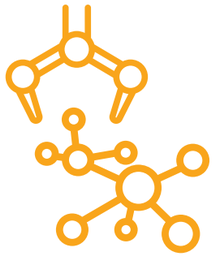
Australian Government

CTPCO
CRITICAL TECHNOLOGIES POLICY COORDINATION OFFICE

Critical minerals extraction and processing



Systems and processes to extract and process critical minerals safely, efficiently and sustainably. Australia has an abundance of critical minerals and has the opportunity to be a global leader in the ethical and environmentally responsible supply of key critical minerals. Applications for critical minerals extraction and processing include mining, concentrating minerals, and manufacturing battery-grade chemicals.

Key Sectors

- Health
- Energy & Environment
- Communications
- Defence & Defence Industry
- Transport & Logistics
- Mining and Resources
- Space

Estimated impact on national interest	Low	Med	High
Economic Prosperity			X
National Security			X

Key Australian Government Actions

Initiatives

- Critical Mineral Facility – providing $2 billion of loans for critical mineral projects supporting the Critical Minerals Strategy
- Critical Minerals Facilitation Office including 2019 Critical Minerals Strategy
- Promotion of investment through the Australian Critical Minerals Prospectus
- US-Australia Critical Minerals Plan
- Modern Manufacturing Strategy
- METS Ignited - Industry Growth Centre | Mining in Australia
- Exploring for the Future (2016–2040), Geoscience Australia
- Global Resources Strategy

Regulations

- Defence and Strategic Goods List 2021
- Environment Protection and Biodiversity Conservation Act 1999
- Foreign Acquisitions and Takeovers Act 1975
- Foreign Investment Review Board

Australia's place in the world

Australia ranks 4th for research impact, led by the Curtin University of Technology, which ranks 37th internationally. China has five institutions in the top 10 internationally, with three institutes in the top five. Canada has the highest venture capital (VC) investment ahead of Sweden, with Australia having the 3rd highest amount of VC investment. Globally, the number of patents has been increasing at around 5% p.a., with China dominating the number of patent families, and Australia in 11th place.

Australia also has world-leading expertise in resource extraction and processing, high-tech engineering and renewables research, as evidenced by our high research ranking. In addition to significant reserves of lithium, cobalt, manganese, tantalum, tungsten, and zirconium, Australia is a global leader for rare earth elements deposits and production. Australia is also a highly attractive destination for investment, with competitive advantages across the full spectrum of technical, capital allocation, and risk considerations, including political and economic stability, technology, training, research and development, environmental and labour standards, and legal and regulatory certainty.

Example Outcomes

- Aim to ensure Australia becomes a supplier of processed critical minerals and capture more of the downstream processing supply chain
- Access to global market demand for critical minerals, including rare earth elements
- Reduced reliance on China as primary supplier of critical minerals including for energy (batteries) rare earth magnets, semiconductors and high-end defence requirements
- Development of innovative and improved raw material extraction methods, including reduced energy-intensity
- Development of improved recovery and recycling methods for obtaining materials from existing products
- Harness Australia's world-leading expertise in resources extraction and processing
- Increased investment in Australia's critical minerals sector and downstream processing

Opportunities and Risks

Technological change and advancement is driving the global demand for critical minerals that are essential for the production of high tech equipment, devices and consumables, including mobile phones and computers, flat-screen monitors, wind turbines, electric cars, solar panels, rechargeable batteries, defence industry technology and products, and many other high-tech applications. The importance of rare earth elements and other critical minerals stems from their unique catalytic, metallurgical, nuclear, electrical, magnetic, and luminescent properties.

As demand for critical minerals grows, there are economic opportunities for Australia. We have existing projects and significant geological reserves of minerals deemed critical by other nations and we are well placed to capitalise on rising global demand for secure supplies of critical minerals. Australia is one of the world's principal producers of several key major mineral commodities (e.g. bauxite, coal, copper, lead, gold, ilmenite, iron ore, nickel, rutile, zircon, and zinc), ores from which many critical minerals are also extracted as by-products. Given Australia's expertise in mining and metallurgical processing and extensive mineral resources, there is an opportunity for Australia to develop into a major, transparent and reliable supplier of processed critical minerals for the global economy, building our sovereign capability, delivering on our geopolitical requirements, and developing stronger regions. Based on a conservative estimate, Australia could add approximately $9.4 billion of value to mineral and metal production (currently valued at $112.2 billion, an increase of about 8%) from existing mines and favourable deposits.

Access to reliable, secure, and resilient supplies of critical minerals will increasingly underpin our prosperity and security, and those of our international partners. Critical minerals projects across the globe face a combination of market, technical and commercial risks. In particular, risks may arise if supply chains are highly geographically concentrated and for critical minerals these supply chains are already dominated by large buyers. Australia and like-minded partners support and promote diversified supply chains and markets to mitigate potential economic coercion and trade disruption risks.

There are a number of risks that may inhibit Australia's ability to develop into a supplier of processed critical minerals including: markets that suffer from small volumes, thin margins, opaque pricing and geopolitical risk; access to funding to invest in new critical minerals processing technology; the development of regulations and standards that ensure Australian critical minerals businesses remain globally competitive; insufficient knowledge of critical minerals in Australian deposits and their behaviour during metallurgical processing; limited geological studies dedicated to assessing and facilitating the discovery of critical mineral resources in Australia; the need for new mining technology and services to economically extract critical minerals; and gaps in capabilities of domestic smelters/refineries to process critical minerals.

Underpinning Science

ANZ Standard Research Classification Category

- Resources engineering and extractive metallurgy
- Analytical chemistry
- Macromolecular and materials chemistry
- Physical chemistry
- Materials Engineering
- Geology
- Geochemistry

Example Applications

Readiness Level – Now

- Geological data on critical minerals
- Raw ore and mineral processing
- Semi-automated and limited fully-automated mineral extraction
- Energy-intensive methods to separate rare earth elements

Readiness Level – 2–5 years

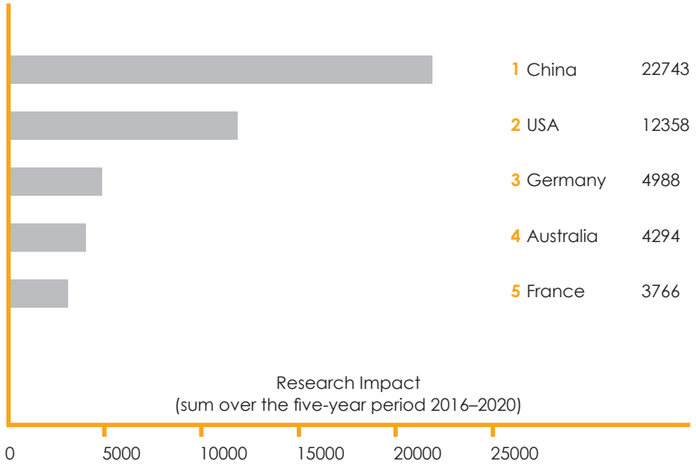
- Improved geological data and knowledge base of critical minerals
- Recycling electronic waste
- High value-add processing for alloys (e.g. rare earth elements)
- Improved geochemical association models of critical minerals to commodities
- Improved efficiency of mineral extraction and downstream processing

Readiness Level – Beyond 5 years

- Systematic mapping of Australia's mineral systems
- Next-generation drilling technology (safer, more environmentally friendly)
- Enhanced understanding of mineral processing behaviours
- Economically-viable separation of rare earth elements from by-products or co-products
- Automated processing for a wider variety of critical minerals
- Extraction of minerals from mining waste using plants that accumulate target metals (phytomining)
- Bio-remediation of mining waste

Research Impact (RI)

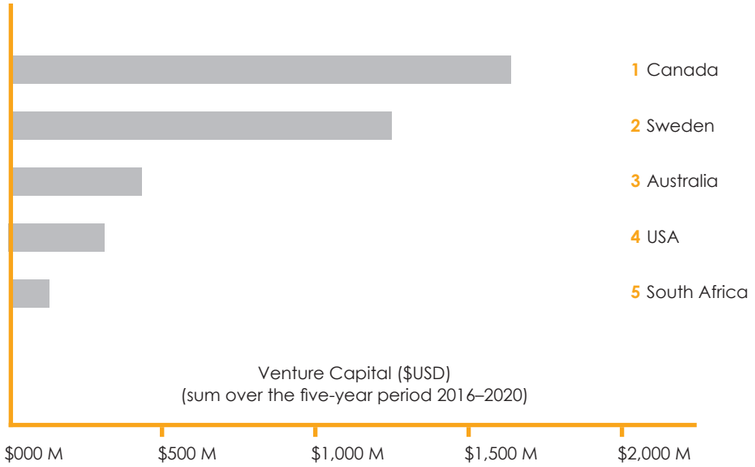
China has the highest research impact in this area, with Australia ranked 4th globally. The total volume of published research has been decreasing at around 9% p.a. over the 5 year period 2016–2020, with 32% of research involving international collaboration.



The research impact provides an indication of the productivity of a country or institution. Here, productivity was assumed to be represented by the volume of publications (i.e. scholarly output) as an indicator of the resources & facilities, and the level of interest in the publications as an indicator of quality.

VC Investment

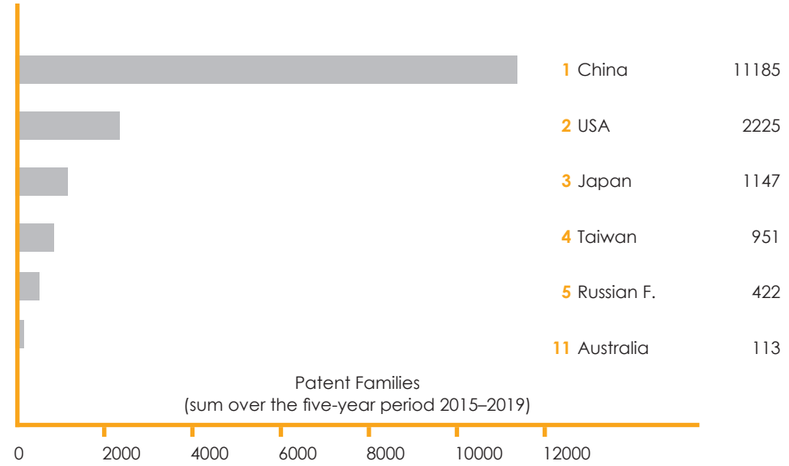
Australia is ranked 3rd for venture capital (VC) investment in this area, with Canada and Sweden having the greatest amounts of VC investment. Investment in this area has been growing at 19% p.a. since 2016.



Data from Crunchbase. The Crunchbase database provides a partial view of the global VC landscape. However the quantity, quality and richness of the data are considered to be statistically significant, and indicative of global trends.

Patents – International

The number of patents filed annually in this field has increased by 5% from 2015 to 2019. Most patents in this field were filed by applicants or inventors from China, 5 times more than the United States. Australia ranks 11th, with the Australian Nuclear Science and Technology Organisation leading patent filings first filed in Australia by Australians.



Research Institutions – International

China has 5 institutes in the top 10 international institutions, with 3 in the top 5. French and Belgian institutes make up the rest of the top 5, and the United States has only 1 institute in the top 10.

Rank	Top International Institution	Research Impact
1	Chinese Academy of Sciences | China	4916
2	French National Centre for Scientific Research (CNRS) | France	2343
3	University of Chinese Academy of Sciences | China	1695
4	KU Leuven | Belgium	1177
5	Chinese Academy of Geological Sciences | China	1079
6	United States Department of Energy | United States	953
7	China University of Geosciences, Beijing | China	952
8	University of Science and Technology Beijing | China	931
9	Spanish National Research Council (CSIC) | Spain	903
10	Russian Academy of Sciences | Russian Federation	818

Research Institutions – Australia

Within Australia, Curtin University of Technology has the highest research impact. Australia has 3 institutes in the top 50 international institution: Curtin University of Technology (37th), University of New South Wales (48th) and University of Queensland (50th).

Rank	Top Australian Institution	Research Impact
1	Curtin University of Technology	501
2	University of New South Wales	451
3	University of Queensland	426
4	Monash University	359
5	Australian National University	338
6	University of Adelaide	331
7	CSIRO	324
8	University of Melbourne	261
9	Macquarie University	234
10	University of Western Australia	226

Patents – Australia

Top 5 Australian Patent Applicants	Patent Families
Australian Nuclear Science and Technology Organisation	7
Lithium Australia NL	5
Urban Mining Corp	5
Iluka Resources	4
Inneovation	4

Patents filed by Australian businesses, 2015–2019.