Critical minerals extraction and processing

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 Prospects
- 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

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**Australia’s place in the world**

Australia ranks 4th for research impact, with the Curtin University of Technology, which ranks 37th internationally, 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 3% p.a., with China dominating the number of patent families, and Australia in 11th place.

**Key Sectors**

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

**Examples of 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, semiconductor 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 exiting 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, litemsite, iron ore, nickel, rutil, zircon, and zirconic), 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 sovereignty 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.

**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 (phytominning)
- Bio-remediation of mining waste

**ANZ Standard Research Classification Category**

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

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.

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.

Patents – Australia  

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.

Research Institutions – Australia  
Within Australia, Curtin University of Technology has the highest research impact. Australia has 3 institutes in the top 10 international institutions; Curtin University of Technology (37th), University of New South Wales (48th) and University of Queensland (50th).

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  

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  