ratio. It will be mined using a dry mining, rapid rehabilitation mining method. Avonbank has no significant environmental issues, and has very strong local community support. Avonbank has existing rail at site, and power & surface water pipelines nearby to the proposed process plant – meaning a lower CAPEX, simple project start-up & operation.

**Mineral inventory**

Commodity(ies):	Zirconium, Titanium, Rare Earths								
<b>Mineral Resources as at 31 December 17 (1% total HM cut-off)</b>	Resource Category	Tonnes (Mt)	THM (%)	Zircon (%)	Rutile (%)	Leucoxene (%)	Ilmenite (%)	Monazite (%)	Xenotime (%)
	Measured	300	4.3	20	15	8.5	26	2.0	0.6
	Indicated	150	3.6	19	17	9.3	28	1.9	0.6
	Inferred	40	3.0	21	16	9.0	27	2.3	0.6
	<b>Total</b>	<b>490</b>	<b>4.0</b>	<b>20</b>	<b>16</b>	<b>8.8</b>	<b>27</b>	<b>2.0</b>	<b>0.6</b>
	<b>Contained (kt)</b>	<b>19,600</b>	<b>3,920</b>	<b>3,136</b>	<b>1,725</b>	<b>5,292</b>	<b>392</b>	<b>118</b>	
<b>Ore Reserves as at 1 June 18 (1% total HM cut-off)</b>	Reserve Category	Tonnes (Mt)	THM (%)	Zircon (%)	Rutile (%)	Leucoxene (%)	Ilmenite (%)	Monazite (%)	Xenotime (%)
	Proved	220.4	4.4	20.2	14.9	8.4	26.4	2.0	0.6
	Probable	91.4	4.0	19.3	16.9	9.1	28.5	2.0	0.6
	Total	311.8	4.3	19.9	15.4	8.6	27.0	2.0	0.6
	<b>Contained (kt)</b>	<b>13,407</b>	<b>2,668</b>	<b>2,065</b>	<b>1,153</b>	<b>3,620</b>	<b>268</b>	<b>80</b>	

**Project Status**

Feasibility Study (completed in 2021)

**Offtake Available**

Yes

**Min Mine Life (Yrs)**

36

**Post-tax IRR:**

please contact WIM for investor information

**Capital Cost:**

please contact WIM for investor information

**Product & Annual Production Rate**

- **Heavy mineral concentrate:** 500,000 tpa
- **Containing on average:** Zircon – 30%, Titanium – 55% RE by-products – 2%

**Zr**

Zirconium

## Cyclone Zircon Project

Diatreme Resources Ltd

ASX-listed (DRX) • www.diatreme.com.au



Cyclone is an attractive investment opportunity amid the lack of suitable high-grade zircon supply. Diatreme is seeking to sell the Cyclone project or find a suitable investment partner to fund the development of this high-grade zircon project located in Western Australia's zircon-rich Eucla Basin. The project is 'shovel-ready' with primary approvals and permitting in place. With a structural supply deficit of zircon projected amid shrinking supply and rising demand, Cyclone is an attractive opportunity for the right development partner to advance Australia's zircon production for the global market, supporting the growth of this critical mineral industry.

Cyclone has the potential to become a significant global supplier of zircon, accounting for an estimated 6% of global zircon supply. Cyclone also contains titanium minerals such as leucoxene, rutile and ilmenite and has potential for supply of the rare critical mineral hafnium within the zircon component of its heavy mineral concentrate (HMC). Shallow free-dig mining using a bulldozer and dozer trap method with progressive rehabilitation as the pit advances, will mine approximately 10Mtpa ore supplied to a Wet Concentrator Plant (WCP) on site. The WCP will process the sand via several stages of gravity concentration using spirals, classifiers and shaking tables producing a Heavy Minerals Concentrate (HMC). Life of mine production is estimated at 1.94Mt of HMC containing 936 Kt of zircon and producing 772 Kt of final zircon product. The Definitive Feasibility Study (DFS) completed in 2018 showed a post-tax NPV of A\$113m, an IRR of 27% and capital payback within three years, with estimated capex of A\$135m.

### Mineral inventory

Commodity(ies):		Zircon, Titanium, Hafnium							
Mineral Resources as at 31 December 21 (1% HM cut-off grade)	Resource Category	Tonnes (Mt)	Total HM (%)	Zircon (% HM)	Rutile (% HM)	Leucoxene (% HM)	HiTi (% HM)	Altered Ilmenite (% HM)	Siliceous Ti-oxide (% HM)
	Measured	156	2.4	28	3	6	24	12	22
	Indicated	48	1.9	21	2	5	33	16	18
	<b>Total</b>	<b>203</b>	<b>2.3</b>	<b>27</b>	<b>3</b>	<b>6</b>	<b>26</b>	<b>13</b>	<b>21</b>
	<b>Contained (kt)</b>		<b>4,669</b>	<b>1,262</b>	<b>140</b>	<b>280</b>	<b>1,214</b>	<b>607</b>	<b>980</b>
Ore Reserves as at 31 December 21	Reserve Category	Tonnes (Mt)	Total HM (%)	Zircon (% HM)	Rutile (% HM)	Leucoxene (% HM)	HiTi (% HM)	Altered Ilmenite (% HM)	Siliceous Ti-oxide (% HM)
	Probable	138	2.6	28	3	7	23	13	22
	<b>Total</b>	<b>138</b>	<b>2.6</b>	<b>28</b>	<b>3</b>	<b>7</b>	<b>23</b>	<b>13</b>	<b>22</b>
	<b>Contained (kt)</b>		<b>3,588</b>	<b>1,005</b>	<b>108</b>	<b>251</b>	<b>825</b>	<b>466</b>	<b>789</b>

**Project Status**

Feasibility Study (completed in 2018)

**Offtake Available**

Yes

**Min Mine Life (Yrs)**

13.2

**Post-tax IRR:**

27.2%

**Capital Cost:**

A\$135m

**Post-tax NPV<sub>10%</sub>:**

A\$113m

**Product & Annual Production Rate****• 147 ktpa HMC containing:**

59 ktpa Zircon

9 ktpa HiTi87

49 ktpa HiTi67





