ARC CENTRE OF EXCELLENCE IN CRITICAL MINERALS

“...THE MIDDLE EAST HAS ITS OIL, CHINA HAS RARE EARTHS...”

CHINESE PARAMOUNT LEADER,
DENG XIAOPING, 1987

“...THESE RARE EARTHS AND CRITICAL MINERALS ARE WHAT LITERALLY PULLS TOGETHER THE TECHNOLOGY THAT WE WILL BE RELYING ON INTO THE FUTURE”

AUSTRALIAN PRIME MINISTER,
SCOTT MORRISON, 2021

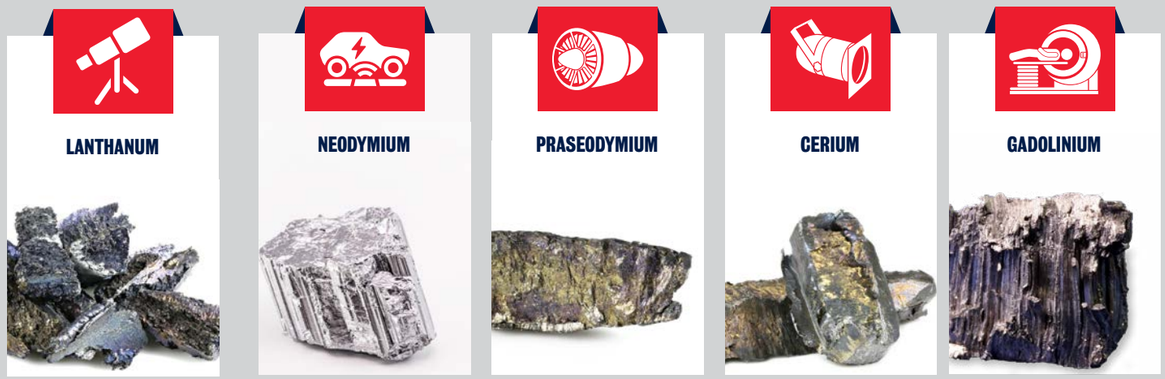
THE CRITICAL MINERALS IMPERATIVE

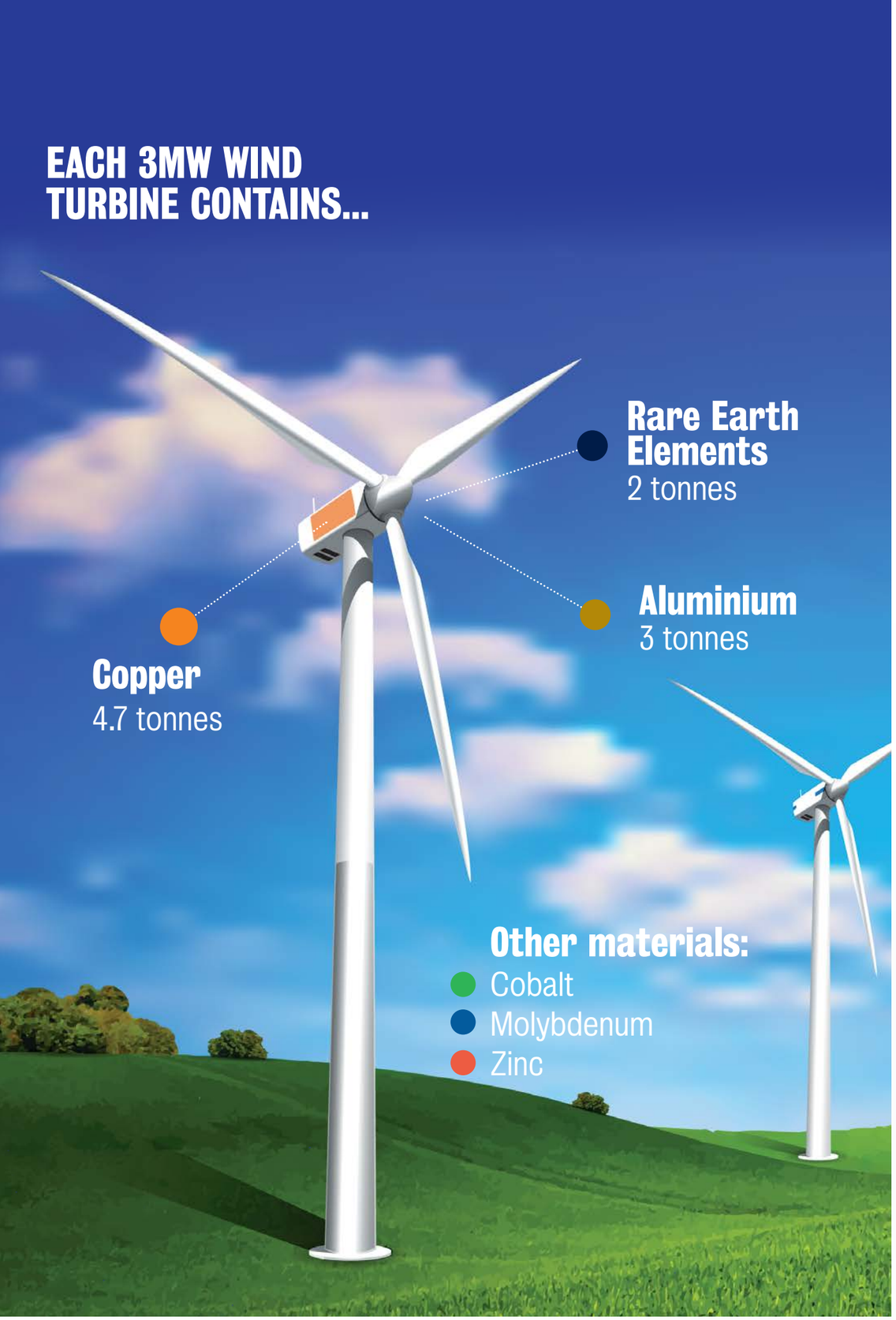
Critical minerals are vital to our future. Critical minerals include rare earth elements, lithium, cobalt, niobium, indium, tellurium and gallium, to name a few.

These are an evolving list of metals and a few non-metals that are essential to all manufacturing industries and are key to enabling Australia’s transition to a high tech, clean energy and secure future. Certainty of supply of critical minerals is a matter of national security. Concerningly, that supply is at risk due to factors such as geological scarcity, geopolitical issues, and international trade policy.

The sustainable supply of critical minerals for Australia, from Australia, is a grand challenge requiring transdisciplinary research across physical and social sciences, engineering and economics. This bid draws on unique expertise in those fields within six Australian universities, and research partners. Our consortium boasts access to state-of-the-art laboratory infrastructure and knowledge together with world-leading expertise in the social and economic dimensions of the mining industry.

The research to be conducted by this Centre of Excellence will shape Australia’s future prosperity by securing the critical mineral supplies required for Australia, and its key international partners, which form the backbone of modern manufacturing, decarbonising energy generation and defence technologies.





ARC CENTRES OF EXCELLENCE

The Australian Research Council's (ARC) 'Centres of Excellence' scheme is its premier funding scheme.

Centres of Excellence are prestigious foci of expertise through which Australia's most esteemed researchers undertake innovative and transformational research leading to significant advancement of capabilities and knowledge in areas of national priority. They drive collaborations between universities, publicly funded research organisations, governments and businesses in Australia and overseas, and they build critical mass with new capacity for interdisciplinary approaches to address the most pressing research problems facing the nation.

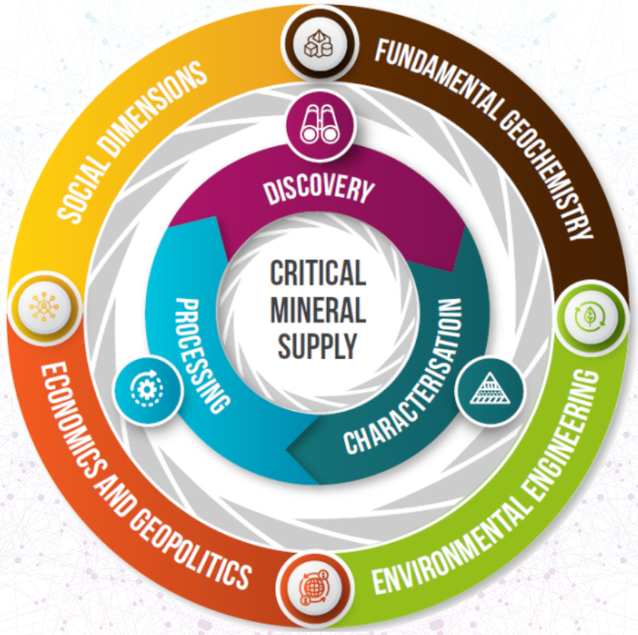
Centres of Excellence typically have a cash budget of ~$50 million and run for seven years. We will submit an Expression of Interest for a Centre of Excellence to the ARC in July 2021. If the Expression of Interest is successful, we will submit a full bid in 2022 with the Centre commencing in 2023.

Globally Recognised Research Excellence

The ARC Centre of Excellence in Critical Minerals bid is a consortium of six leading Australian universities (University of Adelaide, University of South Australia, Monash University, Australian National University, Curtin University, and the University of Queensland), with support from partner organisations including Geoscience Australia, CSIRO, Commonwealth and State government organisations (including Geological Surveys and the Critical Minerals Facilitation Office), the minerals industry, METS companies and leaders across the critical minerals sector globally.

The core group of researchers have diverse, yet complementary expertise, established international profiles, and a history of successful research collaboration and publication over decades. This group has produced 75% of the world's publications on Australian rare earth element deposits in the last 20 years. To that core group, the Centre will add expertise in social sciences, economics, geopolitics and environmental engineering, including from ANU's Crawford School of Public Policy, the nation's leading public policy school, and the University of Queensland's Centre for Social Responsibility in Mining (Sustainable Minerals Institute).

Our team of geologists, geometallurgists and mineral processors has unparalleled access to leading laboratories across Australia. These research facilities will enable us to study fundamental geological processes, mineral solubilities and critical mineral geochemistry that can be applied in mineral exploration and economic geology. Underpinning this bid is access to mineral characterisation at the micron- to nanoscales in ores, concentrates, slags, tailings and other wastes. Coupled with detection and measurement of radionuclides, this will support innovation in physical separation and hydrometallurgy, novel processing technologies (including energy and water reduction opportunities), and waste management. The team currently collaborates in the use of ~$1 billion of Australian Research Infrastructure. Shared infrastructure will integrate the Centre's research programs and broaden the reach and impact of that national research infrastructure.



Our Vision: Sustainable Critical Minerals for Australia, from Australia, 2030

Australia has defined resources in the ground, prospective geology for further resource discovery, expertise in minerals processing, a world-leading industry framework, and the training and research institutions required to produce the people and technologies to be the world leader in the mining and processing of critical minerals. The sustainability dimension is key to our consortium, and expertise in social sciences, economics, geopolitics and environmental engineering has been combined with our strong core of expertise in resource discovery and minerals processing. The Centre will build a new, transdisciplinary collaboration in order to underpin a new industry.

Traditional mining industry challenges of resource discovery, characterisation and processing comprise the *three application programs* at the core of the challenge (**Discovery**, **Characterisation** and **Processing**) and require transformational research in geology, geometallurgy, and mineral processing to solve not only the unique problems of finding critical minerals, but to initiate a new industry of clean, green onshore processing that will protect and ensure Australia's supply of these commodities into the future.

The three application programs are supported by *four foundation programs* that impact throughout on the discovery/characterisation/processing chain and are required to build a new, sustainable industry:

- **Fundamental geochemistry** (critical mineral distributions in natural materials)
- **Environmental engineering** (avoiding environmental harm)
- **Economics and geopolitics** (understanding the commodity markets and geopolitics of critical minerals)
- **Social dimensions** (avoiding harm at source, and enhancing societal benefit)

Training and Outreach

Our research program will be complemented by training of researchers, students and industry professionals to create a new generation of individuals who can implement centre outcomes and achieve transformation in industry and across society. We anticipate the Centre will employ and accelerate the careers of more than 20 postdoctoral fellows, graduate over 40 uniquely qualified PhD students, and assist in the advanced training of approximately 200 honours students. Micro-credentialed short courses and workshops will provide training in critical minerals to professionals from academia, industry and government.

An imperative will be developing career pathways for early career researchers and redressing the gender imbalance and under-representation of minority groups in academia and the mineral resources sector.

We will connect with the Australian community to raise awareness of the importance of critical minerals for our future, and the opportunities that they offer for our nation. We anticipate that these activities will, in turn, catalyse new research opportunities and energise university-level education in an exciting new discipline.

Innovation through Integration

Innovative research approaches are required to meet the complex challenges of critical mineral supply. We will undertake transformational, transdisciplinary research that integrates traditionally independent disciplines though case studies of key Australian mineral deposits and/or ore systems and of specific critical mineral commodities, such as cobalt.

Research programs will be designed in consultation with industry and will interweave expertise from all of the seven research programs. In this way, advancement of individual programs will be informed and guided by all others.

WE ENVISAGE THAT THIS NOVEL CROSS-DISCIPLINARY APPROACH WILL NOT ONLY MAXIMIZE THE BENEFITS OF THE CASE STUDIES, BUT ULTIMATELY WILL ENHANCE PATHWAYS TO CRITICAL MINERAL SUPPLY.

OUR RESEARCH PROGRAMS AND LEADERS

Society has mined precious and base metals, and many other commodities, for millennia, and the associated accumulated knowledge is vast.

The challenge of finding and mining ores of critical minerals is a new one, and whether it is with respect to their geological origins, the processing required to extract them, their environmental impacts, or their global economic markets, our depth of knowledge and breadth of perspective is far more limited. Research is thus required in all aspects of the critical minerals sphere.

WE WILL INTEGRATE TRADITIONALLY CLOSELY ALLIED, AND TRADITIONALLY INDEPENDENT DISCIPLINES THOUGH CASE STUDIES OF KEY AUSTRALIAN CRITICAL MINERAL DEPOSITS.

Centre Director

Prof. Richard Hillis FGS ATSE
University of Adelaide

Geology

Former CEO Deep Exploration Technologies CRC
South Australian Scientist of the Year (2018)
Pro-Vice Chancellor

FUNDAMENTAL GEOCHEMISTRY

Predicting the behaviour of critical minerals in complex systems: ores, processing streams and waste

This program will generate much needed fundamental thermodynamic and kinetic data for critical minerals in natural and engineered systems, enabling accurate prediction of their distribution, and solubility in melt-fluid-mineral-biota systems. That knowledge in turn impacts on the economics and sustainability of the critical mineral value chain in Australia, from mineral exploration, through innovation in mining and processing, to management of environmental risks associated with mining operations. We will use an integrated approach combining state-of-the-art experimental work, computational chemistry, and numerical modelling to produce a step change in our ability to predict the behaviour of critical minerals in complex systems.

Program Lead

Prof. Joel Brugger
Monash University

Experimental geochemistry, geobiology and mineralogy

ENVIRONMENTAL ENGINEERING

Developing new technologies to provide responsible environmental stewardship

Large volumes of waste, radiation, and acid mine drainage are among the environmental challenges associated with critical minerals operations. This program aims to eliminate environmental harm and reduce associated risk to acceptable levels. Supported by data from other programs, this program will investigate the role of bioremediation in removal of contaminants and toxins from solid and liquid media. Similarly, we will monitor and track the distribution of radiation in concentrates and waste products based on unique expertise and analytical infrastructure. We will also apply disruptive technologies such as miniaturised production strategies that offer potential step change reduction in waste without loss of efficiency and production throughput. Microfluidic unit operations, pioneered by our team, can be utilized for purification of a range of critical minerals.

Program Lead

Prof. Volker Hessel
University of Adelaide

Chemical engineering, green chemistry, microfluidics and environment

SOCIAL DIMENSIONS

Environmental, Social and Governance (ESG) context of critical mineral extraction

The risks and benefits of critical mineral exploitation in Australia will be examined from a social and human rights perspective. Our research will characterise the Environmental, Social and Governance (ESG) context of resource extraction and processing activities and how the nation's critical mineral dividend can be equitably distributed across local communities and regions. The program will explore those social dimensions that constrain access or inhibit supply of critical minerals, including the possibility that even where resources may be extractable, they may not be accessible due to non-technical factors. The aggregated outcomes of this and other programs will facilitate a unique interdisciplinary perspective on critical minerals and test the viability of novel extraction and processing pathways from the perspective of social risk and benefit sharing.

Program Lead

Prof. Deanna Kemp
University of Queensland;
Director, Centre for Social Responsibility in Mining Sustainability

Social and political challenges of the global mining industry

ECONOMICS AND GEOPOLITICS

Understanding the complex commodity markets for critical minerals

Market structures for critical minerals are very different from those for traditional commodities. Competition for their scarce supply and the current monopoly positions of countries such as China create challenging, highly complex market environments. This program explores the nature of these markets and the roles of market power, industry policy, trade policy, commodity cycles, export markets, and the interaction of critical minerals with the economy. Given the great uncertainty about the likely role played by critical minerals over the next 30 years, we will develop global economic models to better understand possible futures. Coupled with findings from other programs, alternative scenarios can be analysed under various assumptions about the impact of technological change, policy interventions and geopolitics on the supply and demand for critical minerals in Australia and globally.

Program Lead

Prof. Renee Fry-McKibben
Australian National University; Crawford School of Public Policy

Macroeconometrics and financial econometrics

DISCOVERY

Finding new resources of critical minerals in Australia

This program addresses major knowledge gaps in where and how to find new critical mineral orebodies, including conventional deposits that contain critical minerals as by-products (e.g., Co and PGM in Cu and/or Ni deposits), or deposits where critical minerals are the primary target commodity (e.g., carbonatite- or laterite-hosted REE deposits). Exemplar case studies from across Australia and cutting-edge geochemical, isotopic, structural, and geospatial data will be combined to provide new knowledge on the geodynamic settings and periods of Earth's history that favour deposit formation, the processes that form and concentrate these resources, and the mineral associations, zoning, and footprints that allow for more efficient and successful exploration. Cross-program collaboration integrating fundamental geochemistry, process mineralogy, and recognition of social, economic and environmental factors, will deliver holistic and dynamic mineral exploration models tailored to specific critical mineral groups, and for the Australian continent.

Program Lead

Prof. Katy Evans
Curtin University

Geochemistry of open systems

CHARACTERISATION

Pathways to critical mineral recovery based on state-of-the-art knowledge of mineralogy

Uncovering new opportunities for critical mineral recovery from higher volume but lower grade resources, including tailings and waste, demands exceptionally detailed, multi-layered information on critical mineral deportment. Innovation in critical mineral microanalysis coupled with advances in fundamental geochemistry will facilitate robust predictive models for the physical form, mineral speciation, and partitioning of elements of value in even the most complex, fine-grained resources and processing circuits. Comprehensive multi-scale mineralogical characterisation of existing high-grade ores is a key driver of optimisation in efficiency/profit and minimisation of waste and environmental impact. A transformative approach in the way characterisation data is integrated and implemented will, in turn, encourage knowledge-driven development of smart processing options aimed at efficient low-cost, low environmental impact generation of clean products for market.

Program Lead

Prof. Nigel Cook
University of Adelaide

Mineralogy and geometallurgy

PROCESSING

Extracting critical minerals efficiently and sustainably to meet market demands

Diminishing ore grades and accelerating demand require step-changes in beneficiation and refining to massively improve rates of recovery and selectivity in separation of critical minerals; whether it be from run-of-mine ores, process streams or from re-processing of tailings. Solutions lie in a deeper understanding of the complex pulp and surface chemistry of critical minerals within concentrator and solvent extraction processes, the use of new engineering technologies, process intensification, and innovative platforms for sensing and monitoring. We will investigate the fundamentals of critical mineral chemistry in processing environments, low-footprint technologies (wet/dry) in concentrate production, and the exploitation of microfluidic technologies for fast, selective recovery, refining, and sustainable production of commodities.

Program Lead

Prof. William Skinner
University of South Australia

Mineral processing and microanalysis

An enduring impact

Sustainable supply of critical minerals into the future is essential for global security and prosperity. The Centre of Excellence in Critical Minerals will provide the fundamental science and economics foundations to elevate Australia to pre-eminence in global critical mineral supply.

We envisage that our novel, holistic research approach, building on and integrating existing expertise across the nation, will spawn a new research field of *Critical Mineral Science* that will see rapid take-up worldwide.

Our vision is *Sustainable Critical Minerals for Australia, from Australia, 2030*. To achieve this, we are seeking additional partners from across Australia whose goals align with our vision, and who are passionate about developing this research program with us.

Get involved!

For further information about the Centre of Excellence, and to find out more about participation, please contact the bid team at the University of Adelaide, or any of our Program Leaders.

We welcome engagement and participation from industry, government, and other institutions via our sponsorship package, which is detailed in a separate one-page flyer.

Centre Director

Prof. Richard Hillis
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THE UNIVERSITY of ADELAIDE

MONASH University

Curtin University

Australian National University

University of South Australia

CSIRO

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Australian Government
Geoscience Australia