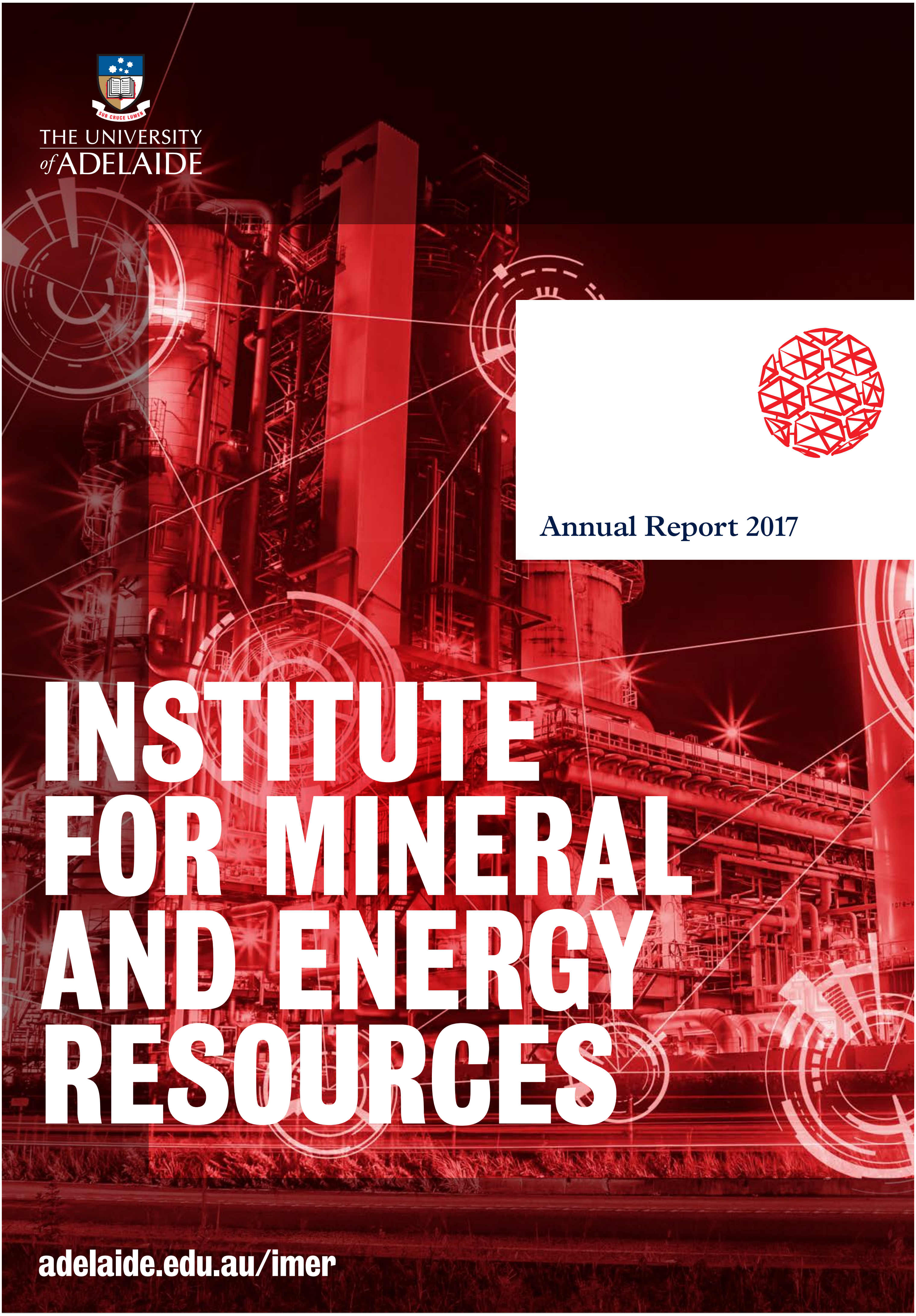


THE UNIVERSITY of ADELAIDE

Annual Report 2017

INSTITUTE FOR MINERAL AND ENERGY RESOURCES

adelaide.edu.au/imer

IMER

BUILDING TEAMS OF SPECIALIST PROBLEM-SOLVERS, WITH EXPERTS ACROSS MULTIPLE DISCIPLINES AND PARTNER COMPANIES FROM ACROSS THE GLOBE.

CONTENTS

IMER

The Institute for Mineral and Energy Resources (IMER) is part of the University of Adelaide, and is the University's principal point of contact for mineral and energy resources research, including industry and government partnerships.

We believe industry-led, challenge-based, interdisciplinary research is key to the sustainable use and development of the world's resources. Our research addresses scientific, technological, environmental and social challenges.

IMER's key role is to assemble interdisciplinary teams from the University of Adelaide and research partners to address global challenges in Deep Resources, Deep Mining, Complex Processing, Tight Energy Resources and Low Cost, Low Emissions Energy.

Deep Resources

Deep Mining

Complex Processing

Tight Energy Resources

Low Cost, Low Emissions Energy

As a member of the *Group of 8* (Australia's eight leading research universities), the University of Adelaide attracts some of world's top researchers.

Go8

Member of Group of Eight*

At IMER, we have more than 140 of the world's experts to help you innovate and push past challenges in your business. Our strengths are in geology, geophysics, petroleum engineering, mining engineering and energy technology.

The following research centres are at IMER's core:

Centre for Tectonics, Resources and Exploration

Centre for Energy Technology

South Australian Centre for Geothermal Energy Research.

We also work closely with three University of Adelaide faculties. Through the Faculty of Engineering, Computer and Mathematical Sciences we're involved with the schools of: Mechanical Engineering; Chemical Engineering; Electrical and Electronic Engineering; Civil, Environmental and Mining Engineering; Mathematical Sciences; and the Australian School of Petroleum. Through the Faculty of Sciences we collaborate with the School of Physical Sciences. Through the Faculty of the Professions we work with the Adelaide Business School and the Entrepreneurship, Commercialisation and Innovation Centre.

The University of Adelaide is also a leading research and postgraduate training facility for the mining and energy sectors in the Asia-Pacific region.

160 STAFF
225 STUDENTS
33 PhDs COMPLETED
7 MASTER DEGREES COMPLETED
3 BOOKS
10 BOOK CHAPTERS
606 JOURNAL ARTICLES
193 CONFERENCE PAPERS
2 PATENTS

* *A coalition of Australia's leading research intensive universities.*

PROVOST AND DEPUTY-VICE CHANCELLOR AND VICE-PRESIDENT (RESEARCH) REPORT

Professor Michael Brooks

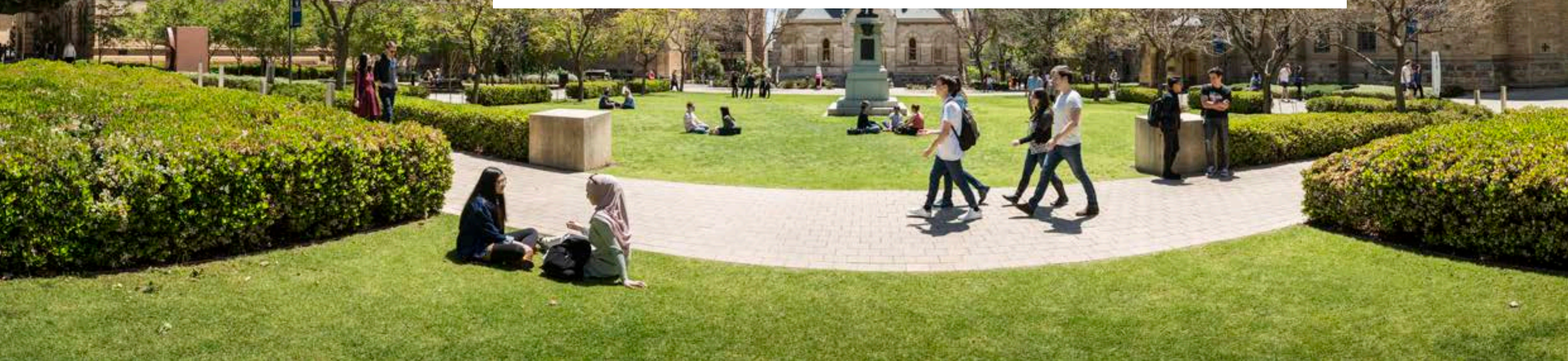
The Institute for Mineral and Energy Resources (IMER) is tasked with addressing the grand challenge in minerals and energy facing Australia and the world: maintaining industry growth in an economically, socially and environmentally sustainable manner.

IMER uses its extensive and deep understanding of the technologies, trends, issues and challenges facing industry to undertake strategic initiatives. These involve strong industry engagement; creating practical industry collaborations; delivering new and innovative products, processes and services; and delivering meaningful, long-term positive impacts for industry and society.

The world is now seeing the mineral and energy resources sectors converge, with the emerging discipline sometimes referred to as 'Industry 4.0'. Whereas previously the challenges IMER focused on may have been about where to find resources, how to mine and process them, and transforming the world's energy mix now, digital technology, data analytics, artificial intelligence, and optimisation are engaged in association with the traditional disciplines.

No project serves as a better example of this than the Premier's Research and Industry Fund consortium for integrated operations and lean processing in mining. IMER's vision is keeping the University of Adelaide ahead of the curve in this space.

This annual report showcases how IMER's research expertise supports major activities in our state, as well as nationally and globally, and I have no doubt this success will continue.



EXECUTIVE DIRECTOR REPORT

Professor Stephen Grano

In 2017, IMER focused on an important emerging global trend—the minerals energy nexus. In this reciprocal relationship, the minerals industry seeks cleaner, affordable energy, while the rapidly transforming energy industry needs, in greater quantities than ever before, materials like lithium and copper to build renewable technologies. IMER is on the front foot, with large projects already underway, such as our $15.1M project on introducing solar thermal to alumina processing, and our $5.3M project to integrate batteries with the grid.

This year also saw a renewed focus on gas, particularly exploration and efficient extraction. Through the Australian School of Petroleum, IMER is seeing plenty of projects on reservoir interpretation and hydrocarbon recovery. Even though petroleum will have a different role in future energy systems, there are still multiple opportunities for research as resources become harder to find and extract.

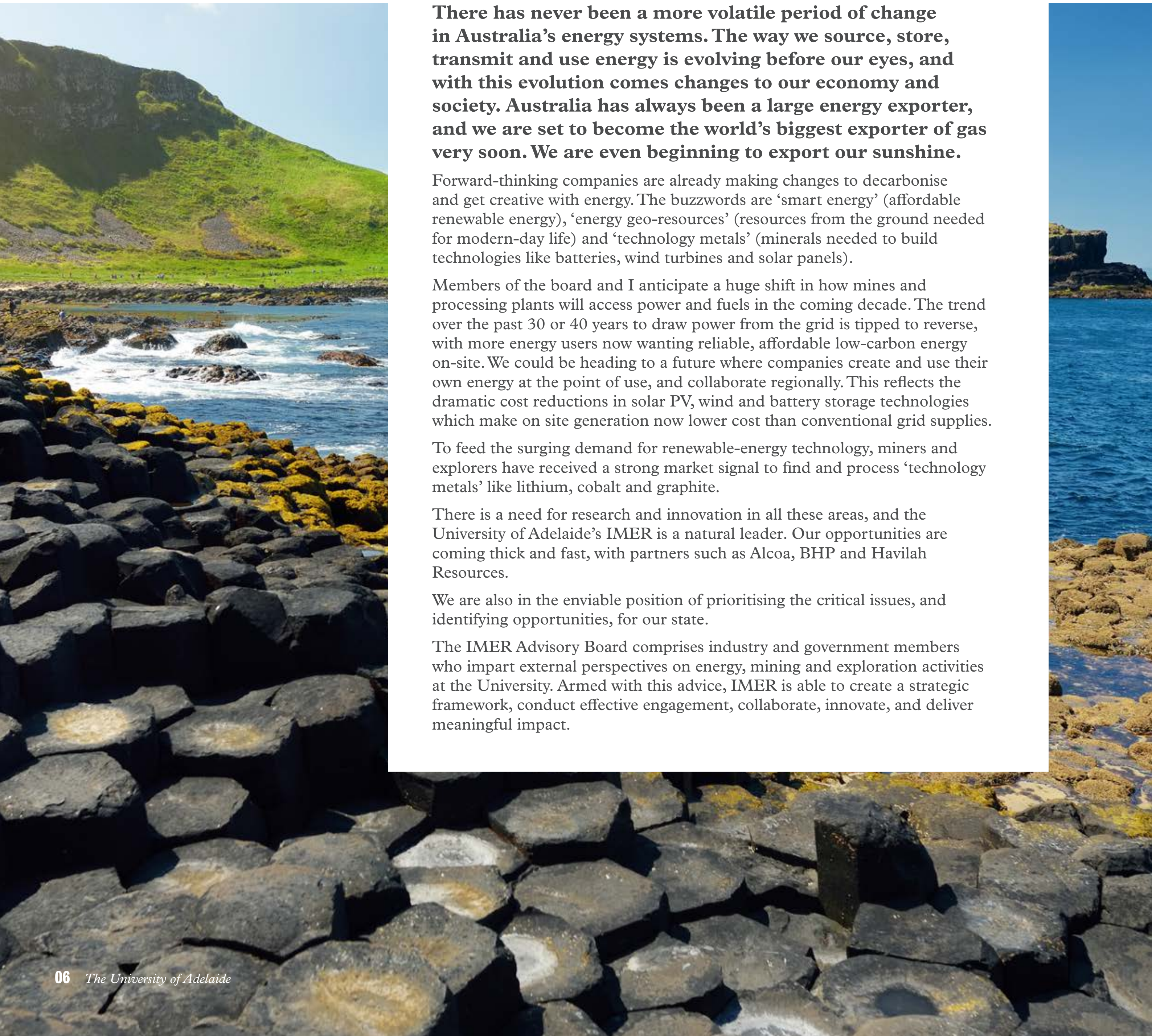
We continued to connect high-level University of Adelaide capability with industry, and sought avenues to fund the linkages. Here are some examples of our successes across our five priority areas:

- **Deep resources**. Drilling giant Boart Longyear is partnering with IMER in the $4.5M Geovision CRC project, which is fusing multiple scanning and sensor technologies, and using machine learning to automate mineral exploration decision-making.
- **Deep mining**. CRC ORE provided $1.3M to the University for the Up-conversion Fluorescence for Real-time Mineral Identification project, which is developing rapid mineral characterisation technology.
- **Complex processing**. The South Australian Government Premier's Research and Industry Fund awarded IMER $4M for the $14.6M consortium program Unlocking Complex Resources through Lean Processing. The program is developing technologies to tailor mining and processing to maximise complex ore bodies' value. Industry partners include BHP, OZ Minerals and a host of mining service providers, such as Manta Controls, Rockwell Automation, Maptek and Scantech.
- **Tight energy resources**. IMER's Centre for Tectonics, Resources and Exploration secured a $645K ARC Linkage grant for the iconic McArthur Basin Tectonic Geography project. Partners include Santos, Origin and Imperial Oil and Gas.
- **Sustainable energy**. ARENA awarded IMER $500K to establish global leadership in Mission Innovation's Converting Sunlight Innovation Challenge, by running workshops on solar fuels, and engaging leading solar fuels researchers in Australia and overseas.

It was another breakout year, in which we continued to lead interdisciplinary research with an external view to global challenges. We look forward to further successes in 2018.

IMER ADVISORY BOARD CHAIR REPORT

Mr Andrew Stock



There has never been a more volatile period of change in Australia's energy systems. The way we source, store, transmit and use energy is evolving before our eyes, and with this evolution comes changes to our economy and society. Australia has always been a large energy exporter, and we are set to become the world's biggest exporter of gas very soon. We are even beginning to export our sunshine.

Forward-thinking companies are already making changes to decarbonise and get creative with energy. The buzzwords are 'smart energy' (affordable renewable energy), 'energy geo-resources' (resources from the ground needed for modern-day life) and 'technology metals' (minerals needed to build technologies like batteries, wind turbines and solar panels).

Members of the board and I anticipate a huge shift in how mines and processing plants will access power and fuels in the coming decade. The trend over the past 30 or 40 years to draw power from the grid is tipped to reverse, with more energy users now wanting reliable, affordable low-carbon energy on-site. We could be heading to a future where companies create and use their own energy at the point of use, and collaborate regionally. This reflects the dramatic cost reductions in solar PV, wind and battery storage technologies which make on site generation now lower cost than conventional grid supplies.

To feed the surging demand for renewable-energy technology, miners and explorers have received a strong market signal to find and process 'technology metals' like lithium, cobalt and graphite.

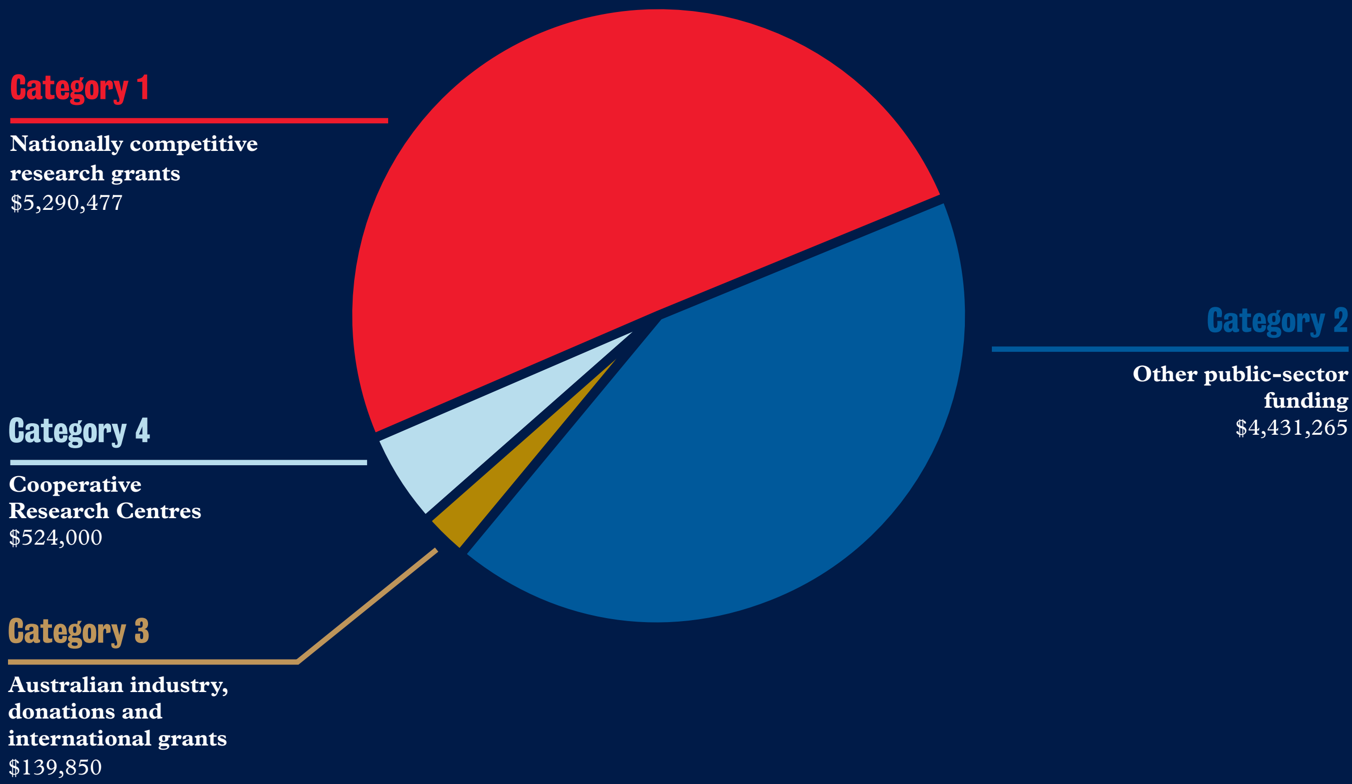
There is a need for research and innovation in all these areas, and the University of Adelaide's IMER is a natural leader. Our opportunities are coming thick and fast, with partners such as Alcoa, BHP and Havilah Resources.

We are also in the enviable position of prioritising the critical issues, and identifying opportunities, for our state.

The IMER Advisory Board comprises industry and government members who impart external perspectives on energy, mining and exploration activities at the University. Armed with this advice, IMER is able to create a strategic framework, conduct effective engagement, collaborate, innovate, and deliver meaningful impact.

RESEARCH FUNDING

In 2017 IMER received over $10M of external funding from new and continuing multi-year grants.



INDUSTRY TRENDS

Deep Resources

INCREASING DEMAND

The global demand for minerals is increasing, driven largely by two demographic factors:

- the world's population is now at 7.6B, and growing at 1.1 % or by 83M per year[1]
- the expanding middle class in developing countries and the global move towards clean energy is driving demand for traditional minerals like aluminium and iron, and creating new markets for energy materials like lithium and cobalt.

The global middle class is expected to grow from less than 2B in 2011 to more than 5B by 2030, with 150M joining annually[2].

The focus on a low-carbon future is driving a growing market for aluminium (including its key constituent, bauxite), cobalt, copper, iron ore, lead, lithium, nickel, manganese, the platinum group of metals, rare earth elements (including cadmium, molybdenum, neodymium and indium), silver, steel, titanium and zinc[3].

INCREASING DEEP RESOURCES

With its rich mineral endowment, Australia will remain an important global resources player. However, existing mines occur mainly in areas with shallow or no cover[4], as can be seen in the map below.

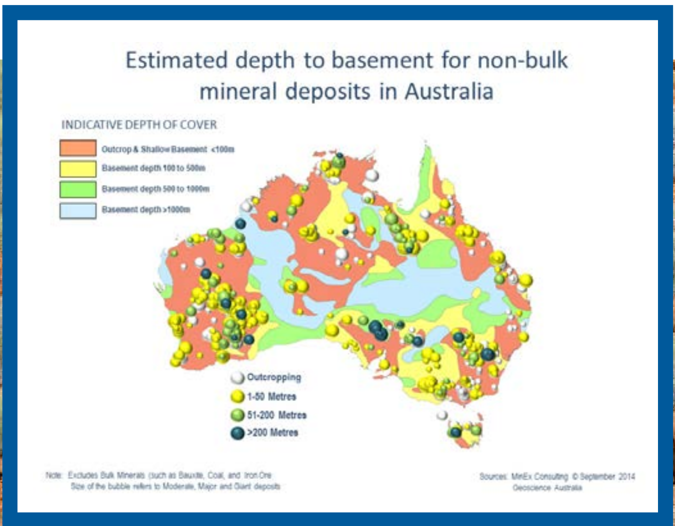
As demand grows and shallow ore bodies are 'mined out', mineral resources will need to come from deeper, lower grade and harder-to-find locations. This is illustrated in the graph below of increasing discoveries in areas of deep cover over the past century[4].

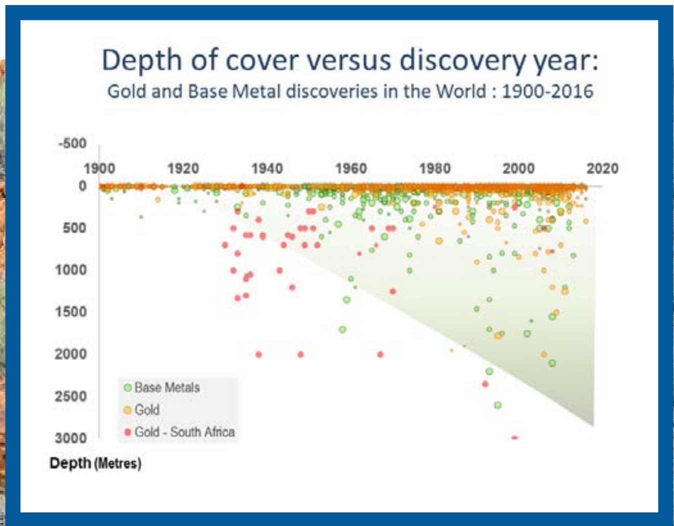
CHALLENGES OF DEEP RESOURCES

Exploring in deep, under-cover areas is challenging and costly. More than 90% of Australia is covered by rock that makes initial and cheaper survey methods, such as surface geochemistry and geophysics, ineffective. This means expensive mapping techniques, such as seismic surveys and deep drilling, are required to map what's under cover. Industry needs more cost-effective techniques to explore under deep cover[4].

X3

Unit discovery costs have tripled in the last decade[4].





HOW IMER IS HELPING

IMER is addressing deep exploration challenges through our involvement in the DET CRC and the newly funded MinEx CRC, which is to be jointly headquartered in South Australia and Western Australia. Our researchers are also helping to map cover in the South Australian Geophysical Reference Model project being run by the Department for Energy and Mining, which incorporates new gravity, magnetic, and magnetotelluric inversions with existing deep-crustal-reflection seismic surveys and seismological velocity models into an integrated 3D model[5]. Finally, IMER supports research to map the crust's architecture through the Electrical Earth Imaging Group, particularly via the AusLAMP project.

THE FUTURE WILL SEE GREATER DEMAND FOR MINERAL RESOURCES, AND THEY WILL BE DEEPER AND HARDER TO FIND.

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INDUSTRY TRENDS

Deep Mining

CURRENT TRENDS

In deep mining—where ore deposits are mined using underground techniques, rather than open cuts—there is a growing trend towards block-caving methods, and mining big open sub-levels. This approach delivers higher tonnage and better metal productivity from lower-grade deposits than conventional methods, such as stoping or cut-and-fill.

CHALLENGES OF DEEP MINING

Deep, lower-grade deposits require smarter, more controlled and accurate extraction methods to enhance productivity, reduce dilution and waste, and improve resource targeting and recovery[1].

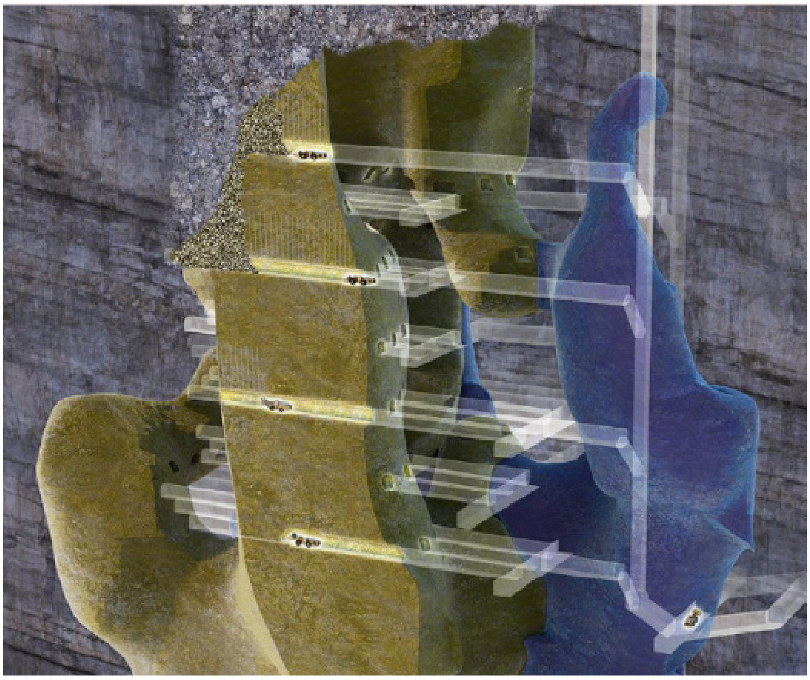
Because mines need to be more efficient and as safe as possible, industry is looking into—and in some cases already implementing—automated drill and blast operations. This involves sensors that give structure, lithology and morphology information to the blast model, and new developments such as wireless blast initiation systems, which improve reliability, mine safety and productivity[2].

Newcrest's Cadia East copper-gold mine in NSW is the first panel-cave, and largest underground, mine in Australia. It uses high-capacity equipment in a single processing line to minimise capital and operating costs[3].

One of Australia's largest new mining developments, OZ Minerals' $916M Carrapateena copper-gold mine will use a sub-level cave mining method, illustrated below[4 5].

HOW IMER IS HELPING

It's said the mines of 2030 will be virtually invisible—underground, automated (or remotely operated) and with minimal environmental footprints. IMER is working with industry on a number of fronts to make this a reality, including through: the Geovision CRC; Premier's Research and Industry Fund Research Consortium Program (PRIF RCP) 'Unlocking Complex Resources through Lean Processing'; and research into in situ recovery.



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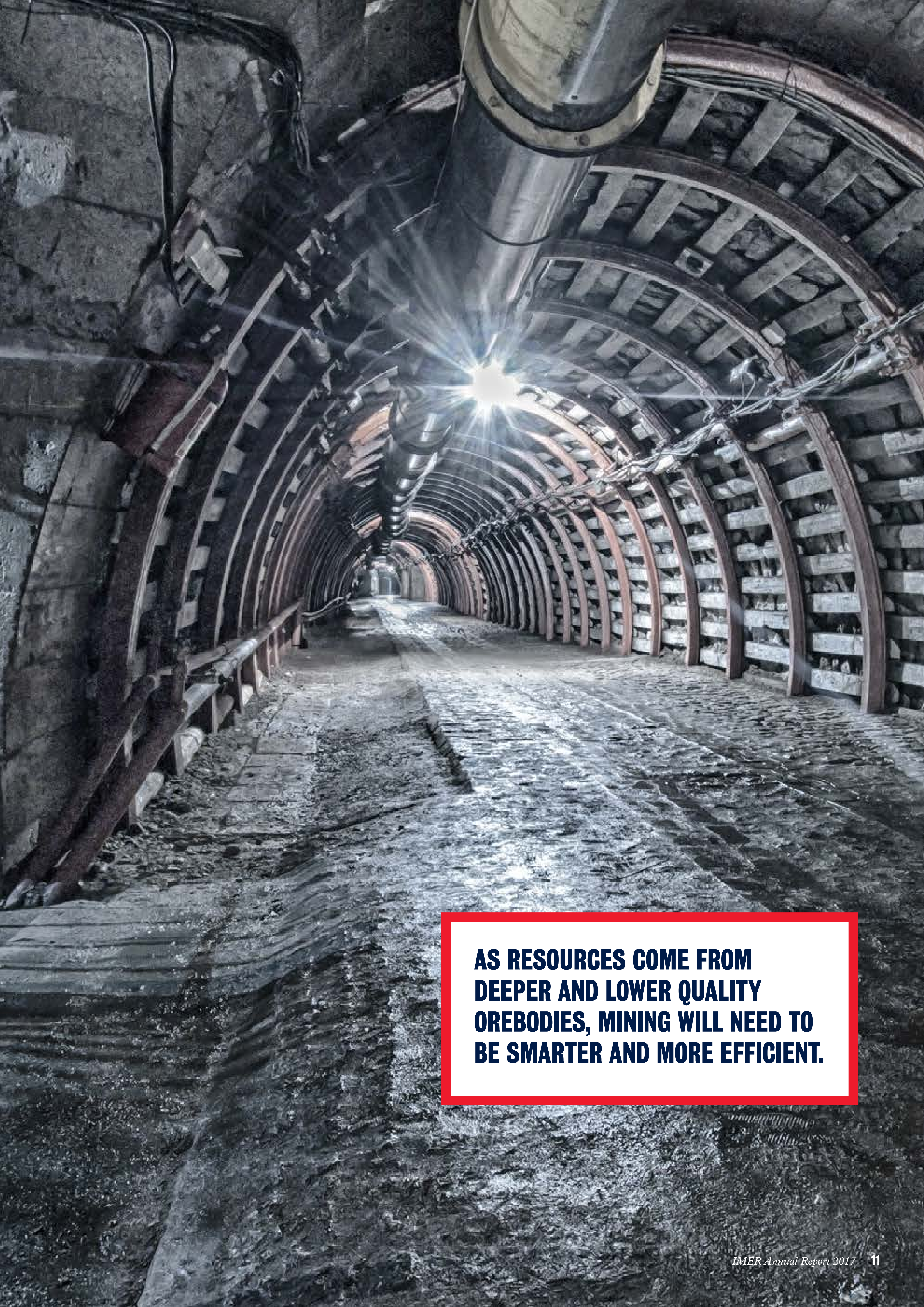


AS RESOURCES COME FROM DEEPER AND LOWER QUALITY OREBODIES, MINING WILL NEED TO BE SMARTER AND MORE EFFICIENT.

INDUSTRY TRENDS

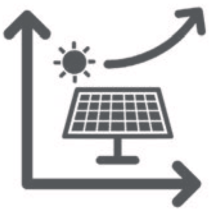
Complex Processing

Our energy systems are trending towards decentralisation, and combined with the shift away from fossil fuels, there is a rapidly growing demand for solar photovoltaic, battery and other clean energy technologies.

Global demand for electric vehicles is increasing exponentially[1]

Over 1M – the global electric car stock in 2015

Over 2M – the global electric car stock in 2016



50% growth in solar power in the last 10 years[2]

Technologies such as these depend on materials with unique properties.
For example:

- solar photovoltaic technology requires indium, gallium and tellurium
- lithium-ion batteries require lithium, cobalt and graphite
- electric motors and systems need much more copper than fossil-fuel ones.

As a result, global demand for these so-called 'technology metals' is ever increasing. Skyrocketing prices reflect this.

Supply of lithium carbonate would need to more than triple over 2015 supply to meet predicted global demand in 2025[3]

Supply of tellurium would need to double over 2015 supply to meet predicted global demand in 2025[3]

Meeting this growing global demand for strategic minerals is made more challenging by the complex ores in which many occur. These ores contain more than one mineral, each with unique chemical properties that require a specific extraction approach. For example, in Canadian mines nickel and cobalt are commonly found together, and require different mineral processing to extract.

South Australia has some of the most complex mineral systems in the world, such as the mineral deposits at the Olympic Dam and Prominent Hill mines, which include copper and gold.

Australia is rich in minerals to serve the next wave of industrialisation. Our economy and mining sector will benefit if the challenges of complex ores can be cost-effectively overcome. A key example is the exponential growth forecast in the global demand for batteries.

Australia is the world's number one producer of lithium, and many other minerals required to manufacture batteries[5]. Currently, Australia exports lithium for processing elsewhere, then imports the batteries that contain that lithium. If we can solve the complex processing problems to reduce the currently high costs of extracting lithium from hard-rock minerals and lithium brines to reach battery-grade lithium, Australia could directly produce battery-grade lithium and batteries[5].

This is not an isolated case; the same can be said for many of our resources, including iron (steel) and bauxite (aluminium), to name just two.

Australia produces 60% of the world's lithium[5]

MINERALS, LIKE LITHIUM, THAT WERE HISTORICALLY NICHE MARKETS ARE NOW BECOMING MAINSTREAM.

HOW IMER IS HELPING

IMER is meeting the complex-processing challenge, with interdisciplinary research teams in the mining-processing value chain working on projects such as the: ARC Hub for Australian Copper-Uranium; FOX project, investigating iron oxides' trace element signatures; and PRIF RCP for lean processing of complex ores.

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INDUSTRY TRENDS

Tight Energy Resources

CURRENT TRENDS

Despite the global focus on renewable energy sources, the world remains dependent on petroleum and petroleum-derived products. Global demand is expected to continue rising due to world population growth and developing countries' advancement[1].

81%

81% Fossil fuels' share of primary energy in 2014; 50-70% Fossil fuels' predicted share of primary energy in 2060[2]

There is also increased interdependence between the natural gas and renewable energy markets, due to the fact that most hydrogen is currently produced from fossil fuels. With abundant resources of natural gas, and as the world's fourth largest exporter of liquefied natural gas, Australia has considerable potential for further development to meet this demand[3].

95%

95% of the hydrogen produced in the United States is made by natural gas steam methane reforming[4]

MAXIMISING RECOVERY

As with minerals, the most accessible oil resources already exploited, only deeper, more logistically complex—and therefore more costly—resources remain. As a result, the trend is to maximise extraction from existing fields as a way of reducing costs and risks.

Enhanced oil recovery (EOR) aims to increase extraction from existing oil fields. Thermal recovery, gas injection and chemical injection techniques offer prospects for increased extraction compared to traditional methods[5].

Proportion of available oil extracted from reservoirs:

10% during primary recovery

20-40% using secondary recovery techniques

30-60% using enhanced oil recovery techniques[5]

Advanced data analytics will also enable better insight into resources and how to maximise their extraction, by accelerating oil discovery and enhanced recovery[6]. Well field data analytics and sensors will also enable better assessment of gas quality and mix.

CHALLENGES OF LOWER-QUALITY RESOURCES

As lower-quality resources are explored and extracted, new approaches are needed. In NSW's Gunnedah Basin for example, the gas deposit's highly variable CO_2 content presents numerous challenges, such as clogged membranes and the presence of CO_2 and water vapour in the gas stream.

The extraction of unconventional gas found in complex geological systems requires better understanding of geology's effect on gas processing and geoprocessing. In Saudi Arabia, Halliburton is working with Saudi Aramco to take an integrated engineering and geosciences approach to unconventional gas extraction[7].

HOW IMER IS HELPING

IMER is leading interdisciplinary teams to aid exploration of, and maximise extraction from, existing sites and lower-quality resources by researching new EOR techniques and better understanding unconventional petroleum systems' geology and geomechanics.

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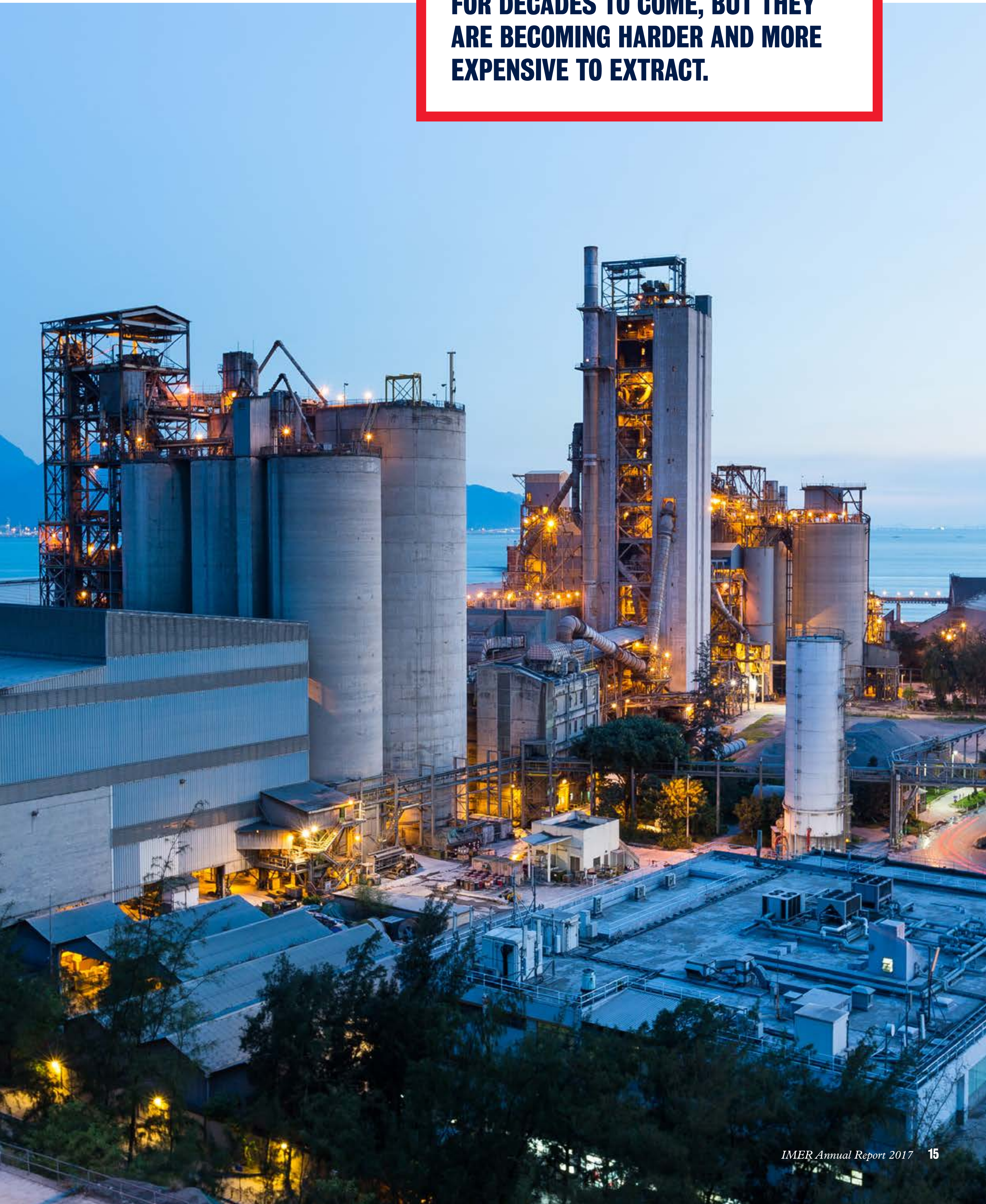
THE WORLD WILL CONTINUE TO RELY ON ENERGY GEORESOURCES FOR DECADES TO COME, BUT THEY ARE BECOMING HARDER AND MORE EXPENSIVE TO EXTRACT.



INDUSTRY TRENDS

Low Cost, Low Emissions Energy

Addressing climate change and unsustainable energy and resource consumption requires a global move towards a low-carbon future, as is well documented in the UN Sustainable Development Goals and the Paris Agreement. Renewable sources of power now represent approximately 30% of the world's total capacity and 23% of total global electricity production[1].

23% growth in wind power in the last 10 years; 50% growth in solar power in the last 10 years

CHALLENGES

While the world has committed to the UN Framework Convention on Climate Change (UNFCCC) Paris Agreement goal of keeping global temperature rise below two degrees, requiring limiting atmospheric CO_2 to 450ppm, some key truths are often overlooked by policymakers.

The focus is often on carbon emissions from power, but power production is responsible for only around a third of global energy emissions, and a quarter of total emissions. The other two thirds of energy emissions come from energy for mobility, such as petrol for cars, and from process heat production, for industries such as steel, cement and alumina. For the world to reach the UNFCCC goals it won't be enough to only focus on power. We will also need to make deep emissions cuts from fuels and heat.

Large-scale, reliable renewable energy storage is critical to the accelerated uptake of sustainable energy and its delivery of global primary energy needs. Storage must overcome seasonal, daily and hourly variability. With large-scale lithium battery storage cost-prohibitive, other energy storage options need to be rapidly developed, such as pumped hydro, thermal energy, and the generation and storage of hydrogen.

CURRENT TRENDS

In South Australia we have recently established global leadership by:

- installing the world's largest battery
- announcing the world's largest solar thermal power plant
- reaching 50% renewable electricity generation
- announcing 90,000 home batteries 'behind the meter'
- creating a hydrogen industry roadmap.

Tesla has built the world's largest lithium-ion battery storage project in South Australia. With 100MW of capacity, it will provide 129MWh of energy generation, load balancing the state's renewable energy generation and providing emergency back-up power[3].

New energy storage models are also shifting residential renewable energy storage systems. German battery maker Sonnen has introduced to Australia an integrated solar and storage system, using its customers' installed battery storage capacity as a virtual power plant to provide grid-balancing services to the network[4].

HOW IMER IS HELPING

IMER, through its Centre for Energy Technology (CET) is working in power, heat and fuels in technology, including solar thermal, wind, biomass and ocean energy. The CET partners with numerous industry partners to develop technologies enabling the transition to a low-carbon, sustainable future. The University of Adelaide also has leadership in energy materials and catalysts (including graphene and hydrogen), electrical energy storage and solar fuels production.

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ENERGY DISRUPTION IS EVERYWHERE. INNOVATION AND NEW THINKING IS NEEDED.

IMER'S RESEARCH

IMER facilitates interdisciplinary initiatives and projects aligned to global challenges by:

- assembling interdisciplinary teams from across the University of Adelaide and external partners
- forging strategic relationships between researchers, research institutions and industry, including internationally
- supporting research leadership by investing in strategic research initiatives that leverage new funding and build capability for high-quality outputs
- increasing the number, scale and success rate of national competitive grant applications to build research capability and capacity.

Key principles

IMER's mission encompasses the following key principles:

- **Engagement.** Engage with industry and government to identify key challenges and link these challenges to innovative capability; engage with the research community and entrepreneurs; and identify value propositions through informed engagement.
- **Collaboration.** Create new collaborative projects to bring in new ideas, companies, products and services; map capability to industry and government imperatives; and establish strategic partnerships with industry and research partners.
- **Innovation.** Develop new processes, policy, products and services in collaboration with partners (research, translation and end-user) in collaborative, large-scale research projects.
- **Impact.** Make meaningful long-term contributions to deliver quantifiable economic, environmental or social impacts.
- **Global recognition.** Position the University of Adelaide as a leading, world-class research university.
- **Outreach.** Recognise the importance of communication in maintaining mutually beneficial relationships between the University, industry and society.

Here you can see IMER'S principles in action, with a sample of our interdisciplinary projects presented across the five global challenges. We built these teams in concert with industry, in direct response to their needs.

LINKING SENSING, DATA ANALYSIS AND AI FOR SEAMLESS PROCESS CONTROL

IMER is leading Australia in the development of fully integrated, artificial-intelligence-driven resource value chains. Linking the University of Adelaide's world-class multidisciplinary research expertise with major industry collaborations, the institute is enabling self-learning extraction-and-processing control systems to extract value from complex resources more safely, faster and at lower cost.

According to IMER Director Professor Stephen Grano, the transition to "smart" automation is becoming increasingly critical for the sector as conventional, easily extracted mineral and energy sources are exhausted.

"For a long time, the sector focused on deposits that were largely of the same mineral, at the same grade, and relatively close to the surface," he says. "So we didn't really need value-chain integration. But those deposits are gone.

"The long-term trend is towards lower-grade, highly heterogeneous resources, in hard-to-reach locations. They vary in terms of: how much materials is there; how difficult it is to extract; how much energy or waters is needed to liberate the minerals; and so on. There's also a high degree of variability in renewable energy resources, so maximising their value poses similar challenges.

"With all that variability, you have to be able to adapt inputs rapidly, precisely and safely—every step of the way—to ensure you deliver materials with the right attributes at the right time, without undue cost. AI-driven digital integration can achieve that."

IMER is coordinating a team of Adelaide earth scientists, petroleum and geochemical engineers, computer scientists and machine learning experts, in a series of industry–research collaborations to refine its work in real-world scenarios.

"In the area of drilling, for example, we're heavily involved with Boart Longyear," Professor Grano says. "We have a long relationship with them in the Deep Exploration Technology Cooperative Research Centre, and now also in the Geovision CRCP (Cooperative Research Centre Project)."

The IMER team is working with Boart to integrate a variety of sensors into their drill rigs, to measure things like how easily the drill penetrates the ground, while drilling. This data is then fed back to other sensors in real time, which can identify what's in the material being drilled, and other key factors.

"All this data is correlated using data fusion. Then we can apply AI approaches to interpret it, and produce real-time adjustments up the chain in things like the resource model and mine plan."

The institute is doing similar work on mining and processing control platforms with BHP, OZ Minerals and others in the Premier Research and Industry Fund Research Consortium Program (PRIF RCP), Professor Grano continues.

"We're even in the early stages of working with Orica to apply digitally integrated AI to blast models, to ensure the desired level of fragmentation and prevent dilution.

"This is cutting-edge work, and an area in which Australia can lead the world."

IMER IS COORDINATING A TEAM OF ADELAIDE EARTH SCIENTISTS, PETROLEUM AND GEOCHEMICAL ENGINEERS, COMPUTER SCIENTISTS AND MACHINE LEARNING EXPERTS, IN A SERIES OF INDUSTRY–RESEARCH COLLABORATIONS TO REFINE ITS WORK IN REAL-WORLD SCENARIOS.

ALL THIS WORK IS ATTRACTING GLOBAL INTEREST

ENHANCING AUSTRALIA'S ENERGY STORAGE CAPABILITIES AND OPPORTUNITIES

With the world's insatiable appetite for new technology and the global move towards electrification gathering pace, demand for energy storage-associated materials is skyrocketing. So too is the need to use what we have more efficiently. Understanding this, IMER is leading the University of Adelaide's involvement in several related industry-connected initiatives—and in the process facilitating enormous economic opportunities for Australia.

Chief among those opportunities, says IMER Director Professor Stephen Grano, is value-adding to the nation's vast stores of lithium, cobalt and graphite, all critical materials in modern batteries.

"We're fortunate in Australia to have an estimated 60% of the world's lithium," he says. "So with potentially every car and home in the world requiring a battery in future, many large companies want to take advantage of that.

"Sonnen has said it wants to produce large volumes of lithium-ion batteries right here in Adelaide, BASF is making all sorts of electro-materials here for lithium-ion batteries, and Tesla's moving in. So our researchers are looking at ways we can leverage this opportunity."

A key part of IMER's efforts in this area will be its involvement in the Cooperative Research Centre for Future Battery Industry (CRC FBI) and a collaboration with other universities, research centres and key industry partners, including Tianqui Lithium, BHP and Neometals.

"In the CRC FBI we're looking to enhance the entire lithium-ion battery value chain in Australia," Professor Grano says. "That includes developing new high-value products, complete with manufacturing control systems, machine-learning optimisation and integration into the power grid."

As significant as the lithium opportunity is, however, it's not IMER's sole energy-materials focus. The institute is additionally:

- coordinating Adelaide researchers' development of new, post-lithium-ion batteries—very small, with relatively low capital cost, enabling the material mix to be readily changed
- working with PMB Defence, makers of lead-acid batteries for Australia's Collins Class submarines, to integrate sensing and analytics for real-time performance monitoring
- developing technology for repurposing and recycling vehicle batteries for grid applications
- exploring opportunities for by-product recovery of various energy-technology-related critical metals, including cobalt, indium, germanium and more.

"We're also investigating other materials-based methods of reducing batteries' cost. Our chemical engineering researchers, for example, are working on using carbon nanotubes and graphene to increase lithium's interfacial area and electrochemical properties.

"All this work's attracting global interest."

OUR PRINCIPLES IN ACTION

Here you can see IMER's principles in action, with a sample of our interdisciplinary projects presented across the five global challenges. The teams have been built by IMER in concert with industry, in direct response to their needs.

The numbers that appear on the Challenges table on the opposite page correlate with the Case Studies listed below.

CASE STUDIES

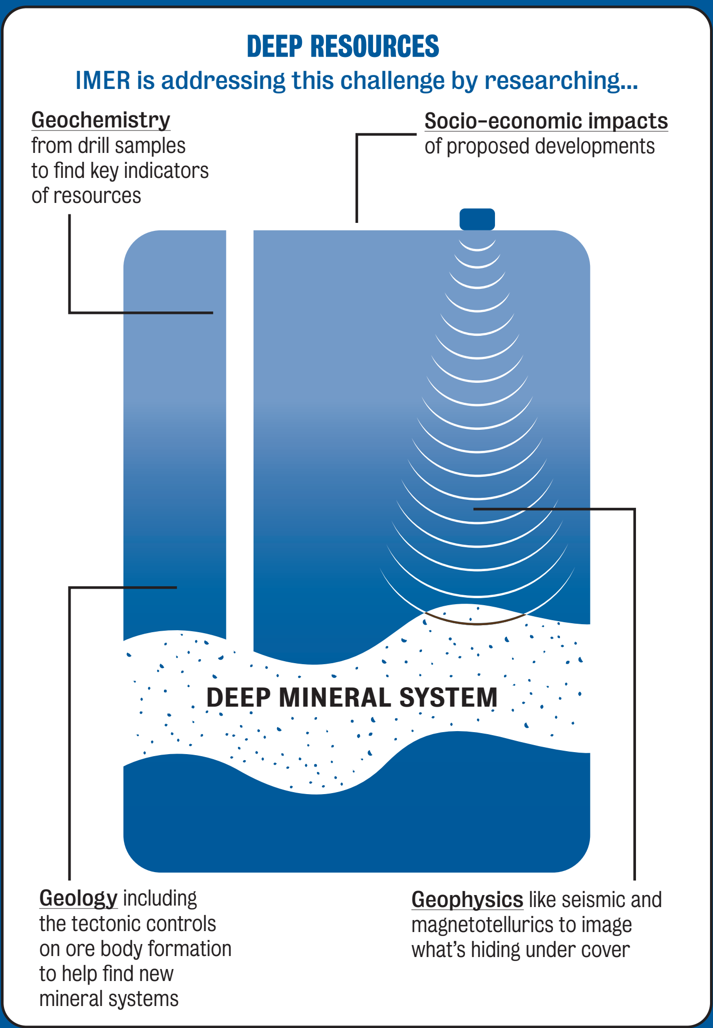
Challenge	Case studies
Deep Resources	**CASE STUDY 1** DET CRC: enabling resource discoveries through technological innovation **CASE STUDY 2** AusLAMP: mapping Australia's deep-earth architecture
Deep Mining	**CASE STUDY 3** Modelling a viable path to hard-rock in situ recovery **CASE STUDY 4** Breathing new life into the Adelaide fold belt
Complex Processing	**CASE STUDY 5** ARC Graphene Enabled Industry Transformation Hub **CASE STUDY 6** Data driven mining consortium: developing tech to facilitate profitable SA copper expansion
Tight Energy Resources	**CASE STUDY 7** McArthur Basin: pioneering exploration promises long-term energy security **CASE STUDY 8** ASP research informs future hydrocarbon exploration in the Great Australian Bight
Low Cost, Low Emissions Energy	**CASE STUDY 9** World-leading solar tech enabling cleaner heat for heavy industry **CASE STUDY 10** ASTRI: developing the world's first solar-generated aviation-grade biofuel

CHALLENGES

	Deep Resources	Deep Mining	Complex Processing	Tight Energy Resources	Low Cost, Low Emissions Energy
Chemical engineering	3, 5, 6	3, 5, 6	3, 5, 6	3, 5	5, 9, 10
Chemistry	5	5	5	5	5, 10
Community engagement	1, 2, 3, 4, 6, 8	1, 2, 3, 4, 6	3, 4, 6	2, 3, 8	
Computer science	1, 6	1, 6	6		
Data analytics	1, 2 3, 6	1, 2, 3, 6	3, 6	3	
Digital modelling	2, 3, 6	2, 3, 6	3, 6	3	
Economics	1, 4	1, 4	4		9, 10
Electrical/electronic engineering	1, 6	1, 6	6		
Environmental science & management	3, 4, 5, 6, 7, 8	3, 4, 5, 6, 7	3, 4, 5, 6	3, 5, 7, 8	5, 10
Fuel technology					9, 10
Functional materials	5, 6	5, 6	5, 6	5	5
Geochemistry	1, 2, 3, 4, 6, 7	1, 2, 3, 4, 6	3, 4, 6	3, 7	
Geology	1, 2, 3, 4, 6, 7, 8	1, 2, 3, 4, 6	3, 4, 6	2, 3, 7, 8	
Geomechanics	1, 3, 4, 5, 6	1, 3, 4, 5, 6	3, 4, 5, 6	3, 5	5
Geophysics	1, 2, 3, 4, 6, 7, 8	1, 2, 3, 4, 6	3, 4, 6	2, 3, 7, 8	
Geostatistics	1, 3, 6	1, 3, 6	3, 6	3	
Hydrogen					9, 10
Hydrogeology	2, 3, 6, 7	2, 3, 6	3, 6	2, 3, 7	
Machine learning	6	6	6		
Materials engineering	5, 6	5, 6	5, 6	5,	5, 9, 10
Mathematical sciences	6	6	6		
Mechanical engineering	1, 6	1, 6	6		9, 10
Microscopy	1, 3, 5, 6, 7	1, 3, 5, 6	3, 5, 6	3, 5, 7	5, 10
Mineralogy	1, 2, 3, 4, 6	1, 2, 3, 4, 6	3, 4, 6	2, 3	
Mineral processing	3, 4, 5, 6, 7	3, 4, 5, 6	3, 4, 5, 6	3, 5, 7	5
Mining engineering	3, 4, 5, 6	3, 4, 5, 6	3, 4, 5, 6	3, 5	5
Nanotechnology	5	5	5	5	5, 10
Optics and photonics	1, 3, 6	1, 3, 6	3, 6	3	
Petroleum engineering	3, 7, 8	3	3	3, 7, 8	
Sensors	1, 3, 6	1, 3, 6	3, 6	3	

Deep Resources

It's official: every year shallow resources are harder to find. Explorers must look deeper for mineral systems that lie hidden beneath extensive rock cover.



Global demand for minerals resources such as copper, gold, and the new technology metals such as lithium and cobalt, has never been higher and continues to increase. The problem is, if we can't easily 'see' through the rock cover, how will we find new deposits?

It's no longer economically viable or socially acceptable to extensively drill for exploration. New low cost, low impact techniques for exploration are needed, and this is where IMER's research comes in.

The Deep Exploration Technologies Cooperative Research Centre (DET CRC) has, for the last eight years, been attempting to develop and test new technologies to help the industry better target minerals under cover rocks, and provide exploration answers in near-real time (see Case Study #1).

IMER hosts the national facility for magnetotellurics and is using this technique to investigate new ways to explore for mineral systems under cover (see Case Study #2).

Professor Richard Hillis
Chief Executive Officer,
Deep Exploration Technologies
Cooperative Research Centre

CASE STUDY 1

DET CRC: ENABLING RESOURCE DISCOVERIES THROUGH TECHNOLOGICAL INNOVATION

It's said change is inevitable. But for the mining industry, it's essential. With easily exploited sites all but exhausted, the future lies in discovering and tapping new areas under rock cover at greater depth. For eight years, the Deep Exploration Technologies Cooperative Research Centre (DET CRC) has been developing cutting-edge new tools to help the industry make the transition, with the University of Adelaide playing a major role. Undoubtedly it has succeeded.

The DET CRC has been a major undertaking. Running from 2010 to 2018, with $155M of cash and in-kind funding from the Australian Government and other participants, it was the world's best-supported independent research initiative in mineral exploration.

Adelaide was a joint research and development partner in the venture, along with the CSIRO and Curtin University, while industry partners included BHP, Boart Longyear, Imdex, Barrick Australia, Anglo American, and Vale. The University of Western Australia also participated, as did the Australian and South Australian governments.

As a direct result of the research and development conducted, the centre entered into ongoing licence agreements for 11 new technologies. According to former DET CRC Chief Executive Officer Professor Richard Hillis, an Adjunct Professor in the University's Australian School of Petroleum, their combined impact could be enormous.

"It's independently estimated that our DET CRC–developed tools could collectively contribute to over $2.6B worth of additional discoveries for Australia's minerals industry over a 10-year period," says Professor Hillis, who was named 2018 South Australian Scientist of the Year for his work in the centre. "Extrapolated globally, that figure could be over $20B."

The greatest progress is likely to come from five standout products. These are the:

- AutoSonde sensor, which measures rock's gamma radioactivity, magnetic susceptibility and conductivity around the drill hole in real time
- AutoShuttle platform, which sits within conventional rods and provides incremental measurements to aid progressive rock-type identification
- Lab-at-Rig® top-of-hole sample analysis system, which measures drill-hole geochemistry and mineralogy even before the core has been recovered
- Wireless Sub, which measures drill string rotation speed, weight on the bit, and many other factors, and sends that data wirelessly for analysis to rapidly optimise operating parameters
- RoXplorer® coiled tubing drilling system.

In field trials, the RoXplorer drilled to depths of 500m using continuous malleable steel coil, with no rod handling, providing major cost and safety benefits.
"Its down-hole motors, hammers and bits are also driven by a fluid that's constantly recycled. That avoids fluids escaping into the environment. Plus, it drills straight and fast, and weighs only 15 tonnes, so is easily transported."

The RoXplorer's trials have already opened unexplored parts of the Gawler Craton and Murray Basin to prospecting drilling, Professor Hillis adds.

"We're fundamentally changing mineral exploration."

Professor Graham Heinson
TRaX Director

CASE STUDY 2

AUSLAMP: MAPPING AUSTRALIA'S DEEP-EARTH ARCHITECTURE

The world is watching the Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP). This visionary research is providing the first whole-country, 3D picture of the lithosphere—Earth's rigid upper plate–underneath Australia. It's informing deep, under-cover resources exploration, and providing valuable insight into our geological hazards and history. The University of Adelaide is a driving force.

Funded by Geoscience Australia, the National Collaborative Research Infrastructure Strategy facility AuScope, and state and territory government geological surveys, AusLAMP aims to record data at around 3000 geophysical stations in approximately a 55 km grid across the entire country. Work began in 2013 and is expected to finish around 2023.

Each site will acquire magnetotelluric (MT) data—measurement of Earth's electric and magnetic fields—for three weeks. This record of electromagnetic response, reaching down hundreds of kilometres, enables the construction of remarkably informative 3D images of lithospheric 'architecture'.

University of Adelaide Department of Earth Sciences researchers, led by Professor Graham Heinson, working closely with the South Australian Geological Survey, have been responsible for all South Australian data stations, as well as some in New South Wales and Western Australia. According to Graham, the data is already showing its worth.

"Mineral explorers, in particular, are very interested in this data," he says. "It provides an excellent indication of where deposits might have formed under sedimentary cover, and may be invisible to the naked eye. In 2017, for example, Havilah Resources found an interesting AusLAMP result in Curnamona, near Broken Hill, under significant sediment. So they asked us to take a closer look.

"We put in a more detailed line of MT stations, and those findings are generating a lot of excitement."

AusLAMP data also casts more light on how the earth "works", says IMER Manager Dr Chris Matthews. "That includes, for example, which areas of Australia might be more earthquake-prone, and the full extent of underground water bodies."

With such obvious commercial benefits, a number of parties—including the University, Geoscience Australia, state governments, industry and other research institutions—have put forward a joint proposal for a nationwide initiative called "Uncover". *Uncover's* objective is to help pinpoint Australia's deep mineral deposits that are not "poking out of the ground", using AusLAMP MT data as signposts.

"There's almost certainly another Olympic Dam out there," Chris says, "and AusLAMP shows MT is one of the technologies most likely to find it. It's a monumental achievement."

KEY PROJECTS ACTIVE IN 2017
Deep Resources

Building central Asia: linking the growth of Asia to its exhumation

Sponsor: Australian Research Council
Chief Investigators: *Dr Stijn Glorie*; *Prof Alan Collins*
Collaborators: Curtin University; Institute of Geology and Geophysics (China) (partnership)

NCRIS-AuScope-Earth imaging

Sponsor: Department of Industry, Science and Resources (Australian Government)
Chief Investigator: *Prof Graham Heinson*

Tectonic geography of the world's oldest petroleum play, the McArthur Basin

Sponsors: Australian Research Council; Northern Territory Geological Survey (partnership); Origin Energy Resources; Santos
Chief Investigators: *Prof Alan Collins*; *Dr Juraj Farkas*; *Dr Stijn Glorie*

Enhanced imaging of South Australia's tier-1 mineral resource system

Sponsor: BHP
Chief Investigator: *Prof Graham Heinson*

AusLAMP deep MT imaging of the South Australian crust

Sponsors: Geological Survey of South Australia; AuScope (NCRIS); AusLAMP
Chief Investigator: *Prof Graham Heinson*

DEEP EXPLORATION TECHNOLOGIES COOPERATIVE RESEARCH CENTRE

Impact of melt loss on crustal heat production and Earth geodynamics

Sponsor: Australian Research Council
Chief Investigator: *Dr David Kelsey*
Collaborators: University of Bern; Rensselaer Polytechnic Institute

Rehydration of the lower crust, fluid sources and geophysical expression

Sponsor: Australian Research Council
Chief Investigators: *Prof Martin Hand*; *Dr Derrick Hasterok*
Collaborators: Curtin University; Macquarie University; University of California

Source to spectrum: finding deposits beyond the Fe oxide-Cu-Au envelope

Sponsor: Australian Research Council
Chief Investigator: *Prof Martin Hand*
Collaborators: University of South Australia; Monash University

Testing the UNCOVER paradigm: crustal fluid pathways in the Curnamona Province

Sponsors: PACE Copper; Australian Society of Exploration Geophysicists Research Foundation
Chief Investigator: *Prof Graham Heinson*
Collaborators: Geological Survey of South Australia; Havilah Resources

Deep Mining

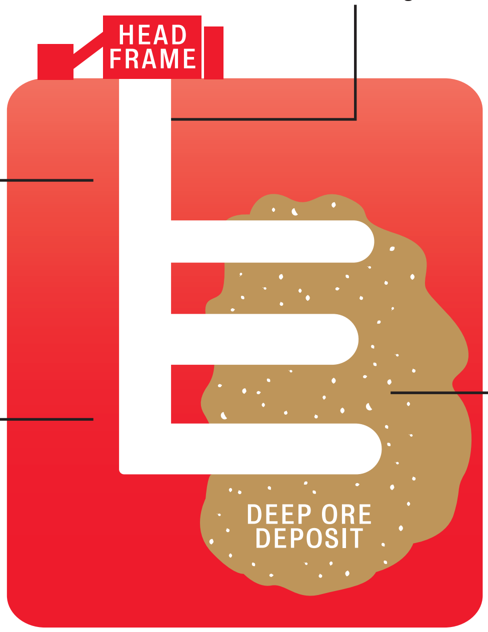
As exploration efforts move deeper and under cover rocks, so does mining. Going deeper means we need to better understand the way rocks behave when we mine deep underground, so we operate safely and efficiently.

DEEP MINING

IMER is addressing this challenge by researching...

Geochemistry and geomechanics to understand how rocks will fracture and predict the impact on mine stability and mineral extraction

Materials to increase stability in mine shafts and tunnels; new backfill materials to improve safety and dispose of mine tailings



Mine planning and optimisation for deep ore bodies

Rock burst modelling to reduce the threat of rock failure and create a safe working environment

This shaft mine is just one type of deep mine. IMER assists industry to choose the optimal mine type for each individual ore body

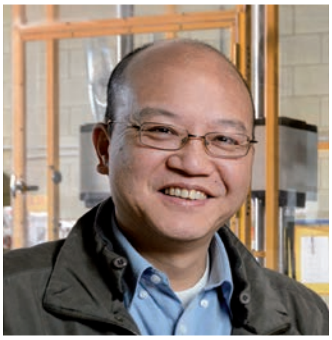
Global production has increased steadily over the last 30 years as demand for minerals continues to rise. But supply is becoming more difficult and costly. As discussed in the Deep Resources Challenge, minerals discoveries are invariably deeper and under cover rocks. The deeper we go, the more complicated the mining challenges become.

At the University we are now looking at ways to mine deep underground without sending people or machines in to bring the ore back to the surface. One way to do this is known as ‘in situ recovery’ and involves using chemicals to extract the target minerals from the rocks directly. To do this the orebody would need to be fractured, and fluid circulated through it from the surface. There is much to research in this space (see Case Study #3).

Excitingly for the State, one of the biggest mining expansions in our history is underway, with BHP commencing mining in the Southern Mine Area (SMA) of Olympic Dam.

CASE STUDY 3

MODELLING A VIABLE PATH TO HARD-ROCK IN SITU RECOVERY



A/Professor Chaoshui Xu
School of Civil Environmental and Mining Engineering

In uranium mining, in situ leaching is king. Compared to open-cut, it's far less costly, and waste and environmental impact is reduced, making smaller and harder-to-reach ore bodies commercially viable. But that's in shallow, porous rocks; and uranium is simple to leach. Extracting other minerals using similar techniques in deep, hard-rock environments requires significant fracturing, which presents real challenges. University of Adelaide research, however, is meeting them.

For a number of years, a research team in the University's School of Civil, Environmental and Mining Engineering has been focused on developing efficient fracture and flow modelling tools and techniques to overcome the challenges of hard-rock in situ recovery. According to lead researcher Associate Professor Chaoshui Xu, they're succeeding.

"There's still a lot we want to do," he says. "But I'm confident that, based on the algorithms and methods we've developed, we could now create a realistic fracture and flow model for hard-rock in situ reservoirs."

The modelling enables miners to predict—and control—how fractures will behave and how fluids will flow into and out of target mineral zones. This information can then inform a number of subsequent planning tasks.

"Understanding where fluids go when you pump them into a fracture is vital for appropriate well-field design and efficient operation," Associate Professor Xu explains.

"It enables good decisions, for example, regarding where to inject fluids and where to recover them. It also helps miners ensure the chemicals pumped in won't leak into the environment outside the ore body. With these tools we'll ultimately be able to design entire in situ recovery mine sites."

The next step, he continues, is to refine the team's modelling in practice; something they're hopeful of initiating later this year in a real-world mining environment.

"We have applied for a grant with a number of resources companies who are very interested in our in situ recovery work. If we're given the green light, we'll be applying our modelling in a large-scale trial project to demonstrate—and enhance—its effectiveness."

Though hard to quantify, in situ recovery's potential future impact on the mining industry could be huge, Associate Professor Xu believes.

"If you take traditional mining techniques as a baseline, then in terms of cost savings and environmental gains, it will be a step change.

"It's not even comparable."

CASE STUDY 4

BREATHING NEW LIFE INTO THE ADELAIDE FOLD BELT

For decades, many presumed the southern Adelaide Fold Belt—host of Australia's first metal mine in 1841—had no more minerals to offer. But it seems they were wrong. Innovative mining engineering and geological rethinking has enabled Hillgrove Resources to extend their Kanmantoo copper and gold mine's life. University of Adelaide research looks to be pointing them towards new opportunities elsewhere along the belt.

Steve McClare
Chief Executive Officer,
Hillgrove Resources

Hillgrove reopened the Kanmantoo mine in 2011, after it had been closed by its original owners in the 1970s. At the time, it was deemed to have limited capacity; the initial lifespan prediction was just four years. Thanks to Hillgrove's resourceful engineering, however, it's now close to ten.

"It took some very different mining engineering thinking," says Hillgrove CEO Steve McClare. "We're using the latest surveying and blasting technology to create a safe and economic steep walled pit operation."

The company has combined two smaller pits into one larger pit, and implemented new wall-control techniques to facilitate working with much steeper walls. "We were able to control blasting, and integrate radar and laser survey sensors to maintain a safe working environment. We are at the forefront of integrating the latest surveying technologies in real time safety control."

A longer mine life has enabled Hillgrove to pursue an innovative exploration strategy and in 2018 researchers from the University of Adelaide's School of Physical Sciences joined with Hillgrove to help them understand the processes resulting in copper orebodies in the Adelaide Fold Belt. The team, led by University Research Fellow Dr Richard Lilly and Hillgrove's Chief Geologist Peter Rolley, believe they have resolved the ongoing debate on the origin of the Kanmantoo district copper-gold endowment.

"Detailed geochemical, petrologic and age dating analysis of the copper-gold lodes and accompanying alteration indicates that significant magmatic processes are associated with the copper gold mineralisation," says Steve. "This could imply that there are large scale copper deposits lying buried in the area, many times larger than those currently being mined. A real growth story."

This has led Hillgrove to explore previously abandoned areas along the belt, with renewed enthusiasm. "The Adelaide Fold Belt is where mining began in Australia, so it's exciting to think we're now writing a new chapter in the region's history."

In a further application of innovative thinking, Hillgrove hopes to fund much of its future exploration and mine development by using its Kanmantoo site to generate saleable renewable energy.

"When the mine's exhausted we're looking at using the pit as a Pumped Hydro Energy Storage system," says Steve, "running the water from a surface storage dam down a 300m drop to the existing pit. We think it could supply around 250 MW for up to seven-hours to the South Australian grid."

KEY PROJECTS ACTIVE IN 2017
Deep Mining

A new damage model for rock burst in hard rocks during deep mining
Sponsor: Australian Research Council; OZ Minerals
Chief Investigators:
A/Prof Murat Karakus; *Dr Abbas Taheri*; *A/Prof Giang Nguyen*

Visual sensing for localisation and mapping in mining
Sponsors: Australian Research Council; Maptek
Chief Investigators: *Prof Ian Reid*; *A/Prof Tat-Jun Chin*

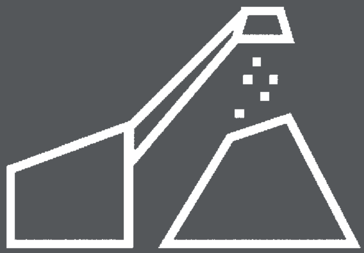
COOPERATIVE RESEARCH CENTRE PROJECT

Intelligent vision, sensing and data fusion for mining and exploration
Sponsor: Boart Longyear
Chief Investigators: *Prof Chunhua Shen*; *Prof Nigel Cook*; *Dr Damith Ranasinghe*; *A/ProfYung Ngothai*
Collaborator: SRA IT

COOPERATIVE RESEARCH CENTRE FOR OPTIMISING RESOURCE EXTRACTION

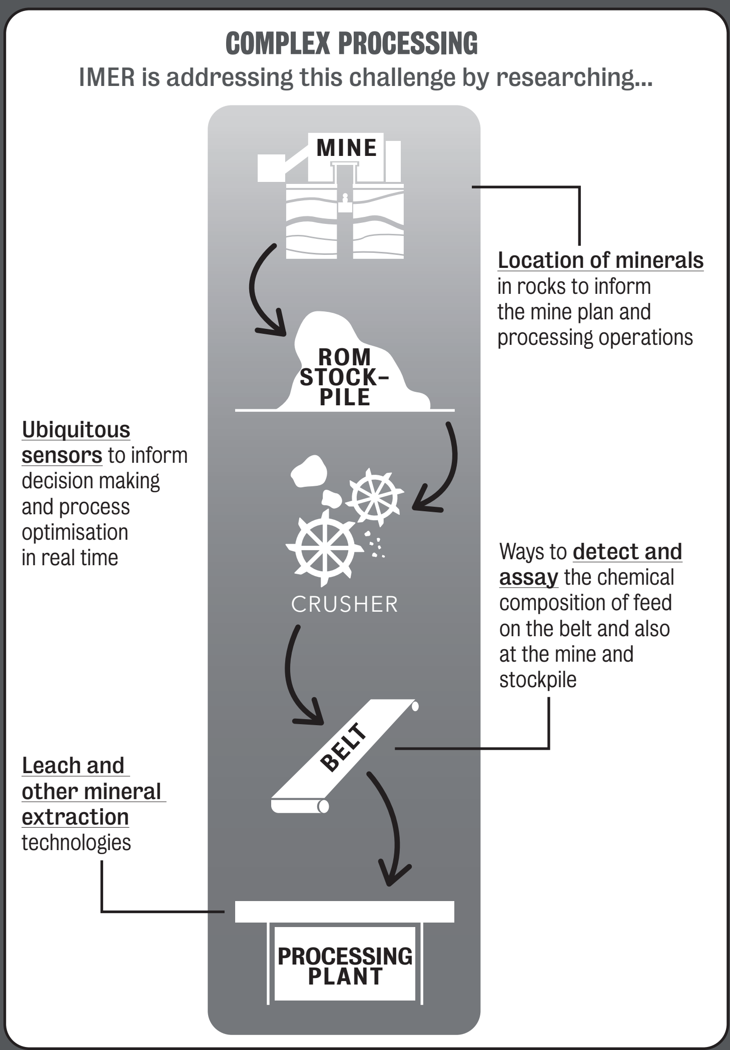
University of Adelaide Essential Participant membership
Sponsor: BHP
Chief Investigators: *Prof Stephen Grano*; *Prof Peter Dowd*; *Prof David Ottaway*; *Adjunct Prof Nigel Spooner*
Collaborator: University of South Australia

Upconversion fluoresence for real-time mineral identification
Sponsor: Cooperative Research Centre for Optimising Resource Extraction
Chief Investigators:
Adjunct Prof Nigel Spooner; *Prof David Ottaway*; *Dr Georgios Tsiminis*



Complex Processing

Turning mineral ores into concentrates or metals for export is becoming a greater challenge. With decreasing ore grades, increasingly complex mineral systems, a shortage of qualified people, plus a new world of target minerals such as lithium and graphite, the need for quality solutions has never been greater.



Complex ores are those that contain more than one economic mineral, such as copper with cobalt, or lead with zinc. Each mineral deposit has distinct chemical properties that require tailored processing to extract the metals.

We are now processing materials in large quantities that we have barely thought about before.

The world's new wonder material – graphene – is a material that has applications ranging from coatings and conductors to electricity storage and fire retardants. In Case Study #5 you'll see that we have launched the ARC Graphene Enabled Industry Transformation Hub, establishing our role in the emergence of this new technology material.

There is also a looming transformation coming in mining and mineral processing – one that's dominated by digitalisation, analytics and optimisation.

The so-called Industrie 4.0 principles will dictate the future of mining. That means automation and the Industrial Internet of Things (IIot) will see information flow in real time along the entire mining chain. For this to happen, mines need ubiquitous sensors, the ability to process large amounts of data, and the ability to make decisions in real time.

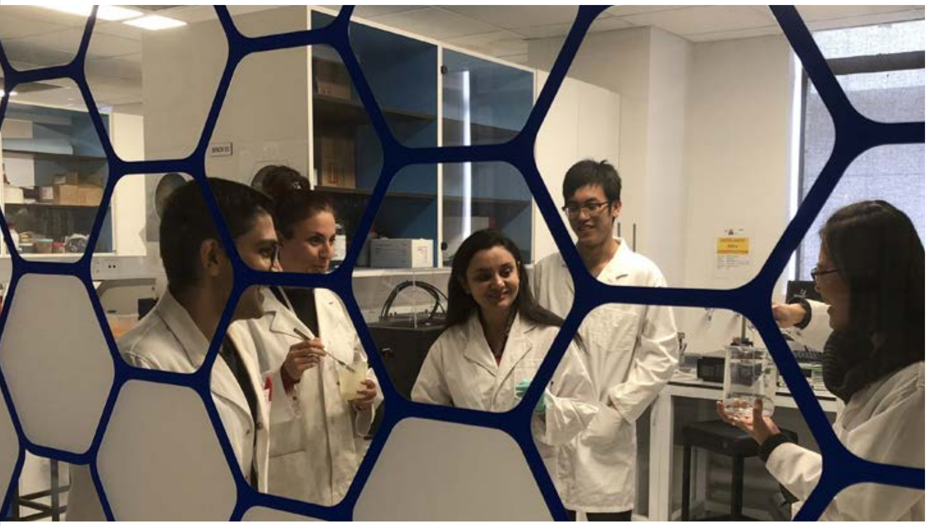
Established in 2017, the Research Consortium for Unlocking Complex Resources using Lean Processing includes research partner University of South Australia, and end-user partners BHP Olympic Dam Corporation and OZ Minerals. See Case Study #6 for more information.

CASE STUDY 5

ARC GRAPHENE ENABLED INDUSTRY TRANSFORMATION HUB

Many consider graphene the 21st century's "wonder material". A form of carbon discovered a decade ago, it's remarkably strong, conductive and flexible. It's also incredibly adaptable industrially. Adding to the appeal locally, graphene is produced from graphite—something Australia, and particularly South Australia, has in ample, high-quality supply. Fittingly, the University of Adelaide is playing a major role in its commercial application.

Professor Dusan Losic
Hub Director and graphene research program leader



The University runs a globally significant graphene research program with support from local graphite mining companies; and in recognition of the program's standing, in 2017 the Australian Research Council (ARC) funded (for five years) a University of Adelaide–based multi-partner Graphene Enabled Industry Transformation Hub (Graphene Hub).

Adelaide is the lead institution, with five industry partners and three other universities collaborating. The Hub's objectives are to deliver manufacturing technologies, advanced materials, energy and premium graphene products to Australia's mining and manufacturing sectors.

According to Professor Dusan Losic, Hub Director and the University's graphene research program leader, it's an incredible opportunity to establish South Australia as a world leader in this exciting, industry-transforming space.

"Our team's already secured six patents and licensed three technologies in graphene production, protective coatings, fertilisers, sound absorption and water purification," Professor Losic says. "One particularly exciting achievement has been developing a fire-retardant graphene-enhanced paint. That's now in final testing and will be launched in the market in 2018."

Other graphene applications in development include: hydrophobic (water-repellent), antibacterial and anticorrosive coatings, offering huge benefits for shipping fleets; sound-attenuating foam, with possible application in submarines; oil-absorbing sponges, for environmental, commercial and domestic use; and ion-targeted water filters, such as to remove ammonium from commercial fish tanks.

There are also promising developments in relation to energy. Hub researchers are creating a new generation of graphene-based hybrid supercapacitors, combining fast charging and high energy-storage capacity to enable a vast array of commercial uses.

"This material will be one of the great global game-changers," Professor Losic adds, "and this University is at the forefront of graphene innovation."

CASE STUDY 6

DATA DRIVEN MINING CONSORTIUM DEVELOPING TECH TO FACILITATE PROFITABLE SA COPPER EXPANSION

Already a big copper producer, South Australia intends to become much bigger. The State Government's *Copper Strategy* outlines ambitious plans to triple production within two decades, based on Olympic Dam expanding to become Australia's largest copper mine, and new mines coming on stream. Naturally, there are challenges, with operating cost front and centre. But a University of Adelaide–led research consortium is helping to pave the way.

Established in 2017, the Premier's Research and Industry Fund Research Consortium Program (PRIF RCP) includes research partner University of South Australia, and end-user partners BHP Olympic Dam Corporation and OZ Minerals. Its objective is clear: deliver new sensing, predictive and optimisation tools to help minimise mining costs, and maximise the extracted ore's value.

A number of mining equipment, technology and services (METS) 'translation partners' are also participating, and will play an important role in taking new tools from the lab to minesite implementation.
The translation partners include: Manta Controls; Australian Semi-Conductor Technology Company; Maptek; Rockwell Automation; Sandvik; Scantech; and CRC ORE.

Though it's still early days, the PRF RCP's first major project is gathering pace, and according to Manta Controls Managing Director John Karageorgos, there's already cause for excitement.

"The first thing we're looking at is a sensing and analytics system to monitor the performance of hydrocyclones, which are used to separate particles in processing," John says. "It will be relatively inexpensive to incorporate, but the potential value to the industry is massive."

Being developed by Adelaide in collaboration with Manta Controls, the system will gather and analyse a range of acoustic, vibration and other operational data in near real-time, enabling rapid time-and-cost-saving adjustments.

"The initial tech should be ready very soon. Then we'll start testing with live data. We're hoping that will come from Olympic Dam and possibly Prominent Hill, but the sky's the limit in terms of industry interest. Every site I talk to wants to know about it."

The hydrocyclone project is expected to lead into a number of additional investigations to enhance various mineral processing tasks. These include grinding, flotation, mineral recovery, leaching and thickening.

"We're addressing real problems that exist on sites globally. So although our initial focus is South Australia, several major international resources companies are keen to participate."

Another valuable PRIF RCP benefit, adds John, will be a more industry-ready workforce, with Adelaide and its research-partner university heavily involving their students in program projects.

"One aim is to establish Adelaide as a global METS capital. We're on a journey together—and this is just the beginning."

KEY PROJECTS ACTIVE IN 2017
Complex Processing

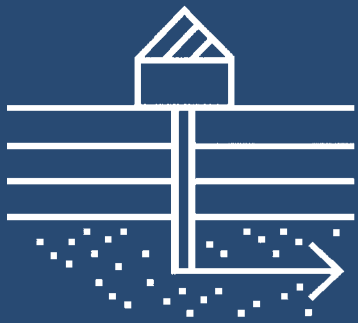
ARC Research Hub for Australian Copper-Uranium
Sponsors: Australian Research Council; BHP; OZ Minerals; Department of State Development (Government of South Australia)
Chief Investigators: *Prof Stephen Grano*; *Prof Nigel Cook*; *Prof David Ottaway*; *Adjunct Prof Nigel Spooner*
Collaborators: Environmental Protection Agency SA; Flinders University; University of Queensland; Monash University; Defence Science and Technology Group

ARC Research Hub on Graphene for Advanced Manufacturing
Sponsor: Australian Research Council
Chief Investigators: *Prof Dusan Losic*; *Prof Christophe Fumeaux*; *Prof Michael McLaughlin*; *A/Prof Reza Ghomashchi*
Collaborators: University of South Australia; Monash University; Tsinghua University; University of Cambridge; Catalan Institution for Research and Advanced Studies; Case Western Reserve University; Qingdao University; Ziltek; Tata Steel

FOX project – trace elements in iron oxides: deportment, distribution and application in ore genesis, geochronology, exploration and mineral processing
Sponsors: BHP; Mining and Petroleum Services Centre of Excellence (Government of South Australia)
Chief Investigators: *Dr Cristiana Ciobanu*; *Prof Nigel Cook*
Collaborators: Curtin University; University of Tasmania; British Geological Survey

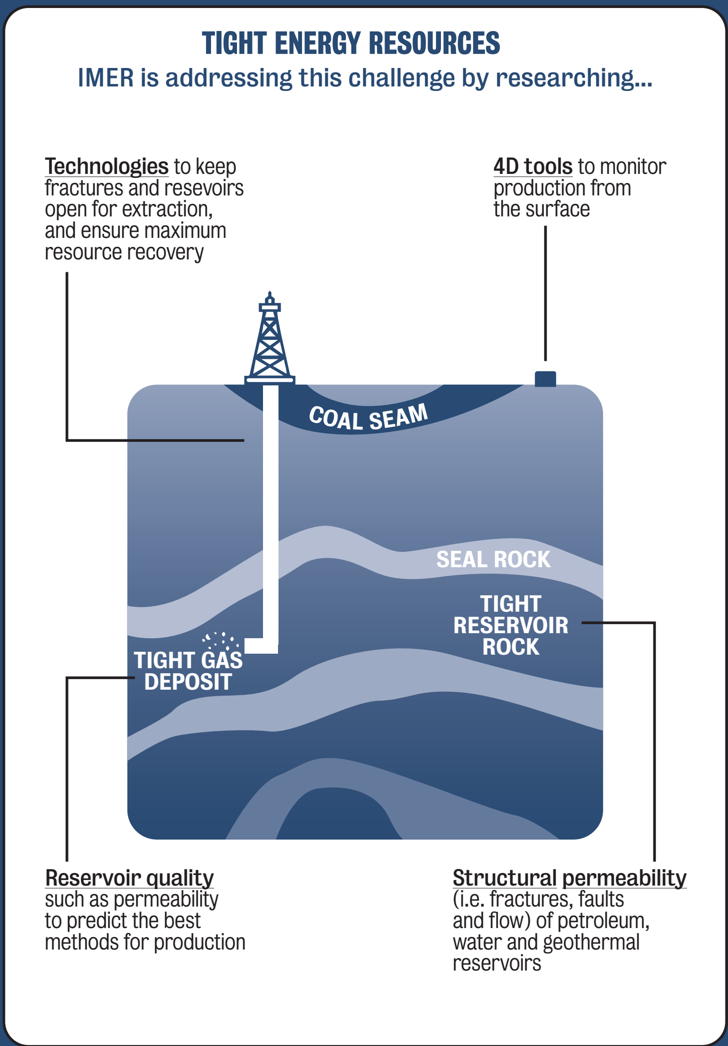
Geobiological gold cycling: golden opportunities for the minerals industry
Sponsor: Australian Research Council
Chief Investigator: *Dr Frank Reith*

Unlocking complex resources through lean processing
Sponsors: Department of State Development (Government of South Australia); BHP; OZ Minerals
Chief Investigators: *Prof Stephen Grano*; *Prof Peter Dowd; Prof Chaoshui Xu*; *Dr Tien-Fu Lu*; *Prof Nigel Cook*; *Dr Said Al-Sarawi*; *A/Prof Zeyad Alwahabi*; *Prof Chunhua Shen*; *Prof Frank Neumann*; *Dr Damith Ranasinghe*; *A/Prof Murat Karakus*; *Prof Carl Howard*; *Prof Craig Mudge*; *Dr Markus Wagner*



Tight Energy Resources

Accessing tight petroleum, gas and geothermal resources efficiently is a massive technical challenge.



Tight energy resources are "unconventional" deposits of oil, gas and geothermal energy that are located in settings that make them difficult to extract. In conventional settings, the resources can be pumped from the ground with minimal or no stimulation. In tight settings, the resources are often trapped in rock pores and the rocks must be engineered in some way for the resources to flow.

Conventional resources are more accessible and for that reason most have already been exploited. As they dry up, industry is turning its attention to deeper, tighter, resources.

Australia happens to have one of the most unusual petroleum deposits in the world. Located in the McArthur Basin of the Northern Territory, this petroleum occurrence is in rocks that are far older than previously thought possible for hosting oil and gas (see Case Study #7). The research being undertaken could lead to such deposits being found and extracted in parts of Australia and the world that were never thought possible.

New research conducted by the Australian School of Petroleum (ASP) in conjunction with CSIRO and the University of Aberdeen, and funded by Chevron, has helped them to understand the geology lying under the deep water of the Great Australian Bight. This research has enabled safer and more efficient exploration to occur in this region (see Case Study #8). With this work, and our participation in the International Offshore Drilling Program (IODP) in the Bight, the ASP has played a key role in better understanding the nature of this environmentally sensitive location.

CASE STUDY 7

McARTHUR BASIN: PIONEERING EXPLORATION FOR LONG-TERM ENERGY SECURITY

Most rocks from which oil and gas is extracted are "old", perhaps as much as 500 million years. But in northern Australia's McArthur Basin, petroleum has been found in rocks that are positively ancient—around 1.3 billion years of age. Exploration here requires an entirely new scientific toolkit. Undaunted, Santos and the University of Adelaide are embracing the task—and the results could meet Australia's energy needs for centuries.

Santos entered the Northern Territory's McArthur Basin in 2012, and over a five-year period collected a range of data to assess the resource potential within its permits. This included acquiring 2D-seismic data, and drilling a number of core-holes and one deep well, Tanumbirini-1. The signs were excellent, indicating vast volumes of gas, in particular, far in excess of the country's short- and medium-term domestic power requirements.

Being well aware of the area's early-Proterozoic age profile, however, the company sought the University's expertise to help chart a path forward. "We needed to understand the basin's history and evolution," Santos Team Leader McArthur Basin Exploration Andrew McPhail says.

"Knowing things like where the source rocks are, their unique properties, and what the basin's been doing through time, can help us identify where hydrocarbons are most likely to be in the system, and their preservation potential. The University of Adelaide had the expertise to understand these fundamental questions."

In 2017, the University joined Santos and a number of other collaborators—including Origin Energy, the Northern Territory Geological Survey, the universities of Wollongong and South Australia, and the Czech Academy of Sciences—in a three-year ARC Linkage project to explore the opportunity.

For lead researcher Professor Alan Collins, it's an incredibly exciting experience. "This is frontier stuff," he says. "We would normally use fossils to find out how old rocks are, and relate them across regions, but there just aren't many to be found in rock this old. So we're developing a whole new set of techniques."

The work is also touching on some big scientific questions, Professor Collins adds. "Life at this time was basically just algae and bacteria. So we're developing theories as to how these life forms were laid down in sufficient quantities to create the basin's vast hydrocarbon deposits."

Although firmly focused on the McArthur site, all parties agree the project has global significance, with many similarly aged and unexplored areas existing around the planet, including more in Australia. "There's a huge amount of interest in this domestically and internationally," Andrew says.

"There's potential to provide greater domestic supply, while reducing our local carbon footprint. The majors are watching to see how this new petroleum province emerges."

CASE STUDY 8

ASP RESEARCH INFORMS FUTURE HYDROCARBON EXPLORATION IN THE GREAT AUSTRALIAN BIGHT

New research by the Australian School of Petroleum (ASP) has enabled safer, more efficient hydrocarbon exploration in the previously underexplored, but highly prospective, Great Australian Bight (GAB). It's also providing a fascinating insight into Australia's geological history, dating back 80 million years.

Associate Professor Simon Holford
Australian School of Petroleum

Collaborating with CSIRO and the University of Aberdeen, and with funding support from Chevron, the ASP played a leading role in mapping a province of ancient buried volcanoes, some up to a kilometre in height. Initial data was collected in 2014, and the school completed its research in 2017.

According to lead researcher Associate Professor Simon Holford, the team's findings enable a better understanding of the Bight's sub-seafloor geology.

"Subsurface volcanoes can be a huge challenge when drilling for oil and gas," he says. "They're difficult to drill through, can inhibit the imaging of drilling targets, and can have unpredictable impacts on fluids' ability to flow through the subsurface."

The ASP-led team mapped the volcanoes' full expanse using 3D seismic data. This created—for the first time—a complete three-dimensional image of their architecture.

"We were able to reconstruct a submarine volcanic province with around 90 pristinely preserved volcanoes, and ancient lava flows tens of kilometres long," adds Associate Professor Holford.

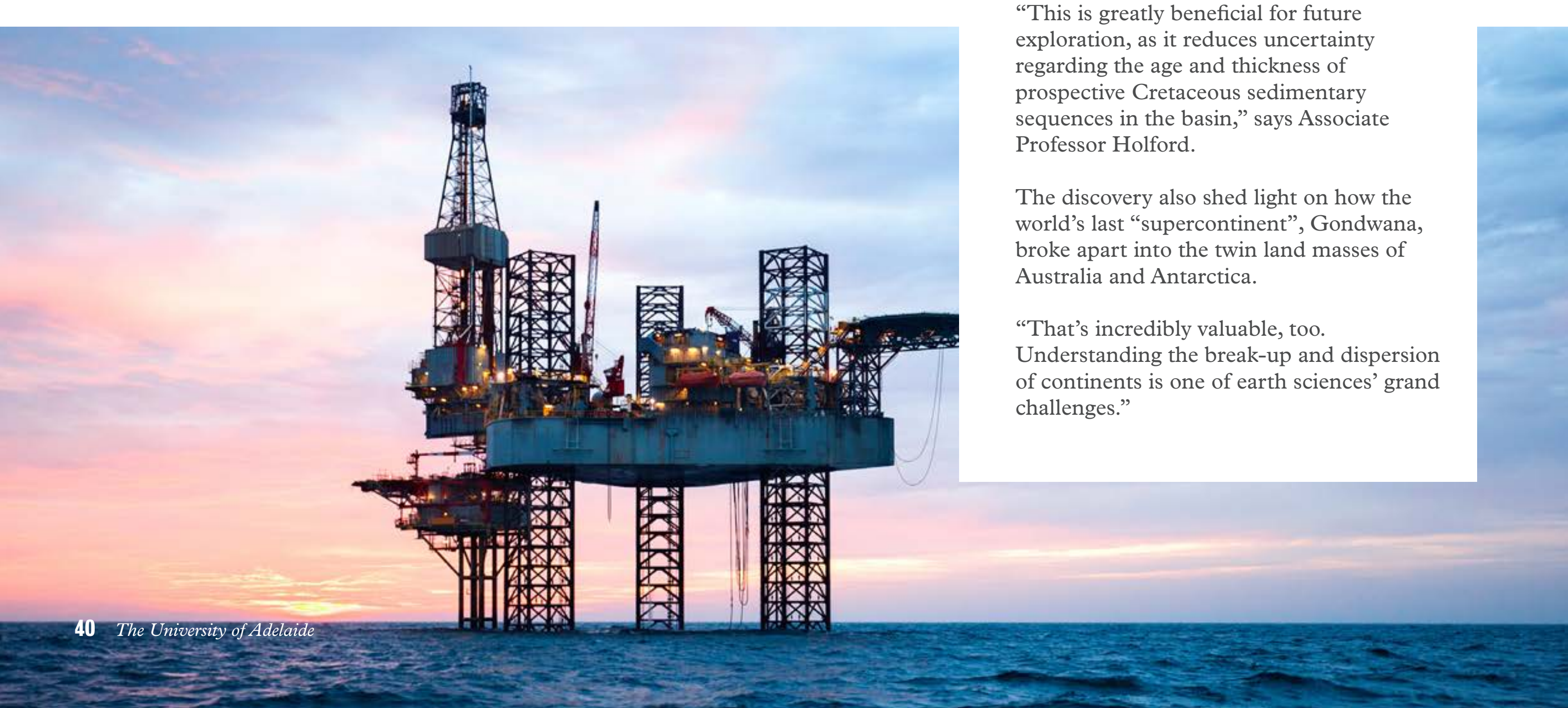
The ASP also led a second, complementary expedition in the GAB during 2017, with one of the world's leading geoscientific research initiatives—the International Ocean Discovery Project (IODP).

Working with a large multinational group of IODP researchers, the ASP developed a successful proposal that led to the offshore recovery of almost 700 vertical metres of rock, including material deposited up to 94 million years ago. Unlike past GAB sampling expeditions that scraped rocks out of the seabed, the IODP project produced a continuous record of marine sedimentary geology deposited over a 10-million-year period, encompassing extreme climatic conditions.

"This is greatly beneficial for future exploration, as it reduces uncertainty regarding the age and thickness of prospective Cretaceous sedimentary sequences in the basin," says Associate Professor Holford.

The discovery also shed light on how the world's last "supercontinent", Gondwana, broke apart into the twin land masses of Australia and Antarctica.

"That's incredibly valuable, too. Understanding the break-up and dispersion of continents is one of earth sciences' grand challenges."



KEY PROJECTS ACTIVE IN 2017
Tight Energy

AusPERM structural permeability mapping in Australia: de-risking geothermal exploration ahead of drilling

Sponsor: Australian Renewable Energy Agency
Chief Investigators: *Prof Martin Hand*; *Dr Rosalind King*; *A/Prof Simon Holford*; *Dr Khalid Amrouch*; *Prof Graham Heinson*
Collaborator: University of Aberdeen

Carbon capture and storage, seals, and unconventional resources

Sponsor: Department of State Development (Government of South Australia)
Chief Investigator: *Prof John Kaldi*

Cenozoic igneous activity in the Ceduna sub-basin: origin, distribution and impacts on petroleum systems

Sponsors: CSIRO Deepwater Great Australian Bight Program; Chevron
Chief Investigator: *A/Prof Simon Holford*

High-resolution pipeline condition assessment using hydraulic transients

Sponsors: Australian Research Council; Detection Services (partnership)
Chief Investigators: *Prof Martin Lambert*; *Prof Angus Simpson*; *Prof Ben Cazzolato*; *Dr Aaron Zecchin*
Collaborator: Flinders University

South Australian State Chair of Petroleum Geology

Sponsors: Primary Industries and Regions SA (Government of South Australia)
Chief Investigator: *Prof Peter McCabe*

Subsurface fluid flow through fractures in sedimentary basins

Sponsor: Australian Research Council
Chief Investigators: *Dr Rosalind King*; *A/Prof Simon Holford*; *Dr Khalid Amrouch*
Collaborators: University of Aberdeen; Deep Exploration Technologies Cooperative Research Centre

New nanotechnologies in shale and tight gas reservoirs

Sponsors: Australian Research Council; Santos
Chief Investigators: *Prof Pavel Bedrikovetski*; *Dr Zhenjiang You*; *Dr Abbas Zeinijahromi*
Collaborator: University of South Australia

Low Cost, Low Emissions Energy

Society's energy needs can be summed up in three main forms of supply: power, heat and fuel.

LOW COST, LOW EMISSIONS ENERGY

IMER is addressing this challenge by researching...

Sustainable fuels, including solar gasification, liquefaction, liquid fuel synthesis and CO_2 to fuel conversion

Secure power, including solar thermal, advanced combustion and hybrids

Sustainable process heat, including concentrating solar thermal in the primary production of materials such as alumina, copper and iron/steel

Sustainable networks, including integrating renewable energy into conventional and micro grids, power networks and markets

Energy storage, including building a mobile energy storage test platform and establishing an online knowledge bank

As energy demand increases globally, there is a pressing need to find energy sources that are reliable, affordable and produce low or no emissions.

IMER's goal, through its Centre for Energy Technology, is to accelerate society's transition to being carbon neutral or even carbon negative. We collaborate with leading organisations to move us closer to this goal, drawing on our research capability in sustainable power, fuels, networks and minerals processing.

Energy-intensive industries, in particular, are looking to renewables to at least partially meet their energy needs. They need stable and secure electricity supply that address the intermittent nature of renewables, and they need reliable technologies to provide transport fuels or alternative mobility, and process heat to industry.

Australia is endowed with many of the world's key mineral commodities, found here in the form of their ores, for example as bauxite for aluminium and iron ore for iron. Processing these ores into the metals used by society is energy and technology intensive, and is often conducted by our trading partners overseas. Through IMER we are now investigating how to use our abundant clean energy resources to process our minerals in Australia (see Case Study #9)

Within IMER, the CET specialises in "solar fuels" – those that convert sunshine into useful and reliable transport fuels (See Case Study 10).

Ray Chatfield
Senior Engineering Specialist, Alcoa

CASE STUDY 9

WORLD-LEADING SOLAR TECH ENABLING CLEANER HIGH-HEAT HEAVY INDUSTRY

When it comes to addressing climate change, heavy industry, which needs heat at high temperature—and lots of it—is a big player. It's estimated to account for a massive 16 per cent of global carbon emissions. In the past, however, incorporating renewable energy into such processes has proven difficult. But ground-breaking University of Adelaide–led research appears to be finding a way—and presenting Australia with incredible economic opportunity.

The University of Adelaide's Centre for Energy Technology (CET) is working closely with the world's largest alumina producer, Alcoa, to investigate incorporating low-cost concentrated solar thermal (CST) energy into the 'Bayer process', the principal means of refining bauxite to alumina. If successful, it will be the world's first commercially viable application of renewable energy into a high-temperature industrial process.

The research is part of an overarching four-year Australian Renewable Energy Agency (ARENA) solar energy project, also investigating solar-generated steam and syngas. Other industry and research partners are the CSIRO, Hatch, IT Power and the University of New South Wales.

According to Alcoa Senior Engineering Specialist Ray Chatfield, the CET's CST technology—and the method of incorporating it into the Bayer process—has just passed its first economic 'stage gate' at the project's half-way point, providing a strong initial indicator of commercial viability.

"There's still work to do, but getting over this hurdle's very exciting," Ray says. "Reducing our carbon footprint is a long-term strategic imperative, and this technology could be retrofitted into our plants everywhere, including in Western Australia. So we're looking forward to developing it further."

CET Director and lead researcher Professor Gus Nathan is similarly delighted with his team's progress, and believes their low-cost CST technology and methodology has great potential for many high-temperature industrial processes—and subsequently for Australia's economic growth.

"Australia's in a particularly favourable position to implement CST-powered ore processing," Professor Nathan says, "because we're blessed with vast quantities of coincident mineral and solar resources.

"In many locations, CST has real potential to displace at least half the energy currently supplied by fossil fuels for high-temperature process heat. If we can show our method for doing this is cost-effective, it could be used for other processes like iron and steel making. That paves the way to value-add to our iron ore, of which 95% is currently exported raw. The flow-on economic and employment benefits could be enormous."

Beyond this, he adds, the technology could ultimately play a significant role in helping Australia meet its international commitments in the fight against global warming.

"The Bayer process produces around 40 per cent of Australia's industrial emissions. Halving that, as we think CST could, would go a long way towards satisfying our Paris Agreement obligations."

CASE STUDY 10

ASTRI: DEVELOPING THE WORLD'S FIRST SOLAR-GENERATED AVIATION-GRADE BIOFUEL

Professor Gus Nathan
Director, CET, School of Mechanical Engineering

Clean fuels, and their production processes, have a huge role to play in reducing global CO_2 emissions. The rise of electric vehicles will help on land, of course. But in the air, electrification is not yet an option—jet engines will likely need energy-dense liquid fuels for years to come. Big strides, however, are being taken. World-first research at the Australian Solar Thermal Research Institute (ASTRI) is charting a bold new course; and it's led by the University of Adelaide.

Researchers from Adelaide's Centre for Energy Technology are developing an aviation-grade liquid fuel entirely from food waste, using an innovative solar-powered production process. Critically, it will look, smell and perform identically to standard fuels, enabling instant market entry.

The emissions reduction potential is enormous. But according to project lead Professor Gus Nathan, this is just one of many benefits offered.

"It also offers a likely path to increase the viability of harnessing under-utilised resources, such as the world's estimated 1.3 billion tonnes of food waste annually," he says. "Rather than relying on crops, which are needed for traditional biofuel production and so compete with food, this leverages agriculture by utilising residues. And the fuel can be produced locally, which improves our energy security."

Professor Nathan's team is using solar-thermal energy to power a chemical process known as gasification. The process converts carbon-based waste into synthesis gas, or "syngas", which is subsequently converted into liquid fuel.

"We've successfully lab-tested several aspects of the technology and hope to demonstrate the whole system within 18 months or so. Then we'll begin to scale up toward commercial demonstration."

The estimated production cost is around $1 per litre, based on certain assumptions regarding the food-waste supply chain, which the University is investigating concurrently through a University Interdisciplinary grant. "We expect to find further opportunities for cost savings as the project evolves," adds Professor Nathan.

"The most expensive solar-thermal component is the heliostats—the structures holding the mirrors and their control systems—because of the engineering required to withstand wind loading. So we're exploring ways to improve their aerodynamics, and potentially reduce their size.

"We're also looking at incorporating particle technology into the gasification process, to complement the solar-thermal. Rather than heating materials in tubes, we irradiate particles in a vortex and store the heat produced in low-cost sand."

Not surprisingly, the ASTRI team's work is garnering international attention. "People increasingly recognise emissions reduction is about more than just electricity," Professor Nathan concludes. "There's interest in this worldwide."

KEY PROJECTS ACTIVE IN 2017
Low Cost, Low Emissions Energy

Bladed receivers with active airflow control

Sponsor: Australian Renewable Energy Agency
Chief Investigator: *Dr Maziar Arjomandi*
Collaborators: Australian National University; CSIRO; Sandia National Laboratories

Commercial-scale production of bio-crude by hydrothermal liquefaction

Sponsors: Australian Research Council; Muradel (partnership)
Chief Investigators: *Prof Gus Nathan*; *Prof Peter Ashman*; *A/Prof Zeyad Alwahabi*; *Dr Zhao Feng Tian*; *Prof David Lewis*; *Prof John Abraham*

Establishing the Australian energy storage knowledge bank

Sponsors: Australian Renewal Energy Agency; Department of State Development (Government of South Australia); Energy Networks Association; Power and Drive Solutions; SA Power Networks; Zen Energy
Chief Investigators:
A/Prof Nesimi Ertugrul; *Prof Gus Nathan*; *Prof Bassam Dally*; *A/Prof Wen Soong*; *Prof Shizhang Qiao*

Integrating concentrating solar thermal energy into the Bayer alumina process

Sponsor: Australian Renewable Energy Agency
Chief Investigators: *Prof Gus Nathan*; *Dr Woei Saw*; *A/Prof Zeyad Alwahabi*; *Dr Maziar Arjomandi*; *Prof Peter Ashman*; *Prof Bassam Dally*; *Dr Zhao Feng Tian*; *Dr Philip van Eyk*
Collaborators: University of New South Wales; University of Newcastle; Swiss Federal Institute of Technology; Australian Nuclear Science and Technology Organisation; Alcoa World Alumina; IT Power Australia; Commonwealth Scientific and Industrial Research Organisation

Nanostructured electrocatalysts for clean fuels production

Sponsor: Australian Research Council
Chief Investigator: *Prof Shizhang Qiao*
Collaborator: Kent State University

Solar-driven sustainable production of fuels and chemicals

Sponsor: Australian Research Council
Chief Investigator: *Prof Shizhang Qiao*

New understanding and models for two-phase solar thermal hybrid reactors

Sponsor: Australian Research Council
Chief Investigators: *Prof Gus Nathan*; *A/Prof Zeyad Alwahabi*; *Dr Maziar Arjomandi*; *Dr Zhao Feng Tian*
Collaborators: Purdue University; Swiss Federal Institute of Technology

Advanced experimental and modelling study to better predict spray flames

Sponsor: Australian Research Council
Chief Investigators: *A/Prof Paul Medwell*; *Prof Bassam Dally*
Collaborator: Aachen University of Technology

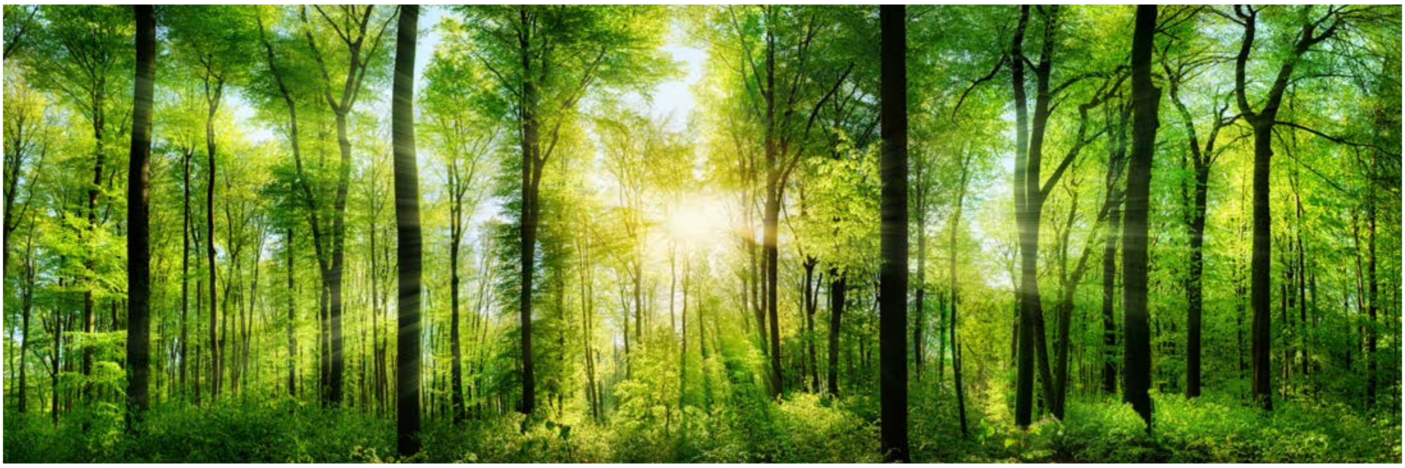
ENERGY PIPELINE COOPERATIVE RESEARCH CENTRE

Emerging energy sources and their transportation

Sponsor: Energy Pipelines Cooperative Research Centre
Chief Investigators: *Prof Peter Ashman*; *Prof Gus Nathan*; *Dr Neil Smith*

Gas pipeline blowdown – Project 2

Sponsor: Energy Pipelines Cooperative Research Centre
Chief Investigators: *Dr Neil Smith*; *Dr Akhilesh Mimani*; *Prof Anthony Zander*



IMER ENGAGEMENT

24 January
workshop: ICT in Resources – Challenges and Opportunities

The year began with a combined workshop organised by IMER and the University of Adelaide School of Computer Science. The workshop brought together experts from mining, artificial intelligence and computer science to workshop the challenges and opportunities that exist in the coming digital mining revolution. More and more, mining companies are seeking to transform their operations to Industry 4.0, and there is a world of interdisciplinary research in this. Participating companies included Petrosys, Schlumberger, Eka, Pacific Challenge, Manta Controls, SRA and Boart Longyear.

19 April
workshop: Sensors and Automation in the Resources Industry

Organised by IMER, the University of Adelaide's Institute for Advanced Photonics and Sensing and the University of South Australia's Future Industries Institute, this workshop brought together South Australian university researchers and leading resources industry figures. The latter included representatives from: Halliburton, Scantech, Datanet, Thermo Fisher Scientific, Sandvik, Magotteaux, Rockwell Automation, and SAGE Automation. Industry 4.0 was again the focus. In keeping with the themes of strategy, engagement, collaboration, innovation and impact, the workshop sought industry and research perspectives on bringing innovation through the value chain to commercialisation. It's said the mine of the future will be low-impact, near-invisible and automated. Transitioning to this future is fertile ground for research and development.

29-31 May
Mines and Technology conference, Helsinki

IMER Executive Director Professor Stephen Grano attended this conference and presented a paper on sensors, data analytics and optimisation for complex resources. As part of his trip, Professor Grano also took the opportunity to visit Sandvik Rock Tool facilities elsewhere in Finland (Tampere) and in Sweden (Stockholm and Svedala), and KGHM plants in Poland (Wroclaw).

27 June
Copper to the World conference

The Copper to the World conference showcased South Australia's Copper Strategy, which outlines plans for the state to produce one million tonnes of copper per annum by 2030. To achieve this, South Australia faces many challenges, relating to: efficient deep mining; mineral processing; energy security; and water security. All of these are part of IMER's core business, so there was a lot of traffic through our booth; and the conference continued to build the IMER brand.

29-30 June
Energy & Mines Australia summit

It may sound obvious, but the location of a mine is determined by the location of the mineral resource in the ground. Consequently, there are several "stranded assets" in Australia—mineral deposits located vast distances from energy or water infrastructure. Naturally, in a world of rising energy costs, mining companies are very keen to find ways to supply secure and affordable energy to their mineral operations. Attending this summit for the first time, IMER's representatives were struck by the need for energy solutions (particularly low-carbon), and the lack of commercially viable options. As the only University present, IMER received a great deal of interest from other delegates.

25–28 August
Unearthed hackathon, Sydney

University of Adelaide PhD students Sasha Krneta and Jonathan Berthiaume joined Peter Kanck, Senior Manager, Technology Development and Integration, Boart Longyear, as mentors at the *Unearthed* hackathon in Sydney. The 54-hour open-innovation event featured real data and challenges from world-leading resource companies. Sydney's top developers, engineers, data scientists, entrepreneurs and start-ups selected one of several challenges on offer and came together to build prototype solutions over the course of a weekend. The Boart Longyear challenge was to "develop a mobile-device-based tool to identify structural features in geological rock samples".

21 October
Vice-Chancellor's Boardroom Lunch series

Guest speaker Professor Gus Nathan, who directs the University's Centre for Energy Technology, delivered a presentation on the centre's research in low-carbon energy. Special guests included a Korean delegation hosted by the Australian Academy of Technology and Engineering.

6 November
Tonsley Innovation Precinct visit

University of Adelaide staff were invited by Renewal SA to tour the Tonsley Innovation Precinct. Tonsley Steering Committee Chair Mr Terry Burgess hosted the visit. Participants were treated to a precinct overview and walking tour, which included meetings with various business operators based at the site. Among them were the South Australia Drill Core Reference Library, SAGE Automation, Siemens and ZEN Energy.

IMER ENGAGEMENT

15 November
Indonesian delegation – Bangka Belitung government mission

The South Australian Government hosted an Indonesian delegation to Adelaide regarding potential cooperation in mining and environment. Led by the Governor of Bangka Belitung Province, the delegates met with IMER researchers to explore collaborative research and training opportunities with the University of Bangka Belitung, particularly in the areas of mining, environmental protection and clean technology.

ARC Research Hub for Australian Copper-Uranium 3rd and 4th six-monthly sponsor review meetings

The ARC Australian Copper-Uranium Transformation Research Hub (the Hub) is funded by: the Australian Research Council; BHP; OZ Minerals; the Department of State Development (South Australian Government); and the Defence Science and Technology Group. Researchers from the University of Adelaide, Flinders University, Monash University and the University of Queensland are halfway through a five-year project to collaboratively develop and test new, cost-effective ways to remove non-target metals from copper concentrates in ores.

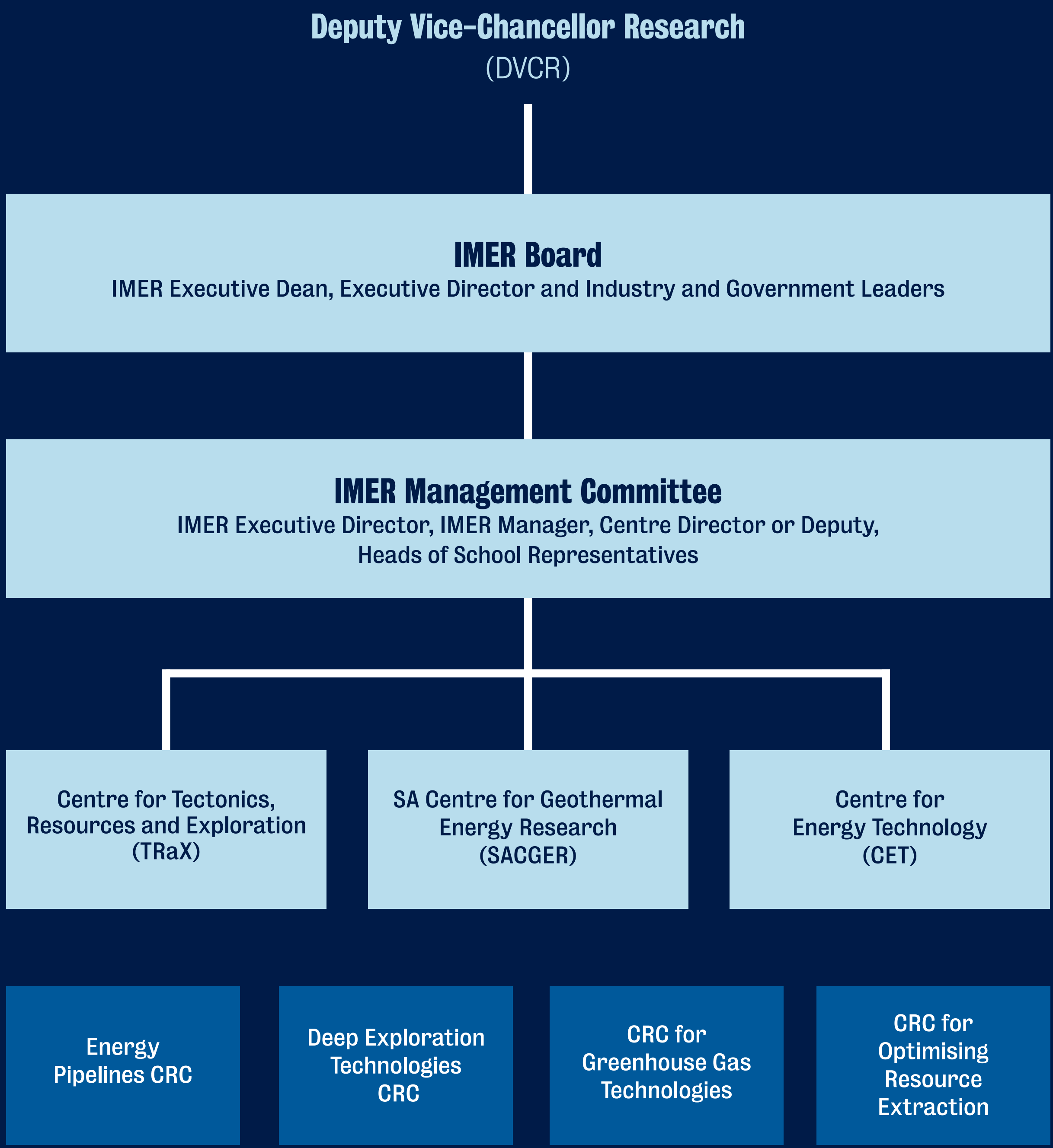
During 2017, the third and fourth six-monthly sponsor review meetings were held in Adelaide and Brisbane respectively. The Brisbane meeting included student development workshops and a tour of the JK Tech mining capabilities.

Hub research developed by the University of Adelaide includes innovative and novel techniques to spatially locate alpha emissions in ores and identify non-target metals using nanoSIMS; work that dovetails with promising University of Queensland research into decreasing non-target metals with low-temperature leaching. In addition to funding the Hub, BHP and OZ Minerals also continue to conduct alpha, beta and gamma spectrometry sample analyses at the University of Adelaide.

13 December
GeoVision CRCP launch

Launched by federal Education and Training Minister Senator Simon Birmingham, the Geovision Cooperative Research Centre Project (Geovision CRCp) is a collaboration between the University of Adelaide, Boart Longyear and SRA Information Technology. The three-year, $4.5M project is being funded by a $2.1M grant from the Australian Government, with another $2.4M in cash and in-kind support coming from the partners. The project aims to develop a range of new tools to enable near-real-time automated decision-making at exploration and mining sites. These tools incorporate core scanners and sensors for improved geological and structural data collection, and data fusion and machine learning technologies.

ORGANISATIONAL STRUCTURE



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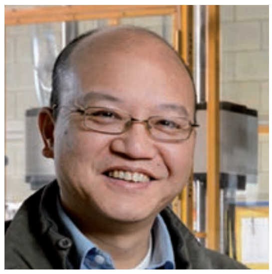

A/Professor Chaoshui Xu
Leader, Resource Engineering
Program, School of Civil
Environmental and Mining
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IT IS PEOPLE THAT DRIVE INNOVATION AND POSITIVE CHANGE.

IMER

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Professor
David Giles
Research Leader, Deep Exploration Technologies Cooperative Research Centre

Professor
Nigel Spooner
Investigator, Cooperative Research Centre for Optimising Resource Extraction

STRATEGIC FRAMEWORK

IMER was formed by the University of Adelaide to focus interdisciplinary research in mineral and energy resources, address globally significant challenges and enhance the impact of research.

IMER'S MISSION IS TO BE A GLOBALLY RECOGNISED CENTRE OF EXCELLENCE FOR INTERDISCIPLINARY RESEARCH, INNOVATION AND TECHNOLOGY TRANSFER IN MINERAL AND ENERGY RESOURCES.

CENTRE FOR TECTONICS, RESOURCES AND EXPLORATION (TRAX)

Understanding the geology of the Earth and its resource potential.

TRaX provides a link between continental and regional-scale geology and deposits of minerals and petroleum to improve our understanding of deposit formation and develop predictive methods for the discovery of new deposits.

Our goal is to be a leading provider of research and teaching in tectonics, resources and exploration in Australia and conduct focused research into Australia's unique geological characteristics.

TRaX research areas

- Basins
- Tectonics
- Geophysics
- Minerals

Professor Graham Heinson
TRaX Director

SOUTH AUSTRALIAN CENTRE FOR GEOTHERMAL ENERGY RESEARCH (SACGER)

Working towards efficiently and sustainably managing the world's unconventional energy resources.

SACGER's research is focussed on understanding the thermal state, structure and evolution of the Australian crust and the continental regions that are connected to it. We carry out practical, high-priority research on geothermal systems and tight unconventional energy resources such as shale gas.

SACGER research areas

- Heat flow
- Structural permeability
- Reservoir quality
- 4D magnetotellurics
- Rock thermal properties

Professor Martin Hand
SACGER Director, IMER Deputy Director

CENTRE FOR ENERGY TECHNOLOGY (CET)

Developing clean, reliable, affordable energy technologies.

CET works with industry partners and builds research teams to develop innovative, low emissions energy solutions for sustainable fuels, mineral processing and power. We do this by retro-fitting innovative technologies to existing systems, and by developing new carbon neutral and carbon negative technologies to replace existing heat, power and fuel production systems, especially through hybridisation.

CET research areas

- **Biomass/waste to energy**
- **Sustainable fuels including hydrogen**
- **Combustion**
- **Electrical technologies**
- **Energy analysis and optimisation**
- **Energy efficiency**
- **Energy materials**
- **Energy storage**
- **Hybrid solar technologies**
- **Mathematical modelling**
- **Solar energy, including solar thermal and concentrating solar power**
- **System integration**
- **Transmission and storage**
- **Wind, wave and tidal power**

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