

India-Australia Research Partnerships: Critical Minerals and Green Steel

Driving innovation, sustainable industry
and economic opportunities together

Highlights summary | 2023-2026



From January 2023 to June 2026, CSIRO delivered two Australian Government-funded partnerships with India to accelerate innovation in critical minerals, green steel, advanced processing, clean energy supply chains and future workforce capability.

The partnerships aligned with major priorities in both countries, including Australia's Future Made in Australia agenda and India's National Critical Minerals Mission and Green Steel Initiative. The work supported value-adding to resources, supply chain resilience, industrial decarbonisation, clean energy manufacturing and workforce capability.

Key statistics

**\$22.7
million
investment**

from the
Australian
Government
(part of the updated
India Economic
Strategy to 2035)



World-first rice
husk biomass
gasification for
steelmaking



Australia-India
researcher and science
network established
to support long-term
collaboration



10 research
projects and
28 student
projects



Establishment
of new research
and piloting
infrastructure
for Australia

High-level snapshot of partnerships

India-Australia Critical Minerals Research Partnership	A\$12.2 million	FOCUS AREAS: Discovery, minerals processing, rare earth metallisation and battery materials. ACTIVITIES: Piloting, demonstrations, industry engagement, technology development.
India-Australia Green Steel Research Partnership	A\$10.5 million	FOCUS AREAS: Ore upgrading, biomass substitution, process optimisation low carbon ironmaking and carbon management. ACTIVITIES: Piloting, demonstrations, industry engagement, technology development.
India-Australia Minerals Scholar Network	Jointly supported	FOCUS AREAS AND ACTIVITIES: Students, study exchanges and travel opportunities, PhD projects, internships and research mobility.

Front cover photo: CSIRO scientists Dr Mario Iglesias-Martinez and Dr Erick Ramanaidou (second and third from the left) working alongside representatives from the Indian Institute of Technology Mumbai and Geological Survey of India sampling REE-containing carbonatites in the Sung Valley, Meghalaya State, India.

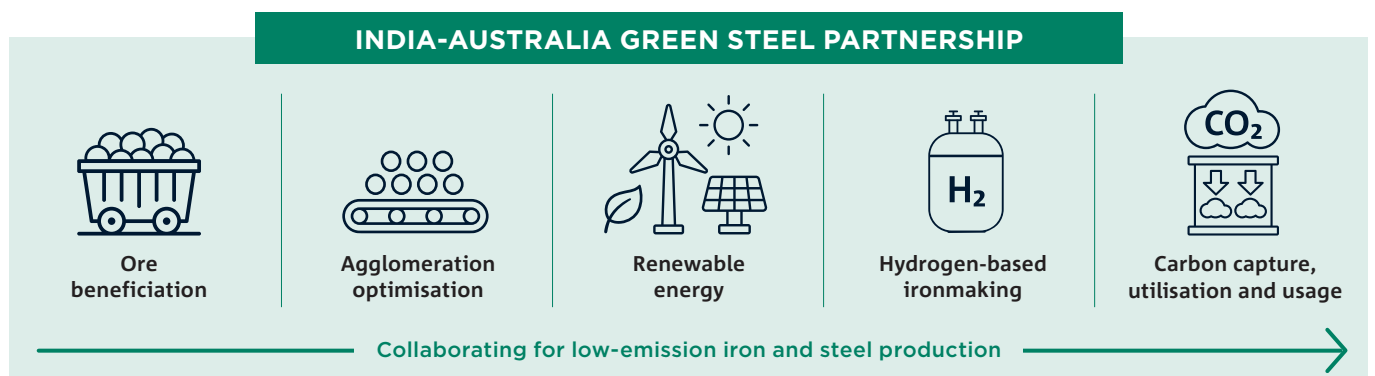
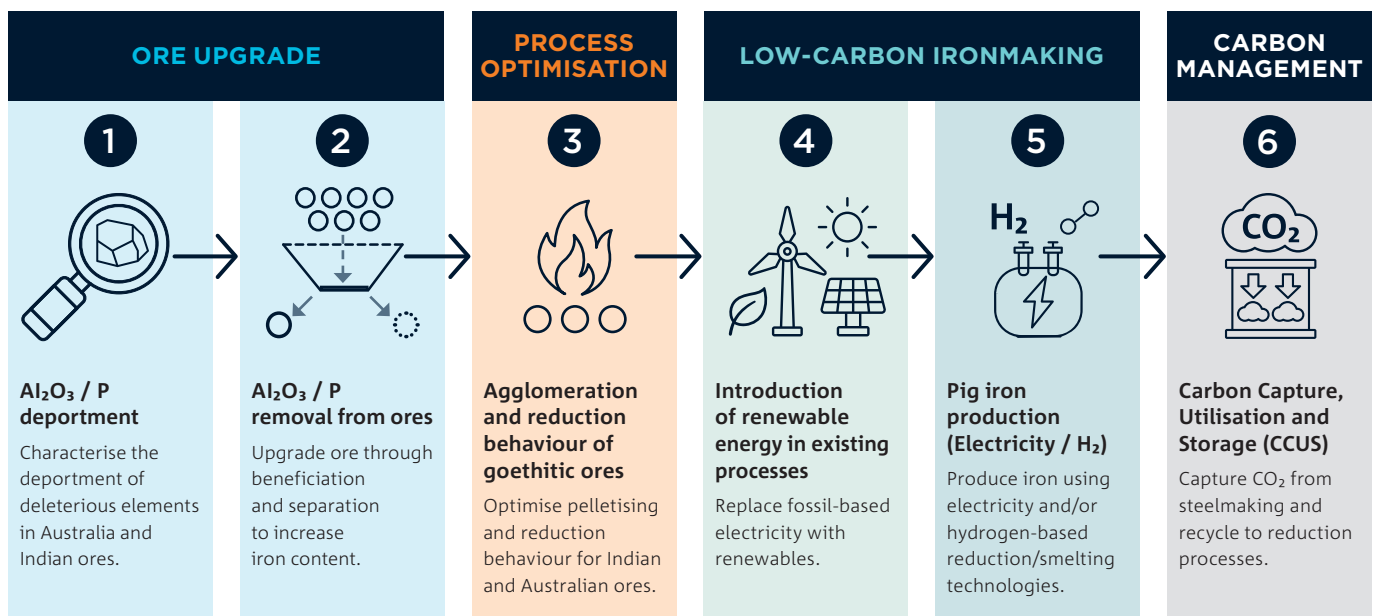
Creating impact through partnership

Australia and India share complementary strengths and common challenges. Australia brings world-class resources, processing capability and research expertise. India brings fast-growing demand, advanced manufacturing ambition and major decarbonisation priorities.

Together, the Critical Minerals and Green Steel Research Partnerships:

- Developed practical pathways to secure critical minerals supply chains.
- Added value to resources through downstream processing.
- Supported resilient and responsible critical minerals supply chains.
- Advanced technologies for low-emissions iron and steelmaking.
- Built enduring research, industry and government networks.
- Created training pathways for the next generation of minerals and steel researchers.

Pathways to reduce CO₂ emissions in steelmaking



Critical minerals research highlights

The Critical Minerals Research Partnership delivered innovation across the minerals-to-products value chain, including exploration tools, titanium–vanadium processing, rare earth recovery and metallisation and battery cathode material production.

HIGHLIGHTS

Exploration

New exploration tools and workflows developed for lithium, rare earth elements, chromium and nickel using integrated mineral systems approaches, hyperspectral mapping, geochemical datasets and critical minerals targeting workflows for India with more refined models for Australia.



Processing

Produce high-purity vanadium, titanium and magnetite products. Pilot-scale titanium–vanadium process demonstrated.



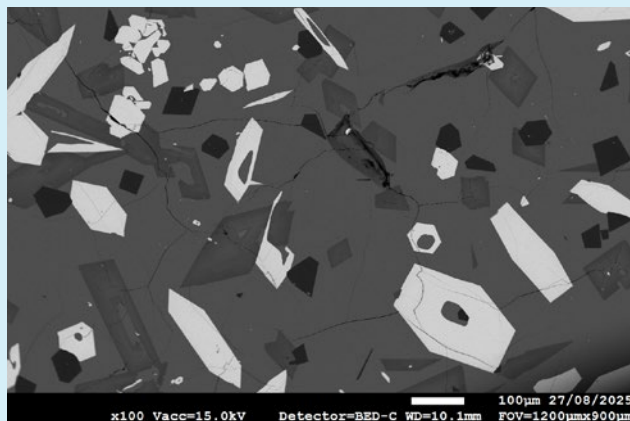
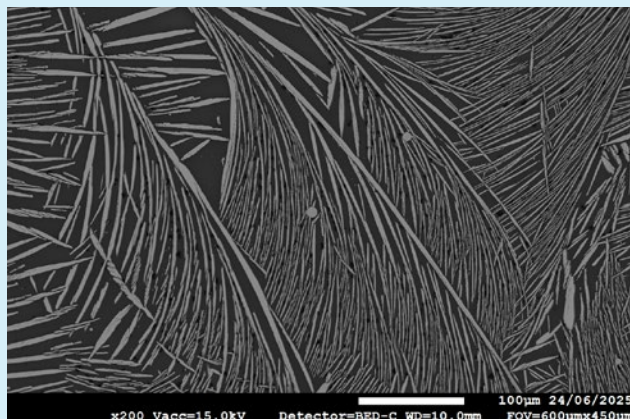
Rare earths

Novel beneficiation and metallisation processes with lower-temperature pathways and new intellectual property potential.



Battery materials

New lithium-ion and sodium-ion cathode active material production methods from mineral-derived feedstocks.



Scanning electron micrographs of rare earth element-bearing crystal phases grown in tailing slags at high temperatures; the recovery of rare earth elements can be enhanced through the formation of these phases.

Green steel research highlights

The Green Steel Research Partnership targeted one of the most challenging decarbonisation challenges: reducing emissions from iron and steelmaking using ore types common to both Australia and India. The work advanced near-term emission reduction options and longer-term technologies for green iron and steel.

- Improved understanding of low-grade iron ore impurities and cold upgrading pathways.
- Demonstrated the potential to prepare goethitic ores for direct reduced iron processes.
- Assessed biomass sources and pathways for low-emissions iron and steelmaking.
- Established foundations for hydrogen plasma smelting and carbon capture and recycling.
- Supported the development of a prototype furnace to undertake proof-of-concept testing for direct reduction/smelting iron by hydrogen ionic gas.



Goethitic ore to pellets for DR shaft furnace and low-carbon ironmaking processes.

World-first demonstration

A standout achievement was the world-first full-scale demonstration of rice husk biomass gasification for iron ore reduction at Jindal Steel in Odisha, India. The trial showed that agricultural biomass can be integrated into steelmaking pathways, with potential benefits for emissions reduction, air quality, agricultural residue management and regional economic activity.



Jindal Steel and Power Limited (JSPL) steelmaking plant in Odisha where the biomass demonstration in steelmaking was undertaken.



An India-Australia collaboration has successfully demonstrated in India that biomass locally sourced from agricultural waste can partially replace coal in steelmaking, using existing gasifiers at a JSPL steel plant. Mr Warren Flentje (CSIRO, left) with a representative from Jindal Steel and Power (JSPL, right).

Translating research into technology and commercial opportunities

Across both Partnerships, technologies progressed through various stages of development, resulting in invention disclosures, patent opportunities, pilot-scale demonstrations and industry engagement pathways.

The Partnerships generated a strong pipeline of technologies with commercial potential.

PATHWAY	HIGHLIGHT	POTENTIAL IMPACT
Titanium–vanadium processing	Advanced from bench to pilot scale.	More value from critical minerals and new processing opportunities.
Rare earth metallisation	Demonstrated novel lower-temperature metal production pathways.	Future capability for rare earth metals and magnets.
Cathode materials	Developed lithium-ion and sodium-ion battery material production methods.	Downstream battery value-chain opportunities.
Carbon capture, utilisation and usage	Established prototype capture and CO ₂ conversion units.	Closed carbon loop pathways for steelmaking.

Shaping the future workforce

The India-Australia Minerals Scholar Network created a pipeline of talent in critical minerals, batteries, iron ore beneficiation, green steel, and carbon capture capabilities. Students and early-career researchers gained international experience through PhD projects, internships, exchanges, workshops and study tours.

Achievements

- Supported collaborative research across Australian and Indian institutions (28 student projects).
- Strengthened links with Indian Centres of Excellence and Australian universities.
- Created opportunities for technical exchange, mentoring and shared research infrastructure.
- Built professional networks spanning research, industry and government.



A delegation of India-Australia Critical Mineral Scholars attending the 2025 AusIMM Critical Minerals Conference (Perth, Western Australia). Pictured here are (from left) Arundhati Jena (Indian Institute of Technology, Kharagpur, India), Meg Fletcher (CSIRO), Sanjay Singh (Indian Institute of Technology, Patna, India), Dr Anindita Pati (RESCONS Solutions Private Limited, Indian Institute of Science, Bangalore, India), Dr Shalini Verma (Motilal Nehru National Institute of Technology, Allahabad, India), Dr Joanne Loh (CSIRO), Dr Nawshad Haque (CSIRO), Jaishree Yadav (RMIT), Dr Pradnya M Bodhankar (Indian Institute of Technology, Bombay, India) and Govardhan Reddy Sontam (UNSW). Dr Bodhankar won the best conference poster presentation award.



A delegation of India-Australia Green Steel Scholars and their Supervisors were funded to visit CSIRO's Clayton site in February 2025 to present their work and attend the 7th Annual Association for Iron and Steel Technology Australia and New Zealand Steel Symposium.



Mr Keith Vining (second from right) and Professor Geoff Brooks (first from right) at the National Institute of Technology Durgapur in February 2025 presenting the 'Decarbonisation Route for Steel' course as part of the India-Australia Green Steel Scholar Network.

Legacy and future opportunities

The Partnerships have demonstrated successful international collaboration with India in critical minerals exploration, downstream processing, rare earths, battery materials, green steel, biomass use, hydrogen technologies and carbon capture research areas.

The Partnerships have also established a trusted and enduring India-Australia network spanning research organisations, universities, industry and government. This network provides a strong foundation for future collaboration ensuring that the benefits of the Partnerships will continue into the future.



Ms Dianne Bedell (left) and Mr Sean Paton (right) (CSIRO) operating the Titanium-Vanadium pilot plant at CSIRO Waterford (Western Australia).

CSIRO is Australia's national science agency,
delivering solutions for a productive,
sustainable and secure future.

Contact us
1300 363 400
csiro.au/contact
csiro.au