THE UNIVERSITY of ADELAIDE

Institute for Mineral and Energy Resources

Annual Report 2012

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seek LIGHT

The Institute for Mineral and Energy Resources (IMER) is part of the University of Adelaide, Australia. IMER undertakes interdisciplinary research that addresses scientific, technological, environmental and social challenges in the provision of mineral and energy commodities globally.

Vision

IMER's vision is to enable the efficient and sustainable use and development of the world's mineral and energy resources for the benefit of society, industry and the environment.

Mission

IMER's mission is to be recognised globally as a centre of excellence for fundamental and applied research, innovation and technology transfer in mineral and energy resources.

IMER – answering the challenge of sustainable and efficient use of global resources

Objectives

- Advance the science and technology required to enhance the prospectivity, discovery and extraction of mineral and energy resources, including petroleum and geothermal resources.
- Advance the science and technology needed to lower the cost of and enhance cleaner energy generation, storage, transmission and use.
- Increase energy efficiency and reduce the impact of industrial processes, especially those related to mining and mineral processing.
- Maximise the social and economic benefits of mineral and energy resource developments across regional, state, national and international communities.
- Advance the prevention, assessment and remediation of environmental impacts of mineral and energy resource developments.

Who we are

The Institute for Mineral and Energy Resources (IMER) is an interdisciplinary research institute of the University of Adelaide which addresses scientific, technological, environmental and social challenges in the provision of mineral and energy commodities globally.

Established in 2008, IMER aims to become a leading research and postgraduate training facility for the mining and energy sectors in the Asia-Pacific region. The University of Adelaide is unique within Australia for its strong research and teaching groups in geology and geophysics, petroleum engineering, mining engineering and energy technology. These groups form the Institute's core.

Key IMER fields of research

Earth sciences: geology, geochemistry, geosequestration, geophysics and physical geography.

Energy technology: combustion and fluid mechanics, renewable energy integration, energy efficiency, alternative fuels, wind energy, energy storage and management.

Resource engineering: petroleum and mining engineering.

Interdisciplinary research is also conducted in geothermal energy, decision analysis, industry and socio-economic studies and environmental impacts specifically related to energy and mineral resource developments.

Some of the University of Adelaide schools and faculties involved with IMER include the Australian Workplace Innovation and Social Research Centre (WISeR); the Australian School of Petroleum; the Business School; the School of Chemical Engineering; the School of Chemistry and Physics; the School of Civil, Environmental and Mining Engineering; the School of Earth and Environmental Sciences; the School of Electrical and Electronic Engineering; the School of Mathematical Sciences; and the School of Mechanical Engineering.

IMER is the principal point of contact for the strategic interests of the University of Adelaide in mineral and energy resources research, including industry and government partnerships.

Contents

Chairman's report

Mr Robert Kennedy

Over the last four years, the Institute for Mineral and Energy Resources (IMER) has consistently delivered innovative and industry-focused research outcomes.

We have continued to respond to industry's need for data, predictive modelling, strategic foresight and technology to harness unconventional energy resources, deliver economically-viable renewable energy systems and develop cost-effective and novel methods of mineral exploration and extraction.

The 2012 Excellence in Research for Australia (ERA) findings highlighted IMER's strong research capabilities. The University of Adelaide was rated 'well above world class' in numerous disciplines associated with IMER, including geochemistry; geology; artificial intelligence and image processing; macromolecular and materials chemistry; and inorganic chemistry. The University of Adelaide's capabilities in resources engineering and extractive metallurgy were recognised as 'above world standard'.

Our world class research capabilities and industry focus led to continued funding success in 2012, with IMER researchers sharing in just under $14 million. Key funding highlights included researchers from the South Australian Centre for Geothermal Energy Research (SACGER) being awarded $1.25 million from the Australian Renewable Energy Agency (ARENA) for research to help increase our understanding of Australia's geothermal energy potential.

The Centre for Energy Technology (CET) is also now part of an eight-year collaboration led by CSIRO worth over $87 million which aims to lower the cost of solar thermal power. The CET will make a significant contribution to this major solar research initiative by leading the node focused on solar fuels.

Our innovative and industry-focused research programs enable us to deliver world-class teaching for the next generation of industry professionals. Our staff and students were involved in numerous industry workshops and conferences throughout the year, which brought together researchers, government and industry to foster collaboration and reinforce our focus on research and teaching that meets industry's key challenges.

A delegation of IMER leaders travelled to South America to promote new research and commercial opportunities in renewable energy technologies and mining and mineral processing operations. Links with research and industry organisations in Canada and China were also strengthened through hosting leading scientists and industry personnel within IMER.

We are actively identifying and nurturing our next generation of research leaders. A select group of staff participated in our research leadership program, designed to help them identify research opportunities and obtain funding. Our investment in this area will ensure the Institute maintains its research leadership well into the future.

IMER researchers also continued their strong publication record, with over 350 articles published in peer-reviewed journals, conferences and books.

Many thanks to the IMER Advisory Board, and particularly to IMER Executive Director Professor Stephen Grano and IMER staff, for their dedication and hard work throughout the year.

Mr Robert Kennedy
Chairman
8th August, 2013

> "The 2012 Excellence in Research for Australia findings highlighted IMER's strong research capabilities."

Executive Director's report

Professor Stephen Grano

The mining and energy sectors are facing major global challenges around efficiency and sustainability.

At the Institute for Mineral and Energy Resources (IMER) we recognise these challenges and our interdisciplinary and applied research programs are tackling them now to put industry and the community in the best possible position for the future.

One of the major developments for the mining industry and South Australia in 2012 was the decision by BHP Billiton to defer the Olympic Dam Expansion. This is a reflection of the challenges being faced by the mining industry globally. Large concentrations of deposits are harder to find and process, accessing deep deposits is less economically viable with current technologies, exploration and processing costs are increasing and economic sustainability is decreasing.

To maintain economic and environmental sustainability, the mining industry must develop innovative mining and processing methods for its current projects as well as when exploring for new prospects and converting those discoveries into mines.

> "There are more challenging times ahead for the mining and energy sectors but I am confident that we are well-equipped to meet these challenges head on..."

The energy industry also needs to develop economically competitive methods for tapping into our unconventional gas and geothermal energy resources.

IMER's research credentials were highlighted once again in 2012, with our researchers successfully obtaining more than $6.3 million of Australian Research Council (ARC) funding. Working in partnership with industry, IMER researchers are at the forefront of finding novel approaches to minerals exploration and processing, accessing unconventional energy resources, developing best practice land rehabilitation methods and increasing the efficiency of renewable energy technologies.

Industry demands an interdisciplinary approach to research and development and we are proud of our continued ability to meet that need. We focus on working across disciplines – not only for attracting investment but also to ensure that research in priority areas is efficient, thorough and in line with world's best practice. Our research in the geothermal sector is a great example of how effective collaboration between geologists, geophysicists, geochemists and reservoir, mechanical and chemical engineers is delivering technologies that are helping address industry's major issues.

While it is important for our research to make an impact in local and regional mining and energy industries, it is critical that we continue to foster collaborations with national and international research and industry organisations. We are targeting specific institutions in Canada, South America and Asia to develop relationships and networks that will further strengthen our research and development capabilities and ensure our research outcomes continue to be world class and globally relevant.

There are more challenging times ahead for the mining and energy sectors but I am confident that we are well-equipped to meet these challenges head on, with our talented researchers, strong industry relationships, collaborative and interdisciplinary approach and world-class academic program.

I would like to take this opportunity to thank the IMER Advisory Board members for their valued input throughout 2012 and acknowledge the significant contribution made by our hard working IMER members.

Professor Stephen Grano
Executive Director
8th August, 2013

Challenges, strategies and priorities

Strategic framework

The Institute for Mineral and Energy Resources (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 globally recognised as a centre of excellence for fundamental and applied research, innovation and technology transfer in mineral and energy resources.

Global resource and energy challenges

IMER is developing long-term partnerships with its stakeholders and producing world-leading research outcomes that address the following global challenges and trends:

- increasing scarcity of large mineral and energy resource discoveries at, or near, the Earth's surface
- increasing depth of mining and extraction of mineral and energy resources
- decreasing grade and increasing complexity of mineral and energy resources
- increasing energy prices due to competition, constraints on carbon emissions and energy infrastructure upgrades
- increasing energy consumption, fuelled by natural gas as a cleaner and lower cost resource in some countries; a small but rapidly growing contribution from renewable energy sources, including biofuels; and an increasing contribution from nuclear energy
- increasing demand from communities to achieve economic sustainability by enhancing productivity and reducing costs.

These trends have become even more marked over the last year as the resources sector faces the challenge of meeting increasing demand, whilst capital and operating costs are also increasing significantly. The trend towards mega-scale projects is still apparent but now appears to be constrained by the very high capital costs of using existing technology at these large scales. Technologies with lower capital and operating costs are emerging that may unlock otherwise uneconomic resources.

Challenges for South Australia

IMER strives to address the central challenges of South Australia's mineral and energy resource industries through innovative and globally-relevant research outcomes. The global challenges of economic, social and environmental sustainability in mineral and energy resource development are reflected in the following key challenges and opportunities for South Australia.

Deep exploration

South Australia's mineral and energy resource potential is still largely untapped due to exploration difficulties associated with the thick sedimentary cover overlaying the basement rock. New exploration tools and methods, as well as improved understanding of ore formation and alteration processes, are key to enhancing the prospectivity of the State's mineral and energy resources.

Deep mining

As resources are being mined at increasing depth, operating costs and the impacts of open cut mining are also increasing. Waste to ore strip ratios, waste rock reporting to surface dumps and hauling costs are increasing as well as the risk on pit slope stability and acid mine drainage. Developing effective approaches to selectively mine targeted areas and reduce the amount of waste rock carted to the surface is imperative to lower costs.

Complex ore processing

South Australian minerals tend to be fine-grained and complex, with fine intergrowths of different value and gangue minerals at the micron and sub-micron scale. Conventional technologies used to grind these minerals for effective mineral separation and concentration have high electrical energy and installed power costs. New low capital and operating cost technologies are needed to process these minerals.

Research priority areas and strategy

Based on these global and South Australian challenges, IMER's research priority areas are:

> deep exploration
> deep mining
> complex ore processing
> unconventional energy resources
> reliable, low cost, low emission energy
> sustainable manufacturing.

IMER will provide leadership in interdisciplinary initiatives that are aligned to these research priority areas by:

> developing high profile, high value, long-term interdisciplinary projects funded by key industries and stakeholders
> forging new strategic relationships, including international engagements, joint ventures and partnerships that bring together interdisciplinary teams
> increasing the number, scale and success rate of national competitive grant applications to build research capability and capacity
> investing in research leadership through professional development and promoting the capabilities of University of Adelaide researchers.

Key principles

IMER's mission encompasses the key principles:

> **interdisciplinary research –** reflects the University of Adelaide's objective for IMER to bring together science, engineering and humanities research disciplines to address globally significant challenges
> **global recognition –** reflects the University of Adelaide's intent to be a leading research university by world standards with globally significant research outcomes
> **fundamental and applied research –** recognises the critical importance of fundamental research to underpin applied research which will directly address State and global challenges
> **innovation –** recognises the importance of step-change research and the breakthroughs required to make a positive and lasting impact on State, national and global communities
> **technology transfer –** recognises the importance of communication in all its forms to maintain mutually beneficial relationships between the University of Adelaide, industry and society.

Tapping natural gas from ultra-tight resources

South Australia has significant resources of natural gas contained in ultra-tight and shale gas deposits. These resources have several advantages over coal bed methane but extraction costs are higher as more drilling and fracturing is required. Research into improving the targeting of drilling and increasing productivity is fundamental to harnessing these resources.

Reliable, low cost, low emission energy

Ensuring reliable electricity supply whilst maintaining ability to meet peak loads and achieve greenhouse gas reduction targets is a major challenge. South Australia must successfully develop and deploy low cost renewable energy technology, biofuels, low cost coal to synthetic liquid fuels and low cost energy storage systems to secure the State's energy supply and reduce vulnerability to price increases in fossil fuel energy.

Demand for a highly-skilled workforce

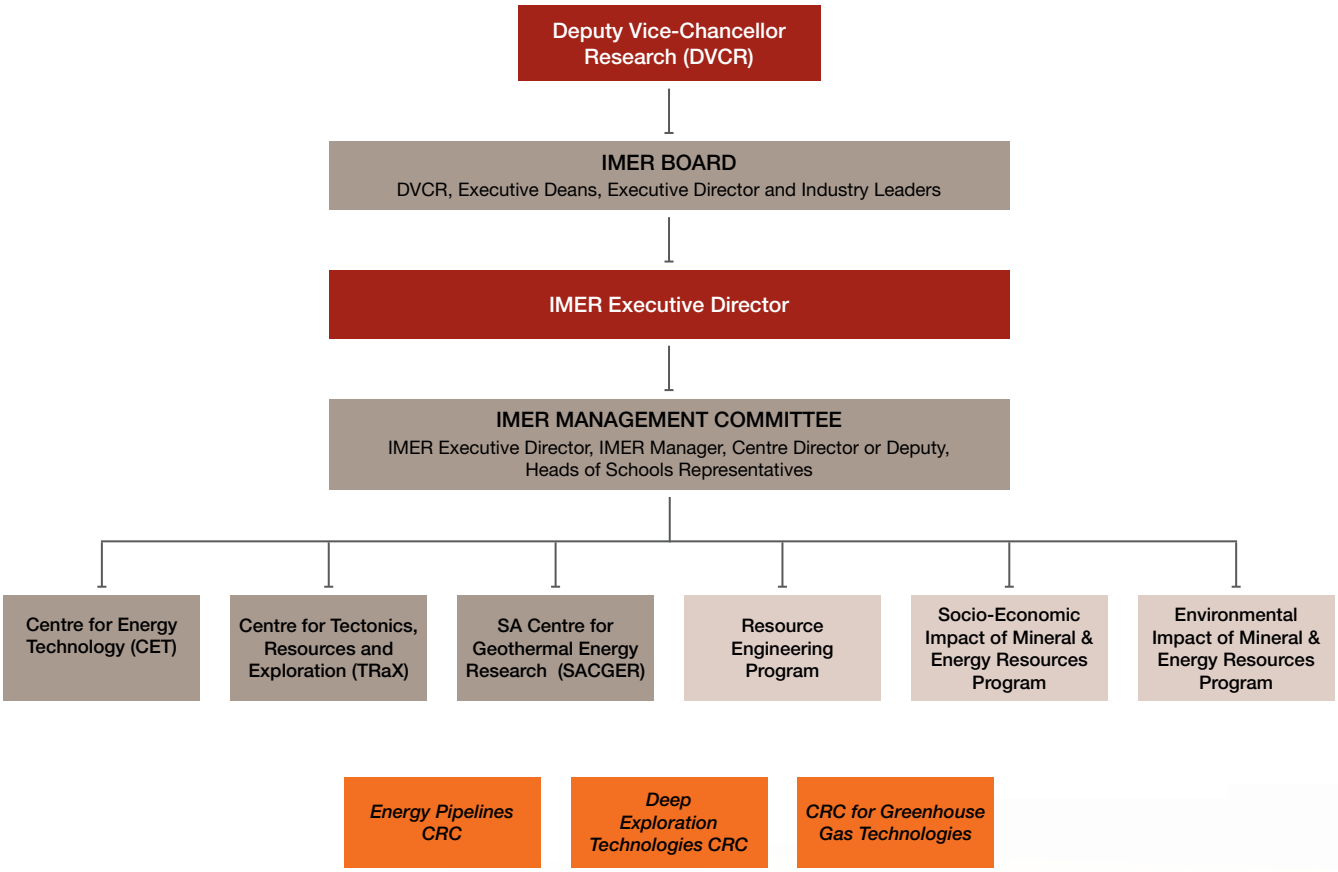
Developing South Australia's mineral and energy resources will require a highly-skilled and diversified workforce. There are growing concerns that the supply of engineers and scientists with skills in geology, mining engineering, mineral processing, extractive metallurgy and energy technology will not keep pace with demand. Investing in strategies to increase and retain professionals in South Australia will be key to protecting our industry and attracting new development.

Manufacturing opportunities

South Australian researchers are developing innovative technology and know-how that has the potential to make positive impacts on global mineral and energy resource industries. The State must capitalise on this research by developing niche manufacturing opportunities and exporting new technology and know-how globally.

> "IMER seeks to develop long-term partnerships with its stakeholders and conduct world-leading research."

Organisational structure



Key leaders

IMER Executive

Executive Director

Professor Stephen Grano

Professor Stephen Grano was appointed Executive Director of IMER in March 2010. He is an internationally-recognised metallurgical engineer with nearly three decades of research experience and a background of delivering successful projects linked to industry.

Manager

Dr Jordan Parham

Dr Jordan Parham combines extensive experience in both research and industrial environments. In his current role, he manages the Institute's strategic research initiatives, business development, outreach activities and internal operations. He holds a PhD from the University of Adelaide in the control and optimisation of mixing and combustion for mineral processing.

Centre Directors

IMER Deputy Director Director CET

Professor Graham (Gus) Nathan

Appointed as founding director of CET in 2009, Professor Gus Nathan specialises in thermal energy engineering in systems supplied by solar, geothermal and the combustion of fossil and biofuels. His research focuses particularly on novel approaches to integrate and optimise these different energy sources.

IMER Deputy Director Director SACGER

Professor Martin Hand

Professor Martin Hand was the inaugural director of TRaX and was appointed SACGER Director in 2009. His current research focus is the emerging geothermal energy industry in Australia. His research expertise is in the thermal evolution of the continental crust, including a PhD focused on the structural and metamorphic evolution of Proterozoic terrains in Antarctica and central Australia.

Director TRaX

Associate Professor Nigel Cook

Associate Professor Nigel Cook was appointed TRaX Director in 2009. Over two decades, his work has been directed to the geology and mineralogy of sulphide ore deposits. He aims to show how mineralogical study can and should be applied to solve a range of questions in ore geology.

Program Leaders

Resource Engineering Program

Associate Professor Chaoshui Xu

Socio-Economic Impacts of Mineral and Energy Resources Program

Associate Professor John Spoehr

Environmental Impact of Mineral and Energy Resources Program

Associate Professor José Facelli

Cooperative Research Centres

Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)

Chief Scientist: Professor John Kaldi

Deep Exploration Technologies Cooperative Research Centre (DET CRC)

Research Leader: Professor David Giles

Energy Pipelines Cooperative Research Centre (EPCRC)

Program Leader:
Associate Professor Peter Ashman

Board and committees

Advisory Board

The Advisory Board brings together industry and government leaders and internal University of Adelaide members with extensive knowledge or experience of the mineral and energy resource sectors.

Chair

Mr Robert Kennedy
Chairman, Ramelius Resources Limited

Professor John Beynon
Executive Dean, Faculty of Engineering, Computer and Mathematical Sciences University of Adelaide

Professor Mike Brooks
Deputy Vice-Chancellor and Vice-President (Research), University of Adelaide

Mr John England
Director of Processing Studies and Technology Resource Planning and Development, BHP Billiton

Professor Stephen Grano
Executive Director, IMER University of Adelaide

Dr Paul Heithersay
Chief Executive Olympic Dam Taskforce and Deputy Chief Executive Resources and Energy, Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE)

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

Ms Susan Jeanes
Chief Executive Officer, Australian Geothermal Energy Association Inc.

Mr Andrew Stock
Non-executive Director, Horizon Oil Limited, Geodynamics Ltd and Clean Energy Finance Corporation

** Dr Stephen Forbes, Director, Adelaide Botanic Gardens was a member from 1 August 2009 until 1 August 2012*

** Professor Robert Hill, Executive Dean, Faculty of Sciences, The University of Adelaide, was a member from 1 August 2009 until 19 July 2012*

Board (Left to Right): Mike Brooks, John England, Paul Heithersay, Robert Kennedy, John Beynon, Susan Jeanes and Stephen Grano. Not pictured Richard Hillis and Andrew Stock.

Management committee

The Management committee comprises relevant members from the University of Adelaide's Interdisciplinary Centres and Programs, as well as School and research leaders. The group generates research ideas, reviews funding and engagement opportunities and discusses project management issues. Committee members develop IMER's research capability and oversee strategy.

Management committee members

Chair

Prof Stephen Grano
Executive Director, IMER

Professor Bruce Ainsworth
Deputy Leader, Resource Engineering Program

Associate Professor Peter Ashman
Deputy Director, CET

Associate Professor Nigel Cook
Director, TRaX

Mr Simon Firth
Commercial Development Manager, Adelaide Research and Innovation Pty Ltd

Professor Martin Hand
Deputy Director, IMER; Director, SACGER

Mr Simon Ladd
Research Development Manager, Faculty of Humanities and Social Sciences

Professor Gus Nathan
Deputy Director, IMER; Director, CET

Dr Jordan Parham
Manager, IMER

Professor Shizhang Qiao
Chair of Nanotechnology, Faculty of Engineering, Computer and Mathematical Sciences

Associate Professor John Spoehr
Executive Director, Australian Workplace Innovation and Social Research Centre (WISeR)

Associate Professor Jennifer Watling
Head of School, School of Earth and Environmental Sciences

Associate Professor Chaoshui Xu
Program Leader, Resource Engineering Program

Management committee alternates

Associate Professor Barry Burgan
Deputy Leader, Socio-Economic Impact of Mineral and Energy Resources Program

Associate Professor Emmanuel Chanda
Deputy Leader, Resource Engineering Program

Associate Professor Bassam Dally
Deputy Director, CET

Associate Professor José Facelli
Program Leader, Environmental Impact of Mineral and Energy Resources Development Program

Dr Simon Holford
Deputy Director, TRaX

Dr Yung Ngothai
Deputy Director, SACGER

Dr Michael Rumsewicz
Business Development Manager, School of Civil, Environmental and Mining Engineering

Dr Mark Tingay
Senior Lecturer, Australian School of Petroleum

Major sponsors

IMER researchers attracted sponsorship funding from leading international companies as well as from South Australian and Australian government departments linked to competitive and prestigious research grants.

CRC for Greenhouse Gas Technologies

Core industry and government sponsors

Australian National Low Emissions Coal Research and Development Ltd (ANLEC R&D)

BG Group

BHP Billiton

BP Australia

Brown Coal Innovation Australia

Chevron Australia

Department of Environment and Primary Industries, State Government Victoria

Department of Mines and Petroleum, Government of Western Australia

Glencore Xstrata

INPEX

Korean Institute of Geoscience and Mineral Resources (KIGAM)

Ministry of Business, Innovation and Employment, New Zealand Government

NSW Trade & Investment, NSW Government

Rio Tinto Ltd

SASOL Ltd

The Shell Company of Australia Ltd

TOTAL

Deep Exploration Technologies CRC

Core industry and government sponsors

Anglo American

Barrick Australia Pacific Ltd

BHP Billiton

Boart Longyear

Department for Manufacturing, Innovation, Trade, Resources and Energy, Government of South Australia (DMITRE)

Gold Fields Australia Pty Ltd

Imdex Ltd

Newcrest Mining Ltd

Vale Exploration Pty Ltd

Energy Pipelines CRC

Core industry sponsor

Australian Pipeline Industry Association Ltd (APIA)

Reservoir architecture and heterogeneity in marginal marine systems – *WAVE* Consortium

Core industry sponsors

Apache Corporation

Badr Petroleum Co

BG Group

BHP Billiton

BP Australia

Chevron Australia

ConocoPhillips

Nexen Petroleum Australia Pty Ltd

OMV Group

Shell

Statoil

Todd Energy

Woodside Energy Ltd

Major research sponsors

Core industry

ACH Group
Adelaide Airport Ltd
Adelaide Brighton Ltd
Australian Institute of Nuclear Science and Engineering
Asian Office of Aerospace Research & Development
Australian Business Foundation Ltd
Australian Society for Exploration Geophysicists
Australian Synchrotron Company Ltd
Barrick Gold of Australia Ltd
Beach Energy Ltd
BG International Limited
Broons Hire (SA) Pty Ltd
Ceramic Oxide Fabricators Pty Ltd
Deep Blue Tech Pty Ltd
Don Dunstan Foundation
EconSearch Pty Ltd
ESSO Australia Pty Ltd
ESSO Exploration Inc
FCT Combustion Pty Ltd
Halliburton Energy Services Inc
Iluka Resources Ltd
Imperial Oil & Gas Pty Ltd
Iron Road Ltd
Nature Foundation SA Inc
Newmont Mining Corporation
OzMinerals Prominent Hill Operation
Petratherm Pty Ltd
Playford Memorial Trust Inc
Public Service Association
QGC Pty Ltd
Santos Ltd
Science and Industry Endowment Fund
Shell Development Australia Pty Ltd
Sir Mark Mitchell Research Foundation
Society of Exploration Geophysicists
South Australian Research and Development Institute
SQC Pty Ltd
Telethon Institute for Child Health
The Sir Ross & Sir Keith Smith Fund
TOTAL E&P Australia
Trackside Intelligence Pty Ltd
Water Quality Research Australia Ltd
Woodside Energy Ltd
Xstrata Coal Pty Ltd

State and local government

South Australia

City of Playford
Department for Education and Child Development
Department for Manufacturing, Innovation, Trade, Resources and Energy, Government of South Australia
Department of Environment, Water and Natural Resources
Department of Premier and Cabinet
Forestry SA
Primary Industries and Resources SA
Renewables SA
SafeWork SA
South Australian Museum
SA Water
Workcover Corporation

Victoria

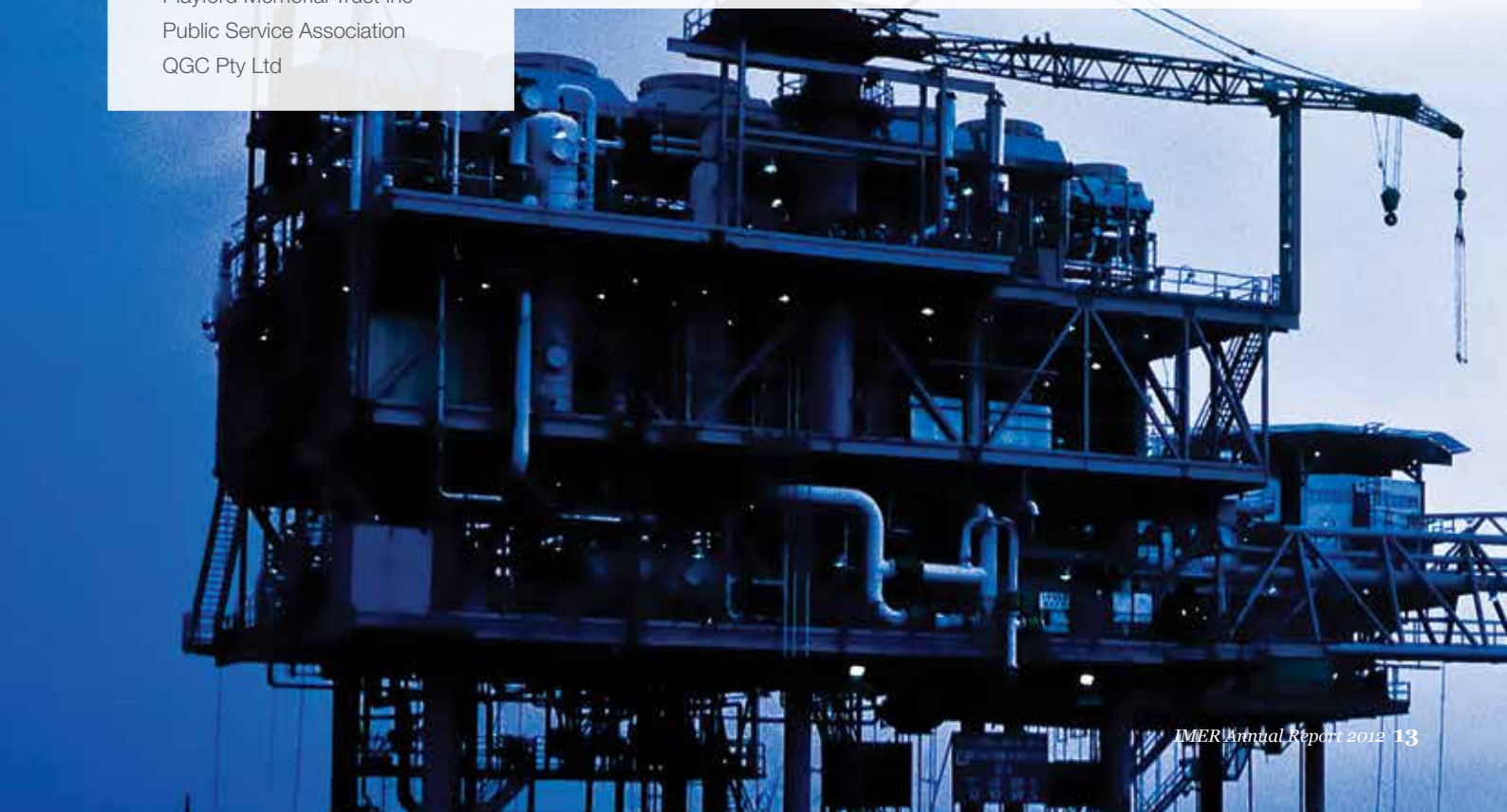
Department of Environment & Primary Industries
Melbourne Water

Western Australia

Geological Survey of Western Australia

Commonwealth Government of Australia

Australian Agency for International Development
Australian Research Council
Australian Solar Institute
Australian Teaching and Learning Council
Commonwealth Scientific and Industrial Research Organisation
Defence Science and Technology Organisation
Department for Education, Employment & Workforce Relations
Department of Foreign Affairs and Trade
Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education
Department of Resources, Energy and Tourism
National ICT Australia
Regional Development Australia



Research funding

Funding which can be attributed to IMER members has been calculated from the total funding obtained by IMER member researchers for projects and research infrastructure grants that are relevant to IMER.

As IMER is highly inter-disciplinary and encompasses a diverse cross-section of research fields, only projects and infrastructure that relate to core IMER research areas of expertise and priorities have been included in this financial data.

Research funding is shown according to the Australian Higher Education Research Data Collection categories:

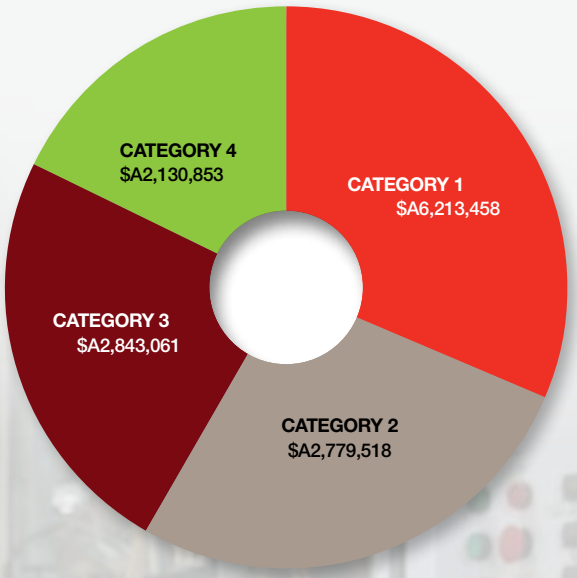
Category 1
Nationally competitive research grants

Category 2
Other public sector funding

Category 3
Australian industry, donations and international grants

Category 4
Cooperative Research Centres

2012 research income
$13,966,890



Key collaborators

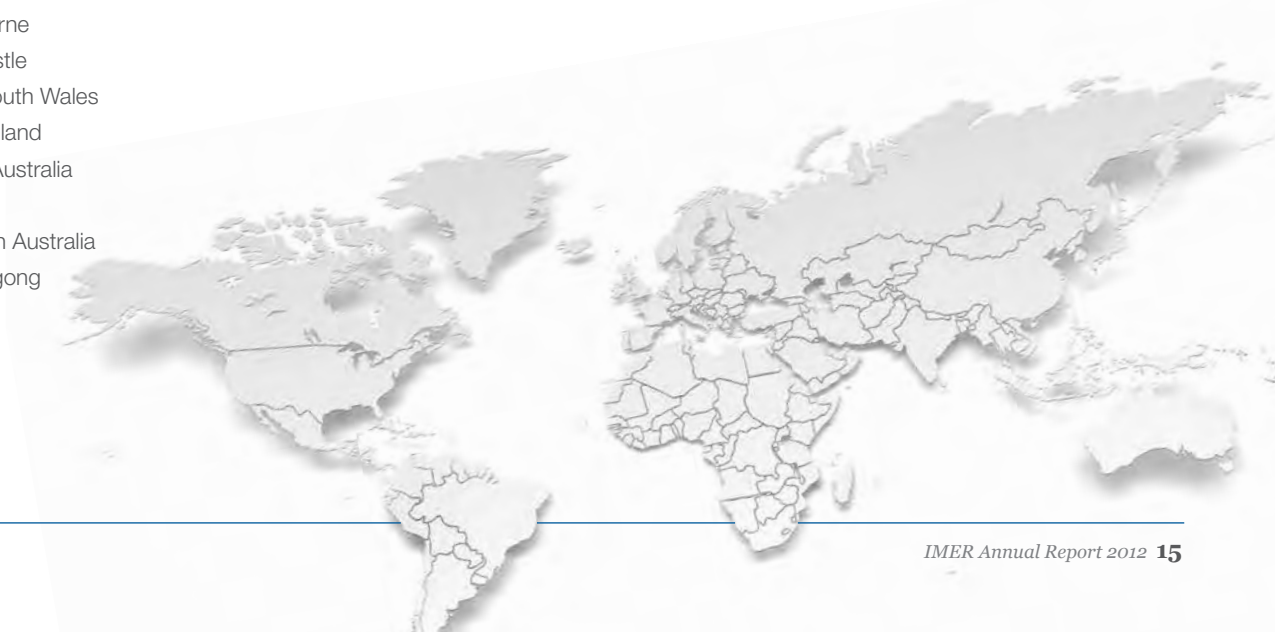
IMER researchers collaborate with leading companies and universities across the globe. These collaborations bring together experts with diverse skills and capabilities, generating a holistic approach to solving current and future global challenges.

Australian

AuScope
Australian National University
Broons Pty Ltd
Charles Darwin University
Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Curtin University
Flinders University
Geodynamics Ltd
Geological Survey of Queensland
Geological Survey of Western Australia
Geoscience Australia, Australian Government
GeoScience Victoria
Geotrack International Ltd
GNS Science
Heathgate Resources Pty Ltd
Macquarie University
Monash University
Muradel Pty Ltd
Northern Territory Geological Survey
Queensland University of Technology
Panax Geothermal Ltd
RMIT University
South Australian Museum
University of Melbourne
University of Newcastle
University of New South Wales
University of Queensland
University of South Australia
University of Sydney
University of Western Australia
University of Wollongong

International

Abo Akademi
Australian Chile Chamber of Commerce
Chinese Academy of Sciences
Chinese University of Geoscience
Coffey International
Delft University of Technology
Dublin Institute for Advanced Studies
East China University of Science and Technology
Federal University of Minas Gerais
Federal University of Rio de Janeiro
Imperial College London
Indian Institute of Technology
Luleå University of Technology
Lund University
McGill University
Memorial University
Northwest University
Peking University
Purdue University
(Bedford New College), Royal Holloway University of London
RWTH Aachen University
Scripps Institute of Oceanography
Stellenbosh University
Tianjin University
Tsinghua University
Tsukaba University
University of Aberdeen
University of Addis Ababa
University of Auckland
University of Birmingham
University of California
University of Cambridge
University of Chile
University of Edinburgh
University of Münster
University of Otago
University of Salamanca
University of Sao Paulo
University of Science and Technology
University of St Andrews
University of Utah
University of Wales
University of Western Ontario



Key awards

Associate Professor Alan Collins

ARC Future Fellowship

Associate Professor Alan Collins, Director of the Centre for Tectonics, Resources and Exploration (TRaX) from 2013, was awarded a highly competitive Australian Research Council (ARC) Future Fellowship.

Associate Professor Collins received $822,606 for a project that will use isotopic proxies for subduction to reconstruct ancient oceans and improve understanding of the origin of Australian Gondwana. The research will examine the geography of Australia between 850 and 500 million years ago, a period of major climatic extremes, and provide new knowledge on the origin of multi-cellular life and the accumulation of the first major petroleum deposits.

The award recognises Associate Professor Collins as one of Australia's best and brightest mid-career researchers and acknowledges his research talent and work in a field of critical national importance.

Dr Paul Medwell

ARC Discovery Early Career Research Award

Dr Paul Medwell, Centre for Energy Technology (CET), was awarded $375,000 in the inaugural round of Australian Research Council (ARC) Discovery Early Career Researcher Awards (DECRA).

The award will fund a three-year project investigating flame stabilisation mechanisms in the transition to moderate or intense low oxygen dilution (MILD) combustion. Next-generation combustion technologies that are required for the transition to more efficient and less polluting energy production will be examined. Flame stabilisation will be investigated on a fundamental level to facilitate the design and development of more efficient and sustainable combustion systems. The award will provide focused support for Dr Medwell and foster his skills in research and teaching.

Professor Steve Begg

Southern Asia Pacific Regional Technical Award

Professor Steve Begg, Head of the Australian School of Petroleum (ASP), received the 2012 Society of Petroleum Engineers (SPE) Southern Asia Pacific Regional Technical Award to acknowledge his exceptional contributions to the Society. This esteemed award is determined by peer review and is recognition of Professor Begg's singular devotion of time and effort to the programs as well as the development of technical expertise in the Management and Information discipline. It also highlights Management Science as a true technical field.

The award presentation was held at the SPE Asia Pacific Oil and Gas Conference and Exhibition (APOGCE) in Perth in October, 2012.

Dr Cris Birzer

South Australian Young Professional Engineer of the Year 2012

Dr Cris Birzer was awarded South Australian Young Professional Engineer of the Year at the 2012 Engineering Excellence South Australian Awards. The award acknowledges Dr Birzer's outstanding efforts to increase enrolment in mechanical engineering at the University of Adelaide as well as his passion for humanitarian engineering projects.

Dr Birzer developed and managed two programs aimed at increasing student engagement with engineering concepts and skills – one for students and one for teachers. He also developed and managed the Engineering Equipped Workshop, a program that equips secondary school teachers with the skills and knowledge to show students that engineering is an enjoyable and rewarding career with wide-reaching benefits for society.

Dr Birzer is a mechanical engineer who lectures in Sustainable Energy Engineering at the University of Adelaide. His current research is focused on fluid mechanics, combustion and laser diagnostics for the optimisation of energy systems and emission control and mitigation.

Peter Hardy

Playford Memorial Trust Scholarships

Peter Hardy, PhD student in the School of Mechanical Engineering, was awarded a scholarship with the Playford Memorial Trust for work on a project to improve the economic viability of wave energy technology.

Peter's research will focus on developing and testing non-linear control algorithms for a high-speed, bi-directional air turbine in an oscillating water column, which can operate at high efficiency over a range of wave conditions. The project is a collaboration between the University of Adelaide and Oceanlinx Ltd, a world leader in wave energy technology.

Ronnie Ling, a final year student in Petroleum Engineering, and **Brenton Schoemaker**, Honours student in Geology, were also awarded Playford Trust Scholarships.

The Playford Trust was established by the South Australian Government to perpetuate the memory of the State's longest-serving Premier by supporting young South Australians in their research training and development.

Additional achievements

- Dr Abbas Zeinijahromi, lecturer in the Australian School of Petroleum, and Dr Max Watson, were each awarded a Dean's Commendation for Doctoral Thesis Excellence.
- Jess Trainor, PhD Student in Geology, won an Eric Rudd Memorial Scholarship.
- Dr Abbas Zeinijahromi was awarded a University Doctoral Research Medal for 2012.

Centre for Energy Technology

The vision of the Centre for Energy Technology (CET) is to deliver innovative technologies for a clean energy future through strategic partnerships.

Mission

The mission of the CET is to accelerate the transition of energy technologies from high to low CO_2 emission intensities, through world-leading research and development in partnership with leading industry and government agencies and other research organisations.

The CET develops cost-effective, clean energy technologies for the sustainable use of fossil and alternative fuels and renewable energy resources including solar, biomass, wind, wave and geothermal. A particular focus is the integration of different energy sources through hybridisation and energy storage.

Objectives

> To increase high quality research outputs in energy technology at the University of Adelaide.

> To accelerate the development and deployment of clean energy technology.

> To provide increased support for CET researchers in line with our mission and objectives.

A particular highlight for 2012 was the naming of the CET as a major node in the new Australian Solar Thermal Research Initiative.

Director's report

Professor Graham 'Gus' Nathan

This year has seen a marked increase in research activities and outcomes from all of the CET priority areas and increased collaboration with industry and other researchers in Australia and around the world.

A total of $9.3 million of new funding was approved in 2012, up from $3.5 million in 2011 and a five-year average of $2 million a year before the CET was established. Our platinum partnership with Adelaide Airport Limited also continued, with research outcomes implemented to reduce greenhouse emissions from the airport itself as well as research breakthroughs with significant mitigation potential for the wider community.

Our research capability in the integration of solar thermal technologies and hybrids with combustion has been significantly increased by the establishment of a new controlled radiation facility and 50 kW thermal solar simulator. These will support the development of a novel hybrid solar receiver combustor in partnership with FCT-Combustion and a concentrated solar and chemical looping combustion hybrid system.

Our solar fuels activities received a boost with ARENA awarding $32 million over eight years to the Australian Solar Thermal Research Initiative (ASTRI). Led by the CSIRO in partnership with six Australian universities, ASTRI will lower the cost of solar thermal power. The CET is leading Node 4, focusing on lowering production costs of liquid fuels through thermal processing of carbonaceous feedstocks. CET researchers will develop novel reactor technologies and catalytic materials, with the latter work further enhanced through a new supercontinuum laser facility. The CET is also a partner in a related ASTRI project with the University of New South Wales to develop tools for design and scale-up of solar thermo-chemical reactors.

A highlight of our combustion research activities was the joint launch of the International Sooting Flames (ISF) Workshop. The ISF Workshop will coordinate the research of the international community to meet the challenge of providing truly predictive capability for sooting flames. This work is critical to the long-term mitigation of soot emissions and will also improve efficiency of fossil and biofuel use into the future.

Our research capability in wind energy has grown with the award of ARC funding to decrease noise generation from wind turbines. CET wind energy researchers also actively engaged with industry and other stakeholders to develop a project that will establish a new framework for assessing and predicting the impacts of wind energy developments.

The CET continued its partnership with Regional Development Australia (Adelaide Metro) and other industry

partners, to better identify the benefits of electrical energy storage for employment and for reinforcing the grid. Our work in novel materials for energy storage technologies also advanced thanks to funding to investigate new metal catalysts for energy efficient fuel cells.

The CET welcomed several new staff in 2012. Professor John Abraham joined us from Purdue, bringing leading computational expertise in combustion and alternative fuels. Professor Shizhang Qiao's specialist expertise in novel materials and nanotechnology significantly enhances research capabilities in our energy storage priority area.

As the range and breadth of our activities continues to grow, we welcome the opportunity to develop further partnerships with industry, researchers and the broader community to deliver a clean energy future.

Advisory Board

Chair Hon Trish White
Executive Strategic Advisor, Worley Parsons

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Mr Mike Congreve
Team Leader Reservoir Development - Roma & Rugs, Santos Limited

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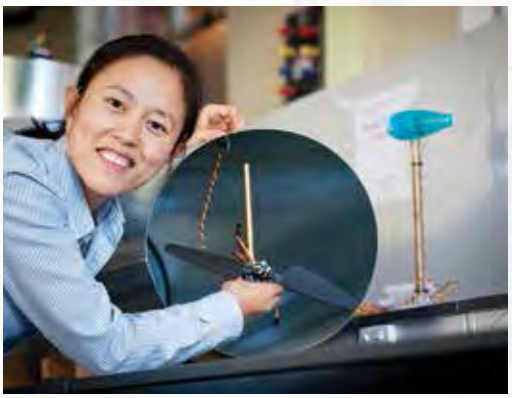


Fang Duan, wind tunnel

CET research areas

- **Combustion and fluid mechanics:** innovative burner technologies, turbulent flows, two-phase flows, heat transfer, clean coal technologies.
- **Renewable energy integration:** solar-combustion hybrids for solar fuels, minerals processing or electricity generation, energy storage and management, techno-economic assessments of energy systems and markets.
- **Energy efficiency:** novel power cycles, aerodynamic optimisation, air-conditioning systems, electrical power quality, conditioning low-cost converter systems.
- **Alternative fuels:** the production and utilisation of alternative fuels from biomass, especially from micro algae.
- **Wind energy:** micro wind turbines, aero acoustics, novel generators, wind farm optimisation.
- **Physical chemistry:** new photovoltaic materials, nanocatalysis, gas storage and separation, nanostructured materials for energy conversion and storage.

Home Schools

School of Chemical Engineering
School of Chemistry and Physics
School of Earth and Environmental Sciences
School of Economics
School of Electrical and Electronic Engineering
School of Mathematical Sciences
School of Mechanical Engineering

Peter Hardy
Wave energy

Project highlights

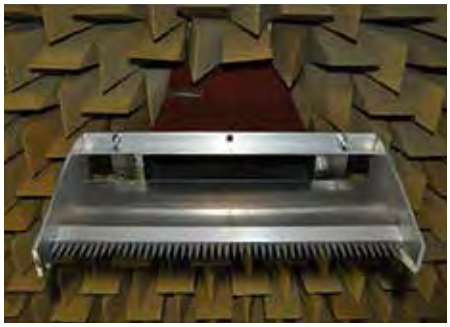
The mechanics of quiet airfoils

Dr Con Doolan, Emeritus Professor Colin Hansen, Professor Lars Davidson, Slawek Koziel and Associate Professor Daniel Feszty.

The fundamental mechanism of airfoil sound generation was investigated in this project. As airfoils, such as wings, wind turbine rotors and fans operate, turbulence at their trailing edge is the major source of sound. This project examined how tonal and broadband noise is generated at trailing edges as well as the influence of geometry on sound production. This created a unique dataset of flow and noise information that is now being used by industry and academia to develop new computational aeroacoustic models.

As a result of this research, new methods for controlling noise have been developed and a novel computational method for predicting noise is being used by industry to design quieter hydrofoils.

This work will be extended in a future ARC Discovery Project to investigate airfoil noise production at a higher Reynolds number and to develop novel passive and active noise control techniques for the next generation of quiet aircraft, submarines and wind turbines.



Serration design tested for controlling airfoil noise

Industrial scale development of energy from microalgae

Associate Professor David Lewis, Associate Professor Peter Ashman, Dr Sophie Fon Sing, Dr Stephen Pahl, Michael Jureidini, Andrew Lee, Wynand van den Berg, Quang Doan, Blessing Eboibi, Mason Erkelens, Amir Forghani, Theo Kalatzidis, Daniel Lane and Andrew Ward.

The current research is focused on the development of processes facilitating industrial-scale production of biofuel and energy co-products from marine microalgae.

Research at the University of Adelaide has focused on a range of complementary and competing technologies, all based around the commercial-scale cultivation and harvesting of hyper-saline microalgae. With an initial focus on lipid production via cell disruption and extraction, it was concluded that existing mechanical disruption methods were highly inefficient. Measured specific energy consumption was far greater than the energy recoverable, despite measurements indicating that the theoretical energy consumption should be several orders of magnitude less. Energy requirements could potentially be optimised by using more energy efficient disruption processes, increasing cell concentration and incorporating solvent extraction into the process. The most recent research has focused on a process called Hydrothermal Liquefaction (HTL) that can directly produce 'green crude' with the potential for direct processing in conventional fuel refineries.

The economics of electroflocculation for harvesting of microalgal biomass from culture media have also been investigated. A process combining electroflocculation, mixing and settling has been optimised at pilot scale. Demonstration of the sustainable and commercial potential of value-added co-products from marine microalgal biomass in large-scale integrated production facilities is a key project outcome.

Low-cost electroflocculation developed at the University of Adelaide

World-first planar measurements of temperature and soot in turbulent flames

Professor Gus Nathan, Professor Bassam Dally, Professor Heinz Pitch (RWTH Aachen), Associate Professor Zeyad Alwahabi, Dr Paul Medwell, Dr Zhiwei Sun, Dahe Gu and Saleh Mahmoud.

Advanced measurements and modelling are improving our understanding of soot formation, evolution and burnout in a series of flames. This research will help reduce pollutant emissions and increase performance of combustion systems for power generation, transport and industrial processes. It will also support the optimisation of carbon nano-particle production.

A novel laser diagnostic technique called Two Line Atomic Fluorescence (TLAF) has been developed at the University of Adelaide. TLAF permits planar measurement of temperature in flames with soot, providing information across an entire flame structure that single-point methods cannot. This is the first time that temperature and soot volume fraction have been measured simultaneously. The International Sooting Flames Workshop coordinates the activities of experimentalists and modellers through the investigation of a series of flames that are both well suited to computational modelling and relevant to applications. In time, these models will be developed into next generation engineering design tools to optimise gas turbines, automotive engines and furnaces.

Future work will extend the flame range investigated and the number of parameters measured as well as conditions relevant to solar reactors.

Investigating future energy media

Dr Neil Smith, Associate Professor Peter Ashman, Professor Gus Nathan and Mark Coates (Hatch Pty Ltd).

Australia's pipeline industry presently focuses on the transmission of natural gas, oil and water, but this may change in the future with the introduction of different fuels and/or the capture of greenhouse gas emissions. A preliminary assessment of technology for producing alternate carbon and non-carbon energy carriers that may be transported in pipelines was undertaken during this project for the Energy Pipelines CRC.

A range of potential energy resources were reviewed including syngas, carbon dioxide, hydrogen, ammonia, liquefied natural gas, crude and refined biofuels, alcohols, slurries, di-methyl ether, synthetic diesel and other fluids touted as hydrogen carriers. The review showed that production and pipeline scenarios need to be considered for future energy media, along with the scale of production and the location of the energy resource and end-users. These factors will strongly influence achievable fluid compositions, pipeline design and associated costs.

A National Facility for the Transportation of Alternative Energy Fluids has been established to engage industry and researchers in a collaborative assessment of the likely energy fluid and pipeline scenarios and to identify areas for future research.

Energy from the ocean

Associate Professor Ben Cazzolato, Associate Professor David Walker, Dr Maziar Arjomandi, Professor Bassam Dally, Professor Gus Nathan, Dr Zebb Prime and Peter Hardy.

CET researchers are undertaking two projects aimed at tapping into one of the world's largest sources of renewable energy – the ocean.

The oscillating water column (OWC) project (funded by an ARC Linkage Grant) is being conducted in partnership with Oceanlinx Ltd. It aims to improve the efficiency, operating bandwidth and capacity factor of OWC through a combination of adaptive-passive and active control strategies for impedance matching. High fidelity analytical models of the coupled OWC have been developed and testing has begun on a full-scale model installed in the University's wave flume.

Research is also underway to investigate how vortex shedding from bluff bodies in flow could be used to extract power from currents. Strategies for optimising the impedance of the load and beneficially deploying arrays of oscillators to enhance performance are being investigated. High fidelity Computational Fluid Dynamics (CFD) simulations have shown that there are 'sweet spots' for downstream oscillators. An experimental rig is being commissioned to validate CFD results and demonstrate load impedance optimisation experimentally.

> "In the future, the research team aims to have projects investigating all sources of ocean power including waves, tidal, currents and gradients - both temperature and saline."

Investment highlights

IMER and CET invest in research projects to advance our leadership in strategic research priority areas that are aligned to industry and community needs. Here we highlight some of the research projects supported by IMER and CET.

Heat transfer in novel solar thermal reactors to process minerals and solar fuels

Professor Gus Nathan, Associate Professor Zeyad Alwahabi, Professor John Abrahams, Professor Aldo Steinfeld (ETH Zurich), Dr Aleksander Kartusinski (Tallin University of Technology), Professor Lyazid Djenidi (University of Newcastle), Dr Tim Lau, Dr Peter Kalt, Rahul Chowdhury and Isaac Saridakis.

Current models of the transport of particles and propagation of radiation through turbulent, particle-laden flows have limited accuracy because of the complexity arising from the non-linear coupling between particle motion and transporting fluid. That is, the flow affects the particles and the particles influence the flow. Accurate models of transport are needed for reliable and efficient engineering design of combustion equipment for burning fossil fuels.

The research team is compiling the first comprehensive, detailed and systematic data set of radiation propagation through a series of well-defined particle-laden flows that span a wide range of conditions. This systematic approach is essential for model development. Reliable models must achieve general predictive capability and not be 'tuned' only to match a few cases. This model will improve the reliability of modelling existing combustion technologies using both pulverised coal and biomass, and also help optimise next-generation technologies such as solar thermo-chemical reactors.

Future work will complete the database and advance understanding through comparison of experimental and numerical investigations.

Solar hydrogen: photocatalytic generation of hydrogen from water

Associate Professor Greg Metha, Dr Tak Kee, Dr David Huang, Jason Alvino and Trystan Bennett.

Hydrogen produced from water is a potential renewable energy source. A photoelectrochemical process for the production of hydrogen of water using sunlight is being developed as part of this project.

Photo-catalysis experiments have successfully produced hydrogen from water vapour by irradiating gold-cluster catalysts deposited on pure titania with ultra-violet light. Researchers are now quantifying the hydrogen production rate through calibration of equipment and other variables are being explored, including treatment of the catalyst, gas-pressure and temperature. Optimisation of the cluster catalysts and their sample preparation are continuing. Computational calculations are also being pursued to provide a better picture of the catalysts at the atomic level, and to also support analysis of synchrotron experiments. This is the subject of two recently submitted papers. The model has been advanced to replicate the experimentally known band-gap of titanium dioxide (TiO_2) and the researchers are now exploring the effect of adding gold atoms and clusters.

Improving energy efficiency at Adelaide airport

Dr Timothy Lau, Dr Lei Chen, Associate Professor Eric Hu.

CET's platinum partnership with Adelaide Airport Limited (AAL) aims to make AAL the most ecologically sustainable airport in Australia. Within the airport, the focus is on reducing energy consumption in the main terminal building (T1); the main contributor

to AAL's direct energy footprint. Beyond the airport, the partnership has invested in the development of novel technologies with strong potential to make a step-change in clean energy in the longer term.

The strategies being adopted to increase energy efficiency in T1 at Adelaide Airport incorporate the development of a comprehensive energy model by CET researchers. The model can estimate energy consumption for any set of input conditions, helping AAL to make informed business decisions on energy use.

The total energy consumption of T1 has been measured monthly over the past five years. In contrast to the annual growth in energy consumption before the partnership, energy use is now decreasing by approximately three per cent per annum. In addition, the investigation of underperforming devices in AAL's heating, ventilation and air-conditioning (HVAC) plant rooms has identified future energy saving strategies to further improve both energy efficiency and customer comfort.

Energy savings of more than two per cent per annum have been achieved by installing 21 variable speed drive units for air handling units (AHUs). Energy efficiency could be improved further by changing the fixed schedule of AHUs to one that is predictive of the changing environment. Future control strategies will optimise the HVAC system in real time.

Research highlight

Economical harvesting of marine microalgae for biofuel production

There is considerable international interest in the sustainable production of biofuel from microalgae.

The inefficiencies of large-scale production have so far prevented the development of commercially-viable production processes. The cost of production of microalgal biomass is estimated at $10/kg, which is at least an order of magnitude higher than that required for commercial biofuel production.

Centre for Energy Technology (CET) chemical engineers Associate Professor David Lewis, Andrew Lee, Theo Kalaitzidis and Associate Professor Peter Ashman are developing processes to facilitate industrial-scale production of energy from marine microalgae. There are several major advantages to using marine microalgae as feedstocks for biofuel production. Marine microalgae do not compete with farm crops or native vegetation for fresh water or arable land and there are species with high specific growth rates and lipid yields.

Biodiesel is only one of several possible routes from microalgae to biofuels. Production of biodiesel from microalgae involves four main steps: cultivation of biomass; harvesting of biomass from culture media; extraction of lipids; and transesterification of lipids to biodiesel. The cost of harvesting microalgal biomass from culture media is estimated to be around 25 per cent of the total production cost and so improving the economic efficiency of harvesting is the main focus.

Pilot scale electroflocculation tank at the Karratha Pilot Plant, 2012.

The research is investigating the economics of electroflocculation for harvesting marine microalgae. In electroflocculation, electric currents are used to dissolve sacrificial metal to supply the ions required for flocculation. The technique is non-species specific, simple to operate and predictable.

The effects of mixing and electrode separation on energy consumption during electroflocculation were investigated using two different processes. Process A used a combination of electroflocculation, mixing and settling. Flocculation efficiency was determined by cell counting and recovery efficiencies and energy requirements were calculated. Process B used electroflocculation and flotation. A black and white Secchi disk, commonly used to measure water transparency, was placed against the back of the electro-flocculator and used to measure flocculation efficiency. Suspended microalgae were carried to the top by rising air bubbles generated from the electrode surface.

While Process B had a shorter processing time than Process A (5.75 minutes compared to 45.5 minutes respectively), the energy requirement was 1.7 times higher at 0.56 MJ/m^3. Using Process A, the total cost of harvesting, including electrical energy, electrode metal dissolution and capital depreciation was estimated at $0.19/kg of the ash free dry mass. Process A was more efficient overall and is being used to design an electroflocculation plant that will be used to reduce harvesting costs on a commercial scale.

The ultimate aim of the wider research program is to demonstrate sustainable, commercial-scale production of microalgal biofuel and co-products in large-scale, integrated facilities. Co-products, such as proteins or colour pigments for pharmaceutical and nutraceutical uses, can often justify the high culturing, harvesting and extraction costs of microalgae because the product values are higher. These co-products may prove the key to economically-sustainable production processes for microalgal lipids.

Associate Professor David Lewis, Biofuels Laboratory

References

Lee AK[a], Lewis, DM[a] and Ashman PJ[a] (2012) *Harvesting of marine microalgae by electroflocculation: The energetics, plant design, and economics.* Applied Energy, 108: 45-53.

[a] Microalgae Engineering Research Group, Centre for Energy Technology, School of Chemical Engineering, University of Adelaide, Australia.

Centre for Tectonics, Resources and Exploration

The vision of the Centre for Tectonics, Resources and Exploration (TRaX) is to understand the evolving 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 innovative predictive methods for the discovery of new deposits.

Mission

The mission of TRaX is to be the leading provider of research and teaching in tectonics, resources and exploration in Australia and conduct focused research into South Australia's unique geological characteristics.

Objectives

> To translate research outcomes into practical applications for mineral and energy industries.

> To support the building of interdisciplinary teams that cross traditional university boundaries and tackle industry's major issues.

> To support and enhance national and international research excellence in tectonics and resource exploration.

> To educate students in the latest research technologies to skill the next generation of geoscience researchers and highly trained geoscience workforce.

> To use our expertise to influence government resources policy.

Director's report

Associate Professor Nigel Cook

Last year was another fantastic one for the Centre for Tectonics Resources and Exploration (TRaX) and earth science research at the University of Adelaide.

In the recent Excellence in Research Australia review the University of Adelaide scored the maximum 5 ('well above world average') in both geology and geochemistry, which confirms the University as having one of the top geosciences groups worldwide. This success was underpinned by record undergraduate student numbers as well as record numbers of PhD start-ups and completions. Earth science capabilities at the University were boosted further by the establishment of a sister research centre, the Sprigg Geobiology Centre.

TRaX had a number of ARC successes in 2012, including the awarding of a Future Fellowship to Associate Professor Alan Collins for a five-year project titled 'The origin of Australian Gondwana: using isotopic proxies for subduction to reconstruct ancient oceans'. Another exciting new project is being developed by Dr Joël Brugger who was awarded an ARC Discovery grant for the project 'Deep and smelly: the roles of pressure and sulphur in hydrothermal metal transport'.

The year also saw record publication outputs from researchers in TRaX's five research groups. Research from some of these groups is included in the project highlights that follow, including projects aimed at increasing the recovery factor of marginal marine systems and productivity of mineral exploration in deep cover environments.

We also said goodbye (but not farewell) to Dr Steve Hill who has taken on a new role as Director of the Geological Survey of South Australia. Steve taught a generation of students and researchers to understand and appreciate the importance of the regolith and cover sequences.

This is my last report as TRaX Director, with Associate Professor Alan Collins assuming the role at the start of 2013. I will remain as a Deputy Director, together with Dr Simon Holford, to assist Alan. Our five working groups are now taking a lead role in decision-making and will continue to focus on interdisciplinary research aligned with our research priorities and core strengths.

With the range of exciting and innovative research coming out of our working groups as well as the Deep Exploration Technologies Cooperative Research Centre and Sprigg Geobiology Centre, 2013 is set to be another successful year for geosciences research and TRaX.

Advisory Board

Dr Frank Bierlein
Manager, Global Project Generation, AFMECO Mining & Exploration Pty Ltd

Associate Professor Nigel Cook
Director, TRaX

Dr Martin Fairclough
Chief Geoscientist, Geological Survey of South Australia

Professor Stephen Grano
Executive Director, IMER

Dr Simon Lang
Co-ordinator Sequence Stratigraphy & Reservoir Analysis, Woodside Energy Ltd

Mr John Roberts
President, SACOME

Dr Ned Stolz
Group leader, Data Acquisition and Stewardship, Geoscience Australia

Dr Pat Williams
Director, Clump Mountain Geoscience Pty Ltd

TRaX research groups

- **Reservoir Analogues:** sedimentology, stratigraphy, petroleum geology, reservoir and seal analogues, 3D reservoir modelling, carbon capture and sequestration, modern environments.
- **Stress, Structure and Seismics:** petroleum geomechanics, tectonics and neotectonics, seismic interpretation.
- **Continental Evolution:** nature of basement rocks in South Australia and Australia – their tectonic evolution and mineral prospectivity, including stress and structure of the Earth.
- **4D Electrical Earth Imaging:** applying electromagnetic (EM) and electrical geophysics to lithospheric studies constraining the electrical resistivity distribution of the Earth's crust and mantle in view of tectonic evolution; exploration and monitoring of fluids in unconventional energy resource and groundwater development; and 3D mineral exploration. This is complemented by expertise in field surveys, data processing, numerical modelling and interpretation and the largest range of field-based equipment in Australia.

Dr Benjamin Wade, Microscopy Laboratory

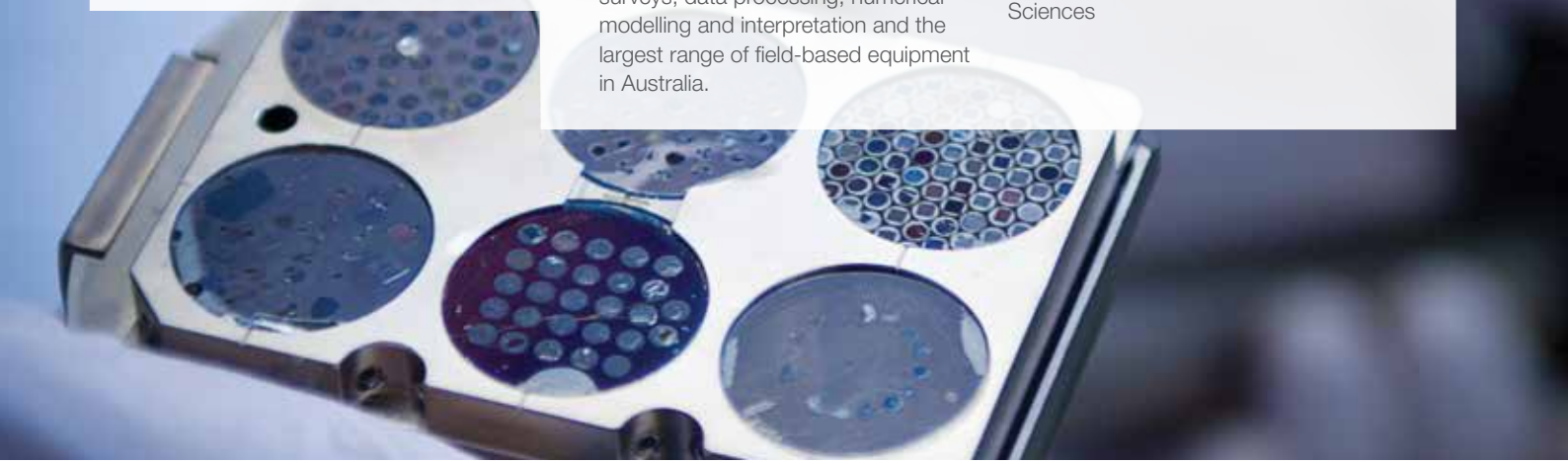
- **Minerals, Microbes and Solutions:** study of metal complexes under hydrothermal conditions, high pressure-high temperature flow conditions and biosensors.

Home Schools

Adelaide Microscopy

Australian School of Petroleum

School of Earth and Environmental Sciences



Project highlights

Evaporite and shale detachments and their control on fold-thrust belt style and wedge geometry

Dr Rosalind King, Associate Professor Alan Collins, Dr Chris Morley (PTTET, Thailand), Dr Mark Tingay and Dr Guillaume Backé.

The structures of detachments are remarkable and can promote and accommodate large amounts of deformation in an overlying fold-thrust belt. Deep water fold-thrust belts comprise large structural traps and are currently a major focus for Australian petroleum exploration. The structural style of a fold-thrust belt is controlled by its detachment and new field analogues are being used in this project to demonstrate the fundamental role of detachments.

Field work to investigate the structure of detachments has been undertaken in central Australia and the Flinders Ranges as well as in Norway, New Zealand, Pakistan and Thailand. Microstructural analysis has provided information on strain patterns, deformation mechanisms and deformation temperature.

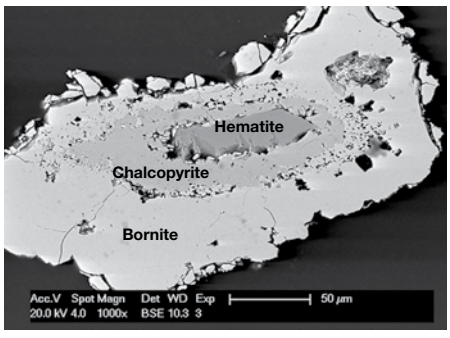
Data collected to date indicate that the general assumption that detachments are homogeneous ductile zones of deformation is incorrect. The zones are often controlled by discreet brittle zones on a much smaller scale than the overlying fold-thrust belt. This result has cast doubt over all assumptions made about detachments to date – all analogue and numerical modelling of these systems may be fundamentally flawed. The geometry of the overlying fold-thrust belt, and therefore the traps (geometry, volume and seal capacity) are controlled by the detachment. By understanding the mechanics of the detachment we can better predict the geometry of structures in the overlying fold-thrust belt and thus, have better constraints on the geometry, volume and seal capacity of the traps.

Experimental studies on hydrothermal reaction processes at the molecular level – the role of mineral replacement reactions in ore formation

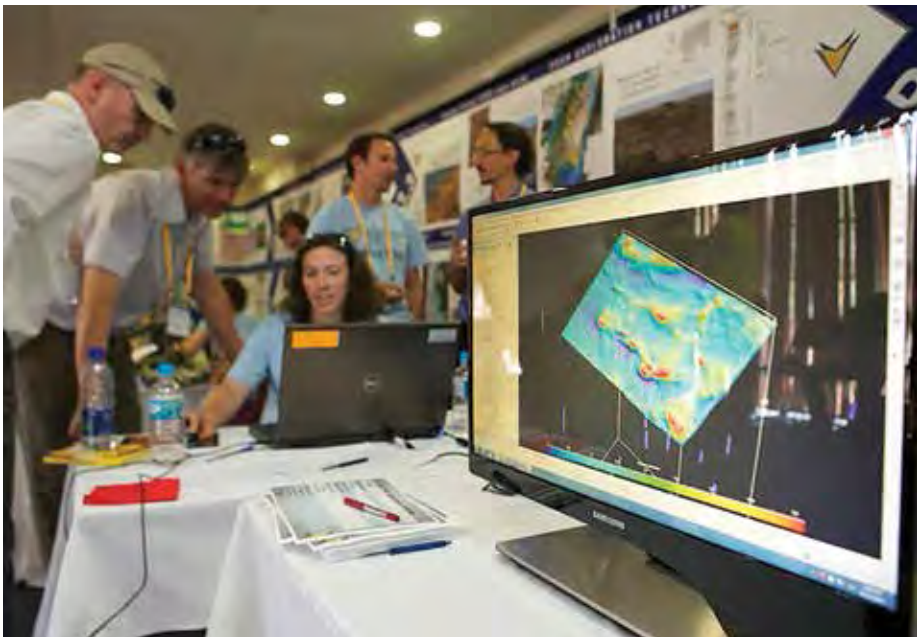
Professor Allan Pring, Dr Joël Brugger, Associate Professor Yung Ngothai, Jing Zhao and Edeltraud MacMillian.

This project has two main research objectives. Firstly, technology is being developed for *in situ* study of mineral dissolution and replacement reactions under hydrothermal conditions by neutron diffraction. Commissioning experiments have been conducted on a flow through hydrothermal cell on the OPAL reactor at Lucas Heights. Researchers followed the kinetics of a simple replacement reaction and showed that the reaction rate initially increases with increasing pressure (up to 250 bars) and then starts to decrease. While it is well established that reaction rates increase with temperature, the effects of pressure on the rate of hydrothermal reactions have not been explored. These pressure effects could trigger ore forming events and also be important in ore processing when high temperature autoclaves are used.

Secondly, two mineralogical systems are under study – the copper-iron sulphide and the gold-silver-pyrite-telluride systems. The formation of chalcopyrite and bornite from hematite and magnetite under hydrothermal conditions similar to those in ore deposits has been examined. Further investigation of replacement of gold-silver tellurides by gold-silver alloys demonstrated solid-state reactions that remove the porosity in the system much more rapidly than recrystallisation reactions. Competition between the two processes results in amazingly complex textures.



Scanning electron micrograph of the experimental replacement of a hematite grain by chalcopyrite and bornite. The chalcopyrite is porous and formed via a coupled dissolution reprecipitation mechanism. In contrast, bornite forms a porosity-free overgrowth.



Deep Exploration Technologies Cooperative Research Centre Program 3: Deep targeting

Dr Steven Hill, Dr Caroline Forbes, Dr Cristiana Ciobanu, Dr Robert Dart, Simon van der Wielen and Professor David Giles.

The Deep Exploration Technologies Cooperative Research Centre (DET CRC) focuses on mineral exploration technologies. Research results directly impact on the hardware and workflows of the mineral exploration business. The objective of DET CRC's Program 3 is to ensure that drill holes for mineral exploration are placed to maximise their success. Researchers are developing new seismic and geochemical methods for exploration that can be integrated into exploration workflows in drilling, logging and sensing.

Program 3 made significant progress during 2012. In collaboration with research partners CSIRO and DMITRE, researchers have provided quantitative geochemical and mineralogical measures of the distal footprints of the economically important class of iron oxide copper gold mineral deposits; of which Olympic Dam is the largest example. This work increases the effective target volume of an exploration drill hole 1000-fold and in combination with integrated drilling, sampling and analytical technology being developed by the DET CRC, provides the underpinnings for a new style of mineral exploration termed 'Deep Regional Prospecting'. The research aims to significantly improve the productivity of mineral exploration in deep cover environments with success ultimately measured in discoveries.

WAVE Consortium: Reservoir architecture and heterogeneity in marginal marine systems

Professor Bruce Ainsworth, Dr Rachel Nanson and Dr Boyan Vakarelov.

Increasing the recovery factor of marginal marine systems can lead to more efficient exploitation of hydrocarbons and extend the life of many oil and gas fields. This research is improving the characterisation of mixed-influence (wave, tidal and fluvial processes) coastal depositional environments and analysing the impact of heterogeneities (shales and cemented zones) on reservoir connectivity and compartmentalisation.

A new process-based architectural classification system has been integrated into the *WAVE* Knowledgebase; a user-friendly, interactive knowledgebase and geospatial database. Predictive aspects of the *WAVE* Knowledgebase can be used in hydrocarbon exploration, development and production to manage and reduce uncertainty in reservoir characteristics. Version 2.0 of the *WAVE* Knowledgebase was released at a workshop in Oslo, Norway in December 2012.

Research outcomes have the potential to improve well placement, reduce well numbers and provide access to bypassed hydrocarbons in pre-existing fields. Benefits will apply to the industry worldwide and across the whole spectrum of marginal marine clastic reservoirs.

This research is supported by Apache, BG, BHP Billiton, BP, Chevron, Nexen, OMV, Shell, Statoil, Todd Energy Ltd and Woodside Energy Ltd.

Investment highlights

IMER and TRaX invest directly in research projects to advance our leadership in strategic research priority areas that are aligned to industry and community needs. Here we highlight some of the research projects supported by IMER and TRaX.

Developments in geochemical and isotopic tools for advanced tectonic analysis and mineral exploration

Dr Justin Payne, Professor Martin Hand, Associate Professor Alan Collins and Associate Professor Nigel Cook.

This project is facilitating geochemical and isotopic research at the University of Adelaide by providing access to Dr Payne's expertise in laser ablation inductively-coupled plasma spectrometry. A large format sample cell for laser ablation has been installed at the University, allowing rapid sample throughput and increased data quality in uranium-lead (U-Pb) geochronology and trace element analysis in geological materials. Workshops on U-Pb geochronology and lutetium-hafnium (Lu-Hf) isotope analysis have been run and methods refined for Lu-Hf isotope analysis in zircon. Techniques for Hf isotope chromatography and solution analysis have also been established.

Continued method development this year will result in the University of Adelaide hosting the only integrated Lu-Hf and samarium-neodymium (Sm-Nd) isochron geochronology facility in Australia. This will assist in constraining the age of mineralising events that lead to the formation of deposits, potentially helping exploration companies develop genetic models for the mineralisation.

Three-dimensional magnetotelluric and controlled-source electromagnetic modelling and inversion in isotropic and anisotropic media with Gaussian Quadrature Grids

Professor Graham Heinson, Dr Bing Zhou and Aixa Rivera-Rios.

This project is investigating three-dimensional (3D) modelling and inversion in isotropic or anisotropic media of plane-wave magnetotelluric (MT) and controlled-source electromagnetic (CSEM) data using new advanced numerical differentiation and quadrature grids. Advanced 3D MT and CSEM inversion schemes will be developed to enhance electromagnetic exploration for imaging various 3D subsurface targets.

Three new 3D computer modelling programs have been coded and numerical experiments have tested the codes in a range of aspects. Calibrations and optimisations of the three programs are continuing to enable adaptation to practical applications such as sub-surface monitoring of fluid movement in extraction of unconventional energy resources, including geothermal energy and shale gas.

This project is supported by the Adelaide Research and Innovation Commercialisation Accelerator Scheme.

Iron isotope variation in subduction magmas: links to fluid flux and oxidation of the mantle wedge?

Professor John Foden and Chris Wawryk.

Using iron isotopes to decipher magmas, fluids and modes of ore deposition as well as ore fluid transport, is an exciting and innovative concept. There is clear potential for developing a geochemical tool that could inform mineral exploration of hydrothermal ore deposits. This research aims to develop models that describe the systematic fractionation of the iron isotopes due to variation in the oxidation state of a number of magma-fluid systems.

New iron isotope data has been determined from over 80 basaltic samples from the global subduction zone network to investigate systematic variation in iron isotope compositions. The data reflect the differences in the oxidation state of the different arcs' mantle wedges. A positive correlation with lead and strontium isotopes is interpreted as a measure of slab input to the wedge. The positive correlation with slab age indicates that cold, old slab subduction delivers more oxidation capacity to the wedge.

Iron isotopes are also being analysed from a range of hydrothermal ore systems to determine if ore minerals precipitated from magmatic-hydrothermal solutions reflect the isotopic composition of the parent magma. The results confirm that pyrite has systematically higher delta^{57}iron than coexisting chalcopyrite. Iron isotopic fractionation between these coexisting phases may represent a useful geothermometer.

The origin of Australian Gondwana – using isotopic proxies for subduction to reconstruct ancient ocean

Associate Professor Alan Collins.

For almost 90 per cent of its history, reconstructions of the Earth's geography are based on continental crust alone, as oceanic crust did not exist. Oceanic crust proxies are the products of ancient convergent volcanic arcs. This project combines field mapping of arcs with isotopic data to reveal the origins of Australian Gondwana between 850-500 million years ago. This Neoproterozoic period is economically significant for Australian and global petroleum resources. It is also an ecologically and environmentally significant period during which the Earth experienced the greatest known expansion in multi-cellular life and the greatest non-anthropogenic climate fluctuations.

Samples have been collected from arc systems preserved in the East African Orogeny of Madagascar and Ethiopia and will be dated using uranium-lead (U-Pb) isotopes. Age and geochemical data will be used to determine the duration and nature of the subduction zones, which will help to locate ocean plates from the period. Future field work will be undertaken in Saudi Arabia, India and eastern Africa.

Honours students Morgan Blades and Xiaochen Xu on fieldwork in western Ethiopia.

Research highlight

Microscopic solutions to major challenges – is biotechnology the future for mineral exploration and processing?

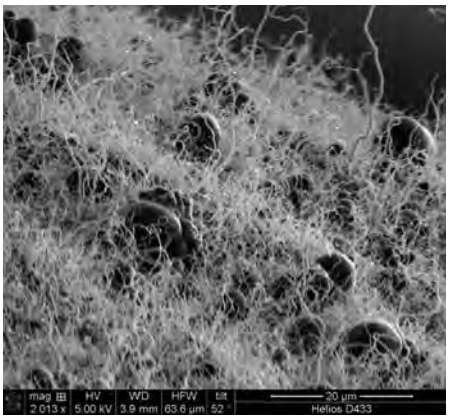
Finding novel approaches to mineral exploration and processing is a major global challenge for the mining industry. Microbial-based exploration and processing is one of the industry's fastest moving research areas and an IMER team is leading the charge.

The researchers are taking an innovative approach, using nature as inspiration to develop new technologies for mineral exploration and processing.

Biological agents are currently used in the mining industry for bioleaching and bioremediation but there are a number of other potential applications. The research team has been sampling gold grains in natural systems to investigate the relationships between metals and microbes.

The research has shown that geomorphological, geological and geochemical factors such as the landform, underlying lithology and presence of buried mineral deposits are fundamental determinants of microbial communities in naturally metal-rich soils. The geochemical properties of a soil determine the microbial communities that are able to cope with the elevated concentrations of toxic metals, like gold, in the soil.

Using a combination of physical and molecular techniques, the team found that certain bacteria, like *Cupriavidus metallidurans*, live only in the biofilms on the gold. The researchers discovered that by culturing these bacteria and feeding them gold in solution, an active genetic response was triggered which led to the formation of a gold nugget. Having identified a set of genes that are gold-specific, the team is now at the proof-of-concept stage, using this genetic response to develop a prototype to measure gold down to the parts per billion level. Biosensors, similar to those that monitor blood glucose levels or detect illicit drugs, are one potential application of the technology.



Scanning electron micrograph of a microbial biofilm on the surface of a gold nugget.

The aim is to produce a relatively cheap, robust and highly selective biosensor for mineral exploration that could be used anywhere and provide immediate results.

The researchers are also investigating potential applications for microbes in gold processing. Traditionally, gold processing has relied on cyanide leaching and/or roasting which is becoming less viable due to increasing technical and legislative concerns and the need to process higher volumes of lower grade ore. Microbes can directly attach to the surface of gold, form a biofilm and begin producing cyanide which dissolves the gold into solution. Bioreactors could be used on site to produce cyanide for use in place of synthetic cyanide. Cyanide-producing microbes could also be coupled with existing technologies like biooxidation to assist in the leaching of gold.

Microbes have been perfecting their biochemical pathways for more than 3.5 billion years and researchers are just starting to realise their potential. With so many promising applications, these microscopic organisms may play a major role in solving some of the mining industry's biggest challenges.

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Zammit CM[ab], Cook N[a], Brugger J[ac], Ciobanu CL[a], Reith F[ab] (2012). *The future of biotechnology for gold exploration and processing.* Minerals Engineering 32: 45–53.

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South Australian Centre for Geothermal Energy Research

The vision of the South Australian Centre for Geothermal Energy Research (SACGER) is for a future in which the world's energy resources are managed efficiently and sustainably for the benefit of society, industry and the environment.

Mission

The mission of SACGER is to establish a world-class centre for practical, high-priority geothermal energy research with a focus on enhanced (engineered) geothermal systems and geothermal power systems that will result in widespread benefits at a state, national and international level.

Objectives

- To conduct research into enhanced geothermal systems and related power systems that deliver economically and environmentally-viable geothermal energy.
- To keep South Australia at the forefront of research and development in geothermal energy which will result in widespread benefits for industry, the community and the environment.

Director's report

Professor Martin Hand

Geothermal technology has the potential to make a global impact in terms of meeting rising energy demands. Australia has significant potential geothermal resources and opportunity to develop the knowledge and technology necessary to harness these resources.

The major technological advancements needed by industry will only arise through targeted research and strong collaboration between researchers and industry.

At the South Australian Centre for Geothermal Energy Research (SACGER) we combine interdisciplinary research excellence with transferable technologies and skills. We are constantly working to align our core expertise in enhanced (engineered) geothermal systems with industry's research needs, to improve the economic viability of geothermal energy technology. SACGER uses seed funding from the South Australian Government to invest in research projects that advance our leadership in geothermal energy research.

SACGER enjoyed significant funding successes in 2012, receiving a $1.25 million grant from the Emerging Renewables Program of the Australian Renewable Energy Agency (ARENA). Predicting permeability and well productivity ahead of drilling is the most significant technical challenge confronting the Australian geothermal industry. The grant will fund a two-year project to investigate how the industry can reliably produce economic flow rates from geothermal wells. Causes of low flow rates will be determined, better geothermal targets identified and remediation and mitigation strategies developed for future geothermal drilling. The research will have significant implications for the geothermal potential of sedimentary basins in Australia and the development of a 'near-zero' emissions industry. SACGER researchers will work in collaboration with CSIRO, Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) and geothermal companies Panax Geothermal Ltd and Geodynamics Ltd.

We are also part of a $5 million national geothermal exploration program led by National ICT Australia (NICTA) which is also managed within the Emerging Renewables Program. The research is seeking improved, automated ways to define geothermal targets using machine-learning techniques and data analytics. Industry and government partners in the project include Geodynamics Ltd, Petratherm Ltd, Geoscience Australia and DMITRE.

SACGER was also awarded $580,000 of funding from AuScope's Australian Geophysical Observing System (AGOS) for two new research projects: 'Determining the resource and energy potential of the northern Gawler Craton, Officer and Arckaringa basins, Musgrave Domain and Torrens Hinge Zone, South Australia', in collaboration with DMITRE and 'Calibrating electromagnetic geophysics for its application to mapping stress orientations, temperature and permeability.'

Identifying and fostering national and international collaborations and opportunities has continued to be a focus for SACGER. Professor Stephen Grano, Executive Director of IMER and I travelled to Chile this year to promote the potential for geothermal energy in mining. The trip generated significant interest amongst Chilean organisations in investing in geothermal technology. We also held a series of workshops to share ideas, develop strategic partnerships and encourage collaboration between researchers, government and industry.

At SACGER we are exploring the potential for connecting geothermal and renewable energy technologies as well as avenues to resolve shared uncertainties with the oil and gas industries. Here, there are common research questions surrounding the permeability of fluids and hydraulic fracturing in geothermal and unconventional gas resources – an area in which we have significant technical capabilities.

Advisory Board

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Home Schools

Australian School of Petroleum
School of Chemical Engineering
School of Civil, Environmental and Mining Engineering
School of Computer Science
School of Earth and Environmental Sciences
School of Mathematical Sciences
South Australian Museum

SACGER research areas

- **Electrical imaging of crustal fluids:** the development of new methods to image the distribution of subsurface fluids to derive information about permeability, fracture orientation and stress and to image fluid movement during fracture stimulation and development of geothermal reservoirs.
- **Regional geothermal assessments:** the improvement of the thermal characterisation of the South Australian crust and beyond via a program of heat flow and thermal conductivity data acquisition to identify new areas of geothermal prospectivity. This includes the potential for direct use geothermal inputs into industrial processes such as mineral processing.
- **Fracture mapping using seismic tools and well logs:** use of 3D seismic data to image fracture systems in Australia's geothermally prospective sedimentary basins, along with production data from existing oil and gas wells, to investigate relationships between fracture density, orientation and permeability.
- **Reservoir fracture and flow modelling:** development of reservoir fracture models for enhanced geothermal systems and linking those to fluid flow models to create an improved understanding of fluid pathways and heat transfer in fractured rock systems.
- **Fluid rock interactions:** focus on the geochemistry of geothermal fluids using our flow-through and batch hydrothermal reactors to evaluate the dissolution of rock minerals and resultant precipitation and scaling within the reservoir and above-ground infrastructure.
- **Crustal stress:** characterising and modelling contemporary crustal stresses in a number of regions around the world including areas of known geothermal potential such as the Cooper Basin. This leads to a better understanding of the stress and fluid-pressure state in unconventional geothermal systems.
- **Reservoir quality and productivity:** development of models that allow understanding of reservoir quality, particularly in sedimentary-hosted

systems. This work includes thermodynamic modelling of fines migration to provide a framework for optimal well design and flow testing. In understanding the thermal and chemical controls on diagenetic processes and their implications for permeability we are able to predict where maximum matrix permeabilities may occur.

- **Thermodynamic modelling of geothermal power plants:** examination of how the efficiency of geothermal power plants is influenced by the complex set of engineered and natural variables that apply to geothermal systems, with the goal of understanding optimal performance criteria over time.

Project highlights

Yulong Yang, Permeability Laboratory

Reservoir quality in sedimentary geothermal resources

Professor Martin Hand, Professor Pavel Bedrikovetski and Professor Allan Pring.

SACGER is leading an Australia-wide geothermal collaboration to investigate reservoir quality in sedimentary geothermal resources. The project will improve our understanding of how rocks change when they are deeply buried and heated as well as when they are drilled to extract hot water. Techniques to probe deep underground and mimic conditions in the laboratory will be identified and previous studies reviewed.

New laboratory equipment, including flow-through cells, has been purchased as part of this project. This will allow researchers to determine the effects of temperature and chemistry on reservoir quality and to measure the effects of reservoir production on sedimentary aquifer permeability.

This research will help geothermal energy explorers to target drilling more effectively and improve their understanding of how reservoir quality is affected by ground fluid production.

Calibrating electromagnetic geophysics for application to mapping stress orientations, temperature and permeability

Dr Stephan Thiel, Professor Graham Heinson, Jared Peacock, Dr Lars Krieger and Dr Simon Carter.

The relationship between the direction of electrical current flow in the crust and regional stresses has been investigated to determine if electrical resistivity of upper crustal rocks can be used to ascertain temperature, porosity and permeability.

A magnetotelluric (MT) survey of some 80 MT stations was conducted at the Geodynamics Ltd Habanero drill site in the central Cooper Basin and delineated broad resistivity structures and geological strata. This survey was followed by a comprehensive time-lapse MT survey which monitored geothermal reservoir conditions prior to flow testing, during the twelve days of injection and post-injection. This survey data will be integrated with existing microseismic data to devise a fluid-imaging workflow applicable to reservoir development.

Goran Boren, Magnetotelluric field survey

Two other surveys are scheduled for 2013 – a high-density broadband survey of approximately 40 stations at Habanero, followed by a large-scale, long-period two-dimensional (2D) profile survey to understand the lithospheric framework of the basin.

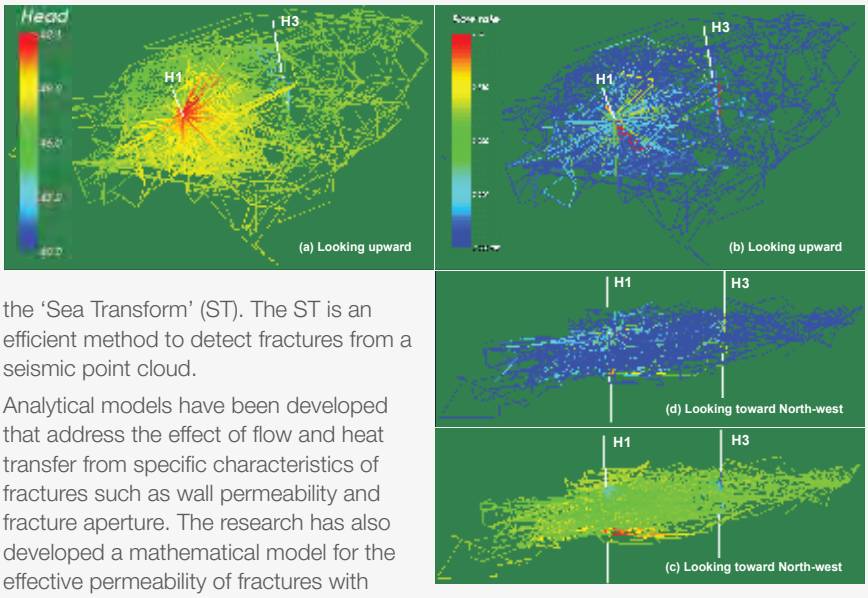
Prediction of fracture distribution and fracture permeability in stimulated geothermal systems

Professor Peter Dowd, Associate Professor Chaoshui Xu and Dr Rosemary Mohais.

This project aims to understand fluid flow and heat transfer within fractured geothermal reservoir systems. A model has been created using seismic events recorded during the fracture stimulation process using a Bayesian framework in the form of Markov Chain Monte Carlo (MCMC) simulation. This effectively produces a fracture model conditioned by the seismic point cloud. The method is being applied to Geodynamics Ltd's Habanero reservoir in the Cooper Basin of South Australia.

Research on stochastic optimisation of fracture network modelling conditional on seismic has resulted in the development of a novel spatial clustering method, named the 'Sea Transform' (ST). The ST is an efficient method to detect fractures from a seismic point cloud.

Analytical models have been developed that address the effect of flow and heat transfer from specific characteristics of fractures such as wall permeability and fracture aperture. The research has also developed a mathematical model for the effective permeability of fractures with permeable walls.



Flow simulation of Habanero reservoir using a pipe model derived from the fracture model.

Magnetotelluric instrumentation in the field

Determining the resource and energy potential of the northern Gawler Craton, Officer and Arckaringa Basins, Musgrave Domain and Torrens Hinge Zone, South Australia

Professor Martin Hand, Dr Betina Bendall (DMITRE), Jeremy Schulz and Cameron Bowker.

This project is increasing the understanding of the South Australian shallow crust. Multiple datasets are being compiled from strategic wells across the northern and eastern Gawler Craton, Officer and Arckaringa Basins, Musgrave Domain and Torrens Hinge Zone – regions of relative data paucity.

The datasets acquired under the Plan for Accelerating Exploration (PACE) program, generally from newly drilled wells, are being used to materially constrain *in situ* stress, geophysical inversions, geological models and regional interpretation. This data will also be made publically available for further research.

Data fusion and machine learning for geothermal target exploration and characterisation

Professor Graham Heinson, Dr Stephan Thiel, Jared Peacock, Professor Martin Hand, Dr Lars Krieger and Dr Simon Carter.

The geothermal industry needs to draw more information from existing datasets to better define potential targets and reduce the risks associated with geothermal exploration.

Researchers from SACGER and NICTA are developing and applying modern statistical machine learning and data fusion methods to improve the process and characterisation of geothermal targets. Characterisation is vital to understanding porosity, fracture susceptibility and fault geometry, which determine the viability of an enhanced geothermal system.

A toolbox is being developed to process magnetotellurics (MT) time series and generate and manage Electronic Data Interchange (EDI) files; the main data exchange format for pre-processed MT data. A feasibility study is also underway using test examples of 2D models to assess the computing power required if existing algorithms are used prior to parallelisation.

In addition, a geophysical inversion is being undertaken through a Bayesian probabilistic approach to develop a scheme for magnetotelluric data inversion. A Bayesian one-dimensional anisotropic inversion code has been written and is currently undergoing testing.

Optimisation of geothermal systems

Professor Nigel Bean and Jo Varney.

Power plants associated with enhanced geothermal systems (EGS) in Australia may operate in remote, outback conditions and, due to the lack of water, use air-cooling. The research undertaken in this project is using mathematical modelling to examine the impact of ambient air temperature on the power output of air-cooled power plants and the performance of EGS and hot sedimentary aquifer plays in Australia. This work provides insights into optimal design for air-cooled Rankine cycles.

The research is also investigating the efficiencies that can be gained by integrating geothermal preheating of feedwater into traditional steam power plants that are predominantly coal fired. The results show that geothermal preheating can lead to extra power production from the traditional steam plant.

Research highlight

Pioneering project demonstrates potential for magnetotelluric monitoring in unconventional energy resources

In enhanced geothermal systems (EGS) fluids are pumped into thermally enhanced lithology where they absorb heat. These hot fluids are then used directly as an energy source or converted to electricity.

As with all renewable energy technologies, novel approaches are needed to help facilitate the efficiency of EGS. The ability to track and characterise fluid movement in the subsurface is necessary for developing EGS into a competitive industry. There is also potential for much broader applications of fluid tracking in other systems where fluid injections are used, such as unconventional natural gas systems.

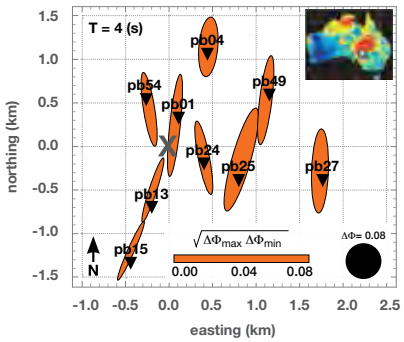
Currently, fluid movement after injection is tracked using microseismic surveys, which provide information about where fractures open but, not fracture connectivity or fluid inclusion. Electromagnetic methods like magnetotellurics (MT) have typically been used to characterise and locate potential geothermal targets and to search for the elusive electromagnetic precursors to earthquakes. The advantage of using MT to monitor geothermal systems is its sensitivity to conductivity contrasts at depth and ability to detect hot, saline, electrically-conductive fluids in resistive host rock. However, MT only measures bulk volumetric conductivity contrasts that are assumed to be fluid-filled fracture networks – not individual fractures.

In July 2011, 3.1 million litres of saline water were injected into a 3.6 kilometre deep borehole at the Paralana 2 injection well, South Australia, owned by Petratherm Ltd. The injection was monitored continuously using both a microseismic array (part of a collaborative research project) and MT methods. Two days prior to the injection, researchers placed 11 broadband 4-component AuScope MT instruments around the borehole and a solar powered AuScope instrument was set up 60 kilometres south of Paralana as a remote reference. The MT instrumentation recorded for a total of eight days – two days pre-injection, four days during injection and two days post-injection.

Data analysis demonstrated that changes in the MT parameters were coherent in space and time and above the measurement error. There was a clear separation between MT responses pre-injection, during injection and post-injection; expected variations in the impedance phase were observed that were above the robust baseline researchers had estimated using an error floor.

Phase tensor residuals were also mapped to obtain information on geoelectric strike transformation during injection and gradients in resistivity structure were mapped to get an indication of reservoir boundaries. This data suggested that the fluids migrated in a north-easterly direction from the injection well, correlating with the concurrent microseismic survey.

The research demonstrated that MT could be successfully used to monitor fluid injections for the first stage of an enhanced geothermal system, where changes in the MT response are assumed to be a result of electrically conductive fluid injection. The technology is also applicable for monitoring fluid injections in other systems, such as shale and coal seam gas systems. As MT and microseismic techniques provide complementary information, they can be used simultaneously for improved monitoring of geothermal and unconventional systems.



Map showing location of Paralana 2 injection well (X) and magnetotelluric stations (triangles) during the injection experiment. Ellipses represent phase tensor residuals. Top right is a temperature map of Australia from Geoscience Australia at 5 km depth – red represents 285°C; grey star is Paralana.

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[a] SACGER, University of Adelaide, Adelaide, South Australia, Australia.
[b] Petratherm Ltd., Adelaide, South Australia, Australia.
[c] TRaX, University of Adelaide, Adelaide, South Australia, Australia.

Program Report

Resource Engineering Program

We have continued to focus on delivering world-class research outcomes.

Program Leader's report

Associate Professor Chaoshui Xu

The Resource Engineering Program comprises the Mining/Geotechnical Engineering and Petroleum Engineering research clusters.

The Mining and Geotechnical Engineering research group brings together capabilities in geostatistics, operations research, rock mechanics and geotechnical engineering with a focus on improving the efficiency and safety of mining operations, both below and above ground.

Research in petroleum engineering is focused on recovery of unconventional resources; mathematical modelling, laboratory and field studies on productivity enhancement and formation damage; reservoir characterisation and simulation; and decision-making under uncertainty.

In 2012 we have continued to focus on delivering world-class research outcomes that provide pathways to low-cost, low-impact and high-yield mining, petroleum and energy resource exploration and extraction. Our strong research capabilities were validated by the recent Excellence in Research for Australia 2012 national report in which the University of Adelaide achieved a ranking of 'above world class' for resources engineering and extractive metallurgy.

Our expertise has produced many innovative research outcomes such as new low-cost fracture detection sensor technology for use in large-scale mines and civil engineering structures which is currently being patented by the University of Adelaide.

Local and international collaborations with researchers and industry remain a key focus. Professor Hongjiang Wang from the University of Science and Technology Beijing spent six months in Adelaide working in our mining engineering research group. We anticipate that this is the start of a long term and mutually beneficial relationship between IMER and the University of Science and Technology Beijing. Together with AusAid, Coffey International and World Wide Project Management Services, we hosted a four-week visit by a delegation of 12 Iraqi scientists from the minerals industry. We also hosted Professor Qi Li from the Institute of Rock and Soil Mechanics (IRSM), The Chinese Academy of Sciences, China.

Another highlight in 2012 was Professor Steve Begg, Head of the Australian School of Petroleum, receiving the 2012 Society of Petroleum Engineers (SPE) Southern Asia Pacific Regional Technical Award. This award recognises Professor Begg's exceptional contribution to the Society and the Management and Information discipline.

Home Schools

Australian School of Petroleum

School of Chemical Engineering

School of Civil, Environmental and Mining Engineering

Alireza Keshavarz, Permeability Laboratory

Project highlights

Drilling and maintaining stable boreholes in poorly cemented formations

Dr Noune Melkoumian, Associate Professor Chaoshui Xu and Saeed Hashemi.

Drilling and maintaining stable boreholes in poorly cemented formations is a major problem for mineral exploration worldwide. Understanding the behaviour of sands around a cylindrical borehole under various ground conditions is key to designing effective, economical and environmentally-friendly borehole supports.

In a project conducted for the Deep Exploration Technologies CRC, researchers are conducting comprehensive numerical and experimental studies on the effects of sand particle bonding on sand movement, borehole deformation and collapse. In particular, the discrete element method is being used to model the bonding between sand particles, the movement of individual sand grains and the mechanical behaviour of poorly cemented formations under *in situ* stress and ground conditions. An extensive set of experiments are currently being carried out which will provide a better understanding of the issues involved and provide data for model validation.

Impact of rolling dynamic compaction

Professor Mark Jaksa and Professor David Airey.

Ground improvement is an essential part of civil construction. Rolling dynamic compaction (RDC) is a relatively new ground improvement technique using a non-circular 'roller'. RDC can compact the ground to greater depths than traditional dynamic compaction, with less energy and at greater speeds. Also, RDC does not rely on large ground vibrations that can restrict use on small sites or adjacent to infrastructure. However, little data is available for predicting outcomes from RDC under varying soil types and ground conditions.

In partnership with Broons Pty Ltd, researchers are conducting laboratory and field tests on a variety of soil types to determine the depth and lateral extent of ground improvement from RDC. The effect of compactor speed, energy and number of passes is also being investigated and numerical models developed to predict ground response. Procedures to reliably quantify the densification of the ground are also being developed.

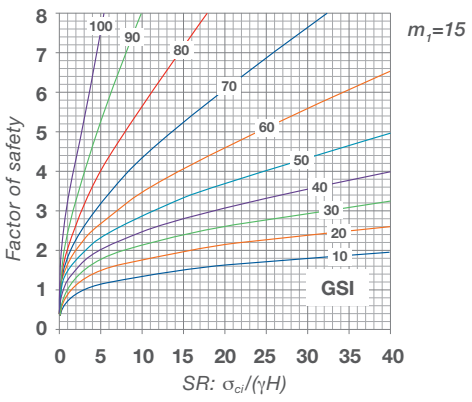
This project will provide a better understanding of the mechanics and advantages of RDC, removing the need for costly field trials and helping this new and more efficient technology gain wider acceptance by the geotechnical engineering industry.

Analytical and numerical analyses for rock slope stability using the generalized Hoek-Brown criterion

Jiayi Shen, Dr Murat Karakus, Associate Professor Chaoshui Xu and Associate Professor Rafael Jimenez.

Rock slope design is critical to slope stability at every stage of open pit mining. Stability is predominantly controlled by the strength and deformation of the rock masses, which characteristically consist of intact rock materials and discontinuities. Due to stress relaxation after the pit excavation, rocks can deform, sliding can occur along discontinuity surfaces and new fractures can form and propagate. These all play a part in the stability of the slope.

In conventional approaches for assessing slope stability, such as the Limit Equilibrium Method (LEM) and Shear Strength Reduction (SSR) method, rock mass strength is usually expressed by the linear Mohr-Coulomb (MC) criterion. However, in reality, the relationship between rock mass strength and stress is non-linear. This research focuses on investigating the application of non-linear Hoek-Brown (HB) criterion on slope stability assessment. A comprehensive set of graphs and relationships are being produced in this research to provide a better set of tools for slope design and slope stability assessment.



Stability chart for rock slope (β=45°, mi=15)

Investment highlights

IMER invests in research projects to advance our leadership in strategic research priority areas aligned to industry and community needs. Here we highlight some of the research projects supported by IMER.

Variations in wellbore productivity from unconventional reservoirs – the GeoFrac Consortium project

Dr Dennis Cooke, Dr Hani Khair, Nicole Ditty, Ehtesham Karatela, Brendon Mitchell, Kunakorn Pokali, Mojtaba Rajabi, Mehrdad Rezazadeh and Stephanie Tyiasning.

Well gas production rates from unconventional reservoirs like shale and coal seam gas reservoirs, are highly variable from well to well and also with time. Increasing the economic viability of these resources relies on predicting and drilling more profitable well locations. The GeoFrac Consortium project is testing the hypothesis that stress and natural fractures play an important role in the productivity of unconventional gas reservoirs.

The GeoFrac research team is harnessing the University of Adelaide's expertise in geomechanics and stress modelling to examine production variability. Computer modelling and simulation are being used to compare and calibrate the results of geomechanical model predictions of production results from Australian basins that are currently undergoing initial phases of evaluation and development. Information contained in South Australia's world-class database of fracture stimulation treatments, well production rates and 3D seismic data, is being used to inform the geomechanical models and hypotheses.

Current postdoctoral and student research projects are examining how stress, lithology and boundary condition control frac plane rotation as well as a full field simulation of stress at the Moomba-Big Lake field.

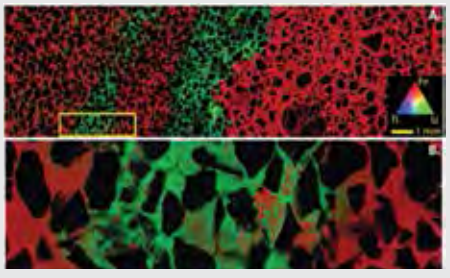
The GeoFrac Consortium is sponsored by Beach Energy Ltd, DMITRE, Halliburton Energy Services, JRS, QGC Pty Ltd, BG Group and Santos Ltd.

Uranium transport and deposition in iron oxide copper gold deposits

Associate Professor Yung Ngothai, Kan Li, Dr Joël Brugger, Professor Allan Pring, Barbara Etschmann, Associate Professor Brian O'Neill and Tony Hooker (Environment Protection Agency).

In southern Australia, iron oxide copper gold (IOCG) deposits often contain economic and sub-economic quantities of uranium. Studies of hydrothermal reactions on uranium-bearing material were conducted in three systems: uranium-titanium-oxygen, uranium-silicon-oxygen and uranium-iron-copper-sulphur. Research focused particularly on uranium during sulphidation reactions in the uranium-iron-copper-sulphur system. By applying the principles of interface-couple dissolution-reprecipitation reactions, IMER researchers reproduced IOCG-style mineral assemblages experimentally through the reaction of a copper-rich fluid with hematite.

Synchrotron experiments were used to characterise the nature of the uranium in ores from the Beverley and Olympic Dam deposits. Uranium oxidation states were homogeneous in single samples, but uranium from sediment-hosted ores tended to be more oxidised than in IOCG-style ores. Further synchrotron experiments will help to improve our understanding of how reactions at interfaces, with conditions far from equilibrium, can control metal endowment. Experiments on the uranium-titanium-oxygen and uranium-silicon-oxygen systems will help us to understand the distribution of these minerals in ore deposits and inform possible pathways for dissolution and geometallurgy.



Synchrotron X-ray fluorescence map of the distribution of uranium, iron and titanium in a sandstone-hosted sedimentary ore from the Beverley mine. Full image (top) and uranium rich band (bottom).

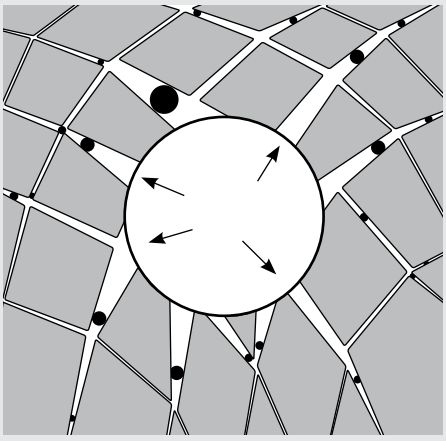
Increasing productivity of coal bed methane wells with graded proppant injection

Professor Pavel Bedrikovetski, Professor Anthony Roberts, Dr Andrei Kotousov and Associate Professor Philip Pendleton (University of South Australia).

To achieve economical production rates, naturally fractured reservoirs such as coal bed methane (CBM) wells often require some form of stimulation. Proppants are solid materials, like sand, that are added to gels or foams and injected into wells to prevent closure of dilated natural fractures and increase reservoir permeability.

This research is investigating graded proppant injection in CBM wells, in which small particles are injected into a fracture first, followed by larger particles. Extensive laboratory and modelling studies are underway and a simple mathematical model has been developed which indicates that fluid injection rate has the biggest influence on the proppant injection schedule and well productivity. A higher injection rate leads to greater opening of cleats, deeper percolation of the smallest particles, shorter injection times and greater increase in well productivity.

Future laboratory and modelling work will develop a more advanced model for particle transport in fractured media, helping to optimise the use of this technology and enhance well productivity. Practical use of the method will also be demonstrated in an Australian CBM well.



Plugging of the natural fracture system by graded proppant particles.

Program Report

Environmental Impact of Mineral and Energy Resources Program

Program Leader's report

Associate Professor José Facelli

Much of Australia's energy and mining extraction activities are based in the vast arid lands that cover the interior of the continent.

Mining sites must be restored to a sustainable ecosystem post operation and this process is often hindered by poor understanding of the functional properties of the ecosystems, particularly the underground components. An increased understanding of the natural ecology and biodiversity of affected areas, as well as landscape restoration techniques, is essential to develop and implement effective rehabilitation and restoration strategies.

The Environmental Impact of Mineral and Energy Resources Program provides innovative approaches for assessment, management and mitigation of the environmental aspects of the mineral and energy resource industries. In the last year we have seen many exciting examples of innovative and world-first techniques used by IMER researchers to uncover essential information about the ecosystems affected by mining and energy activities.

Our strong research capabilities in the field of environmental science were confirmed in the Excellence in Research for Australia 2012 national report. The University of Adelaide was ranked 'above world standard' for environmental science and management; soil sciences; ecology; and plant biology. Along with our strong relationships with industry, these results are further validation of our ability to deliver practical and sustainable outcomes for industry and the environment.

Our affiliation with the Environment Institute assists in strengthening our research capability and collaborations and will mean increased benefits for industry and the community. Increasing demand from all sectors for sound environmental outcomes in the mining and energy industries continues to drive innovation and IMER researchers are integral and contributors to this field.

Home School

School of Earth and Environmental Sciences

> This project will map root distribution, salinity and soil water dynamics of key plant species at the Jacinth-Ambrosia mine site.

Project highlights

Installation of a stem psychrometer.

Root distribution and salinity and soil water dynamics in a chenopod shrubland: implications for restoration ecology

Associate Professor José Facelli, Professor David Chittleborough, Associate Professor Jenny Watling, Dr Emma Steggles, Dr Leanne Pound, Dr Laurence Clarke and Keli Payne.

A research partnership between Iluka Resources Ltd and researchers within the University of Adelaide Rehabilitation Project has investigated a range of methods and technology to lay the ground work for a large ARC Linkage Project. This project will map the root distribution, salinity and soil water dynamics of key plant species at the Jacinth-Ambrosia mine site.

Using modified digging patterns, researchers sampled roots, soil and water to a degree unequalled in any previous research worldwide. New approaches to accessing root material at depth were developed in conjunction with the use of air spading and progressive relocation of roots. DNA-based techniques were the most cost-effective method for identifying roots at depth. Preliminary results from stable water isotope testing will inform future sampling protocols and Mini-PAM technology used for analysing photosynthesis showed promise for monitoring plant health.

This research will help to identify species that rely primarily on surface or shallow stores of water as well as those that are more tolerant to hypersaline tailings buried within reconstructed soil profiles, enabling more effective restoration of sites. Identifying the requirements of the various species that need to be reintroduced in the reconstructed ecosystem will allow companies to design optimum strategies for reconstructing soil profiles after open mine operations are completed.

Water isotope signatures for the Jacinth-Ambrosia mine site

Dr Emma Steggles, Dr José Facelli, Samantha Doudle, Associate Professor Jennifer Watling, Professor David Chittleborough and Dr Kate Holland.

A pilot study at Iluka Resources Ltd's Jacinth-Ambrosia mine site investigated whether stable water isotope signatures and plant-soil water potentials could be used to determine the water sources of western myall (*Acacia papyrocarpa*). Oxygen-18 isotopes were distinctly different between different groundwater sources as well as between surface and soil water, validating the use of this isotope for distinguishing patterns of water use. Use of groundwater and hypersaline water by the trees could not be conclusively confirmed but some twig and taproot signatures and IsoSource™ results provided supporting evidence. Spatial variability studies indicated that trees accessed water from a range of sources emphasising the importance of sampling xylem tissue from twigs, taproots and as many lateral roots as possible. Soil samples will be collected to a greater depth using a sonic drill rig in future studies and Bayesian models will be considered for analysing isotope data.

Socio-Economic Impacts of Mineral and Energy Resources Program

Program Leader's report

Associate Professor John Spoehr

Understanding the socio-economic dimensions and impacts of mineral and energy resource development is vital to make sure that major projects benefit communities in the area and contribute to overall national development objectives.

New technologies can offer considerable productivity and economic gains. Application of integrated design principles and interdisciplinary research and development is key to ensuring maximum socio-economic benefit. The focus of the socio-economic program during 2012 has been to develop significant new capability in these areas.

Key initiatives in 2012 included investigating the socio-economic impacts of wind farm projects to formulate an integrated approach to wind farm impact assessment. An interdisciplinary team was formed to develop methods that can identify the full range of landowner, community and industry perspectives and how these perspectives change over time and in differing circumstances.

IMER also invested in two new interdisciplinary research initiatives linking IMER resources and the social sciences. One initiative led by Professor Lisa Hill will examine supply chains within the mining industry to help mining companies improve their human rights due diligence and capacity to manage the impacts of mining. Another initiative led by Associate Professor Andrew Rosser will deliver new insight into dynamics shaping the Extractive Industries Transparency Initiative (EITI) to improve transparency and accountability in extractive industries.

A major achievement in 2012 has been our involvement with the Stretton Centre. We have been integral to the establishment of this Centre, which will help to capture the benefits of mining and clean technology sector growth. With the opportunities it will create for students, it will help us to become one of Australia's leading research groups in workforce, industry and urban development research.

Key areas of focus for the Socio-Economic Impact of Mineral and Energy Resources Program include:

- understanding the socio-economic and workforce impacts of mining and energy developments and developing models for assessing the socio-economic impacts of renewable energy projects
- workplace innovation and performance in the minerals and energy industries
- governance and transparency in the minerals and energy industries.

Home Schools

Australian Workplace Innovation and Social Research Centre

Business School

School of Economics

School of History and Politics

> “The EITI ... aims to strengthen governance by improving transparency and accountability in the extractive industries sector.”

Project highlight

The Stretton Centre

The Australian Workplace Innovation and Social Research Centre (WISeR), in partnership with the City of Playford, was awarded an $11.3 million grant to establish the Stretton Centre in the new Playford Alive development, South Australia. The Centre will be a focal point for interdisciplinary problem solving and act as a catalyst for innovative projects seeking to better link industry, workforce and urban development objectives. It will play a major role in informing policy and planning at a local, state and national level and help South Australia take full advantage of growth in the mining and clean technology sectors.

Many opportunities will be created for interns and postgraduate students to engage in workforce, industry and urban development research designed to improve quality of life and opportunities in northern Adelaide.

WISeR researchers commenced work on the project in 2012 and construction of the Centre is expected to be completed by June 2015.

Investment highlight

IMER invests in research projects to advance our leadership in strategic research priority areas aligned to industry and community needs. Here we highlight one of the research projects supported by IMER.

Project examines politics of Extractive Industries Transparency Initiative

Associate Professor Andrew Rosser received funding from the Development Leadership Program (DLP), an AusAID-funded program that supports political economy analysis of development issues.

The funding initiated a new research project on the politics of the Extractive Industries Transparency Initiative (EITI). The EITI is a major global initiative supported by western governments and major international organisations, which aims to strengthen governance by improving transparency and accountability in the extractive industries sector.

The project's objective is to explore the way in which political factors have shaped the adoption and implementation of the EITI in several developing countries at different stages in the EITI process including Timor Leste (EITI compliant), Indonesia (EITI candidate country) and Papua New Guinea (not yet a signatory).

A workshop was held in Jakarta that brought together political economy researchers from Australian and international universities, DLP representatives and donor officials. The workshop helped the researchers to better understand the DLP's research program and analytical framework and revise a proposal for submission to the DLP and AusAID.

Key major projects active in 2012

IMER researchers gained support from prominent global companies, government and research partners in a large number of projects during 2012.

Here are details of key projects either initiated in 2012 or continuing as active projects through the year.

Institute for Mineral and Energy Resources

Establishing research and technology collaborations between Australia and Chile, Peru and Argentina in the deployment of geothermal energy in mining and mineral processing operations

Sponsor: Department of Foreign Affairs and Trade
Chief Investigators: Prof Stephen Grano, Prof Martin Hand, Prof Gus Nathan

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Institute for Mineral and Energy Resources

Sponsor: Department of Premier and Cabinet, Government of South Australia
Chief Investigator: Prof Stephen Grano

Centre for Energy Technology

The Adelaide Airport Limited industry partnership

Sponsor: Adelaide Airport Limited
Chief Investigator: Prof Gus Nathan

Detailed understanding of the behaviour of soot in, and emission from, turbulent flames and fires

Sponsor: Australian Research Council
Chief Investigators: Prof Gus Nathan, Prof Bassam Dally

Energy from microalgae - industrial scale development and downstream processing of co-products

Sponsor: Australian Research Council, SQC P/L Partnership
Chief Investigators: A/Prof David Lewis, Dr Stephen Clarke, A/Prof Peter Ashman

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Enhanced mixing of turbulent jet flames via side lateral injection

Sponsor: Australian Research Council
Chief Investigator: A/Prof Bassam Dally

Internally decorated discrete metallo-supramolecular assemblies and infinite metal-organic frameworks as molecular containers

Sponsor: Australian Research Council
Chief Investigator: A/Prof Christopher Sumby
Centre for Advanced Nanomaterials

Investigation of the coupled dependence of concentrated solar radiation and combustion in a novel solar hybrid technology

Sponsor: Australian Research Council, FCT-Combustion Pty Ltd
Chief Investigators: Prof Gus Nathan, Prof Bassam Dally, Dr Zeyad Alwahabi

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The mechanics of quiet airfoils

Sponsor: Australian Research Council
Chief Investigators: Dr Con Doolan, Prof Colin Hansen

Metal-organic frameworks as heterogenous catalytic systems

Sponsor: Australian Research Council
Chief Investigators: Dr Christian Doonan, A/Prof Christopher Sumby
Centre for Advanced Nanomaterials

Multifunctional porous nanospheres engineered composite membranes for hydrogen and methanol fuel cells

Sponsor: Australian Research Council
Chief Investigators: Prof Shizhang Qiao

Multiscale models of nanoporous carbons for a sustainable future

Sponsor: Australian Research Council
Chief Investigator: Prof Mark Biggs

New understanding of the heat transfer in compact, two-phase solar and solar hybrid reactors by advanced laser diagnostics and modelling

Sponsor: Australian Research Council
Chief Investigator: Prof Gus Nathan

Novel vibro-acoustic technologies for detecting bearing and wheel defects in rail vehicles

Sponsor: Australian Research Council
Chief Investigator: Dr Carl Howard

Open framework organic materials for CO_2 capture and conversion

Sponsor: Australian Research Council
Chief Investigator: Dr Christian Doonan
Centre for Advanced Nanomaterials

Professor Hydrology Position

Sponsor: South Australian Research and Development Institute
Chief Investigator: A/Prof Jennifer Watling

Quantifying the impact of wind farm noise on rural communities

Sponsor: Australian Research Council
Chief Investigator: Prof Colin Hansen

Resolving flame stabilisation mechanisms in the transition to MILD combustion

Sponsor: Australian Research Council
Chief Investigator: Dr Paul Medwell

Resolving the mechanics of turbulent noise production

Sponsor: Australian Research Council
Chief Investigators: Dr Con Doolan, Dr Laura Brooks, Dr Paul Medwell

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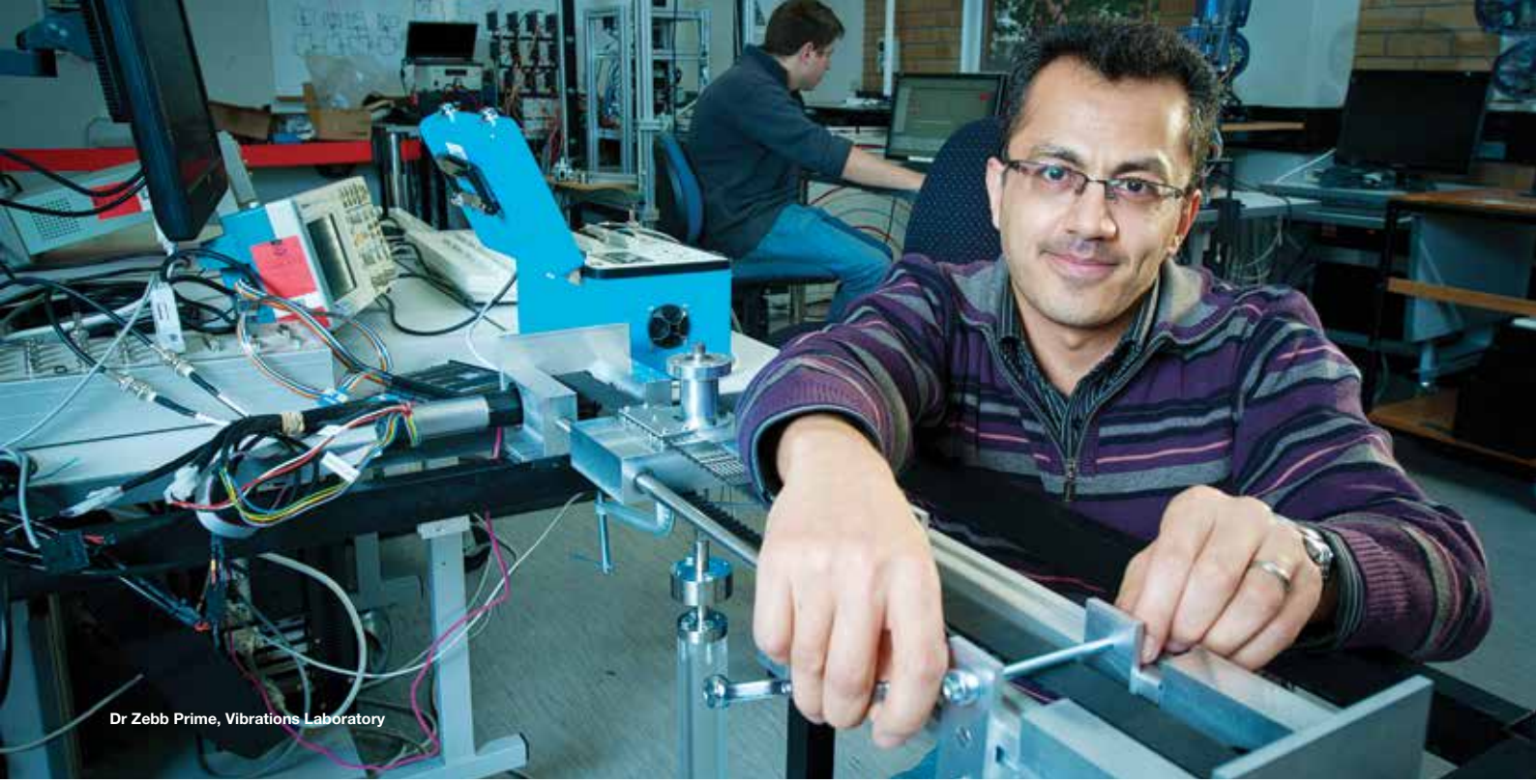
Responsive nanoporous organic cages

Sponsor: Australian Research Council
Chief Investigator: Dr Christian Doonan
Centre for Advanced Nanomaterials

Solar gasification – using renewable energy to produce lower-carbon, high value liquid transport fuels using low grade carbonaceous feedstocks

Sponsor: Australian Solar Institute
Chief Investigator: Dr Philip van Eyk



Dr Zebb Prime, Vibrations Laboratory

Solving the energy waste roadblock

Sponsor: Science & Industry Endowment Fund

Chief Investigators: A/Prof Christopher Sumby, Dr Christian Doonan

Centre for Advanced Nanomaterials

Ultrasound for control of cyanobacteria

Sponsor: Australian Research Council

Chief Investigators: Dr Carl Howard, A/Prof Colin Hansen, A/Prof Anthony Zander

Understanding and predicting submarine hydrofoil noise

Sponsor: Australian Research Council

Chief Investigators: Dr Con Doolan, Prof Colin Hansen, A/Prof Anthony Zander, Dr Laura Brooks

Centre for Tectonics, Resources and Exploration

Carbon sequestration by mineral surface area as a feedback to climate warming in a greenhouse ocean

Sponsor: Australian Research Council

Chief Investigator: Prof Martin Kennedy

Contemporary stress and tectonics of Australia

Sponsors: Australian Research Council

Chief Investigator: Dr Mark Tingay

Constraining conditions and timing of orogeny and reworking in the west Musgrave Province

Sponsor: Australian Research Council, Curtin University, Geological Survey of Western Australia

Chief Investigators: Dr David Kelsey, Prof Martin Hand, A/Prof Alan Collins

Detachments in evaporites and shales: their controls on fold-thrust belt style and wedge geometry

Sponsor: Australian Research Council

Chief Investigators: Dr Rosalind King, A/Prof Alan Collins, Dr Mark Tingay, Dr Guillaume Backé

Development of biosensors and bioindicators for gold exploration and processing in Australia

Sponsors: Australian Research Council, Barrick Gold of Australia Ltd, CSIRO Land and Water, Flinders University, Martin Luther-University Halle-Wittenberg, Newmont Australia, South Australian Museum, University of Nebraska-Lincoln

Chief Investigators: A/Prof Frank Reith, Dr Joël Brugger, Prof Joseph Shapter, A/Prof Claire Lenehan

Experimental studies on hydrothermal reaction processes at the molecular level: the role of mineral replacement reactions in ore formation

Sponsor: Australian Research Council

Chief Investigators: Prof Allan Pring, Dr Joël Brugger

Funding to support, develop and diversify educational and research programs associated with the Centre for Mineral Exploration Under Cover

Sponsor: Primary Industries and Resources SA

Chief Investigators: A/Prof Jennifer Watling, Prof David Giles

Geological control

Sponsor: Imperial Gas & Oil Pty Ltd

Chief Investigator: Prof Martin Kennedy

Iron isotope variation in sub-duction magmas: links to fluid flux and oxidation of the mantle wedge?

Sponsor: Australian Research Council

Chief Investigator: Prof John Foden

Molecular structure and transport properties of hydrothermal fluids under extreme conditions: near-critical, high salinity, high pressure and high volatile contents

Sponsor: Australian Research Council

Chief Investigator: Dr Joël Brugger

Reservoir architecture and heterogeneity in marginal marine systems – *WAVE* Consortium Phase 11

Sponsors: Apache Corporation, Badr Petroleum Co, BG Group, BHP Billiton, BP Australia, Chevron Australia, ConocoPhillips, Nexen Petroleum Australia Pty Ltd, OMV Group, Shell, Statoil, Todd Energy Ltd, Woodside Energy Ltd

Chief Investigator: Prof Bruce Ainsworth

South Australian State Chair of Petroleum Geology

Sponsor: Department for Manufacturing, Innovation, Trade, Resources and Energy, Government of South Australia

Chief Investigator: Prof Bruce Ainsworth

The geomicrobiology and (bio) geochemistry of platinum, palladium and rhodium

Sponsor: Australian Research Council

Chief Investigator: A/Prof Frank Reith

The origin of Australian Gondwana - using isotopic proxies for subduction to reconstruct ancient oceans

Sponsor: Australian Research Council

Chief Investigator: A/Prof Alan Collins

Three-dimensional magnetotelluric and controlled-source electromagnetic modelling and inversion in isotropic and anisotropic media with Gaussian Quadrature Grids

Sponsor: Australian Research Council

Chief Investigator: Prof Graham Heinson

South Australian Centre for Geothermal Research

Advanced matrix-analytic methods with applications

Sponsor: Australian Research Council
Chief Investigator: Prof Nigel Bean

Funding for South Australian Centre for Geothermal Energy Research

Sponsor: RenewablesSA
Chief Investigator: Prof Martin Hand

Environmental Impact of Mineral and Energy Resources Program

Root distribution and salinity and soil water dynamic in a chenopod shrubland: implications for restoration ecology

Sponsor: Australian Research Council, Iluka Resources Ltd
Chief Investigators: A/Prof José Facelli, A/Prof Jennifer Watling, Prof David Chittleborough

Statistical description of hydrographs in the SA River Murray

Sponsor: SA Water
Chief Investigators: Prof Nigel Bean

Resource Engineering Program

Acoustic emission monitoring during drilling/rock cutting for optimising drilling performance

Sponsor: Deep Exploration Technologies Cooperative Research Centre
Chief Investigator: A/Prof Chaoshui Xu

Development of innovative technologies for oil production based on the advanced theory of suspension flows in porous media

Sponsors: Australian Research Council, Santos Ltd, University of South Australia.
Chief Investigators: Prof Pavel Bedrikovetski, Prof Anthony Roberts, Dr Andrei Kotousov

Developing engaging, effective and enlightening practical experiments in geotechnical engineering

Sponsor: Australian Learning and Teaching Council
Chief Investigator: Prof Mark Jaksa

Impact of rolling dynamic compaction

Sponsor: Australian Research Council
Chief Investigator: Prof Mark Jaksa

Modelling the capillary entrapment phenomena and integrity of geological reservoirs for clean energy, water and waste management technologies

Sponsors: Australian Research Council
Chief Investigators: Prof Pavel Bedrikovetski, Dr Yildiray Cinar, Dr Andrei Kotousov

Novel technology for enhanced coal seam gas production utilising mechanisms of stimulated cleat permeability through graded particle injection

Sponsor: Australian Research Council
Chief Investigator: Prof Pavel Bedrikovetski

Permeability Laboratory: Dr Themis Carageorgos and Yulong Yang

Stochastic modelling of fractures in crystalline rock masses for hot dry rock enhanced geothermal systems

Sponsor: Australian Research Council
Chief Investigator: Prof Peter Dowd

Socio-Economic Impact of Mineral and Energy Resources Program

Realising socio-economic rights: law and the politics of access to public services in Indonesia

Sponsor: Australian Research Council
Chief Investigator: A/Prof Andrew Rosser

Cooperative Research Centre for Greenhouse Gas Technologies

CO_2 storage in deep saline formations

Sponsor: Cooperative Research Centre for Greenhouse Gas Technologies
Chief Investigators: Dr Mark Bunch, Dr Richard Daniel

Reactive rocks and their impact on CO_2 storage potential trapping

Sponsor: Cooperative Research Centre for Greenhouse Gas Technologies
Chief Investigator: Dr Ulrike Schacht

Seal geomechanics and retention of CO_2 in the subsurface

Sponsor: Cooperative Research Centre for Greenhouse Gas Technologies
Chief Investigators: Ernest Swierczek, Prof John Kaldi

Monitoring and verification

Sponsor: Cooperative Research Centre for Greenhouse Gas Technologies
Chief Investigator: Dr Ulrike Schacht

Predictive modelling of storage reservoirs

Sponsor: Cooperative Research Centre for Greenhouse Gas Technologies
Chief Investigators: Prof John Kaldi, Myles Regan

Deep Exploration Technologies Cooperative Research Centre

Geochemical sampling of deep cover

Sponsor: Deep Exploration Cooperative Research Centre
Chief Investigator: Prof David Giles

Hypogene alteration

Sponsor: Deep Exploration Technologies Cooperative Research Centre
Chief Investigator: Prof David Giles

Joint inversion of 3D seismic data and magnetotelluric (MT) data

Sponsor: Deep Exploration Technologies Cooperative Research Centre
Chief Investigator: Prof Graham Heinson

3D seismic exploration for hard rock environments

Sponsor: Deep Exploration Technologies Cooperative Research Centre
Chief Investigator: Prof David Giles

South Australian data integration and delivery through mineral potential mapping

Sponsor: Deep Exploration Technologies Cooperative Research Centre
Chief Investigator: Prof David Giles

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CO2CRC

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DET CRC

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Energy Pipelines CRC

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Mandar Oak

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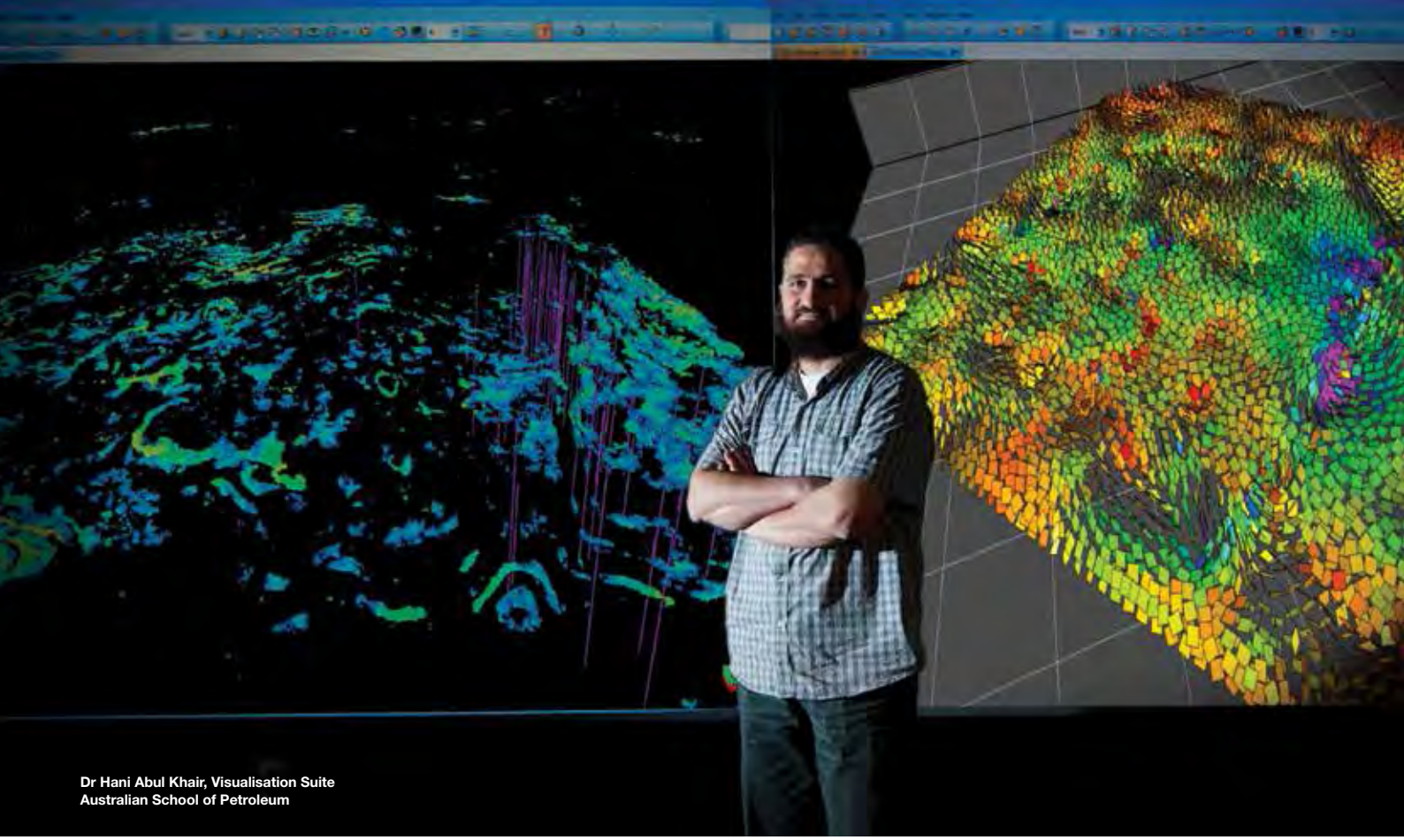
3D geomodelling and fracture imaging

Dr Benjamin Binder

PhD, BSc (Hons), University of East Anglia

Fluid mechanics



Dr Hani Abul Khair, Visualisation Suite
Australian School of Petroleum

Dr An Deng

PhD, Pennsylvania State University; MEng, Tongji University; BEng, Central South University

Characterisation and reuse of solid waste materials as geomaterials, testing and modelling of soil consolidation, electrokinetic remediation and modelling

Dr Christian Doonan

Centre for Advanced Nanomaterials

PhD, University of Melbourne

Porous materials for energy storage, gas separations and catalysis

Dr Matthew Finn

PhD, MMath (Hons), University of Nottingham

Chaotic laminar fluid mixing

Dr Carl Howard

PhD, BE (Hons), University of Adelaide

Acoustics, vibrations, thermoacoustics, ultrasound, condition monitoring, finite element analysis and digital signal processing

Dr Katherine Howard

PhD, BSc (Hons), University of Adelaide

Geochemistry and structural geology

Dr David Huang

PhD, University of California; BSc (Hons), University of Sydney

Theoretical and computational nanoscience

Dr Murat Karakus

PhD, University of Leeds; BEng, Hacettepe University

Mining geomechanics

Dr Tak W Kee

PhD, University of Texas; BSc, Iowa State University

Biophysical chemistry and materials chemistry

Dr David Kelsey

PhD, University of Melbourne; BSc (Hons), University of Adelaide

Petrology and chemical geology

Dr Rosalind King

PhD, BSc (Hons), University of Liverpool

Structural geology and petroleum geomechanics

Dr Andrei Kotousov

PhD, Russian Academy of Sciences; BSc (Hons), Moscow State Technical University

Fracture mechanics

Dr Lars Krieger

PhD, University of Hamburg; Diplom-Physiker, Baccalaureus der Mathematik, University of Freiburg

Magnetotellurics - data collection, interpretation and analysis; computational geophysics

Dr Philip Kwong

PhD, Hong Kong University of Science and Technology; BEng, University of Hong Kong

Biomass energy and combustion

Dr Trent Mattner

PhD, BEng, University of Melbourne

Fluid mechanics

Dr Paul Medwell

PhD, BEng (Hons), University of Adelaide

Combustion and laser diagnostics

Dr Noune Melkoumian

PhD, University of New South Wales; PhD, ME, BE, Yerevan State Polytechnic University

Mining and geotechnical engineering

Dr Rachel Nanson

PhD, University of New South Wales; BSc (Hons), University of Wollongong

Fluvial and coastal geomorphology

Dr Justin Payne

PhD, BSc (Hons), University of Adelaide

Geochemistry and geochronology; evolution of the earth's crust

Dr Zhao Feng Tian

PhD, University of RMIT; MESc, University of New South Wales; BE, Shanghai Jiaotong University

CFD, coal combustion and renewable energy

Dr Benjamin Wade

PhD, BSc (Hons), University of Adelaide

Evolution of the earth

Dr Abbas Zeinijahromi

PhD, University of Adelaide; MSc, Azad University; BsC, Petroleum University of Technology

Formation damage, reservoir simulation and mathematical modelling

Senior Research Associates

Dr Alexander Badalyan

PhD Azerbaijan Petroleum and Chemistry Institute; BEng, Grozny Petroleum Institute

Suspension flow in porous media, characterisation of porous solids by manometric gas absorption and thermophysical properties of fluids

Dr Cristian Birzer

PhD, BEng (Hons), University of Adelaide

Fluid mechanics, laser diagnostics and combustion

Dr David Brautigan

PhD, BSc (Hon), University of Adelaide

Mineral replacement reactions in hydrothermal systems

Dr Joël Brugger

PhD, University of Basel; BSc (Hons), University of Fribourg

Experimental geochemistry, mineralogy and spectroscopy

Dr Shaun Chan

PhD, BEng (Hons), University of Adelaide

Combustion, laser diagnostics and renewable energy

Dr Dennis Cooke

PhD, Colorado School of Mines; BA, University of Colorado

Stress and geomechanics

Dr Richard Craig

PhD, BEng (Hons), University of Adelaide

Solar energy and heat transfer

Dr Richard Daniel

PhD, University of Adelaide; BSc, Macquarie University

Carbonate and elements of drilling engineering

Dr Peter Kalt

PhD, University of Sydney; MA, Macquarie University; BEng (Hons); BSc, University of Sydney

Combustion and advanced laser diagnostics

Adjunct Dr Adam Kosminski

PhD, University of Adelaide; MSc, Szczecin Polytechnik

Combustion and gasification of solid fuels

Dr Peter Lanspeary

PhD, BEng (Hons), University of Adelaide

Fluid mechanics

Dr Saju Menacherry

PhD, University of Adelaide; MSc, University of Kerala; BSc, University of Calicut

Sedimentology

Dr Ulrike Schacht

PhD, University of Kiel; MSc, BSc, Technical University of Berlin

Siliciclastic reservoir quality and diagenesis

Dr Matthew Tetlow

PhD, BEng (Hons), University of Adelaide

Aerospace propulsion, high speed aerodynamics

Dr Benjamin Wade

PhD, BSc (Hons), University of Adelaide

Evolution of the earth

Dr Bing Zhou

PhD, University of Adelaide; BEng, Chengdu University of Technology

Wave modelling

Research Associates

Dr Hani Abul Khair

PhD, MSc, University of Jordan; BSc, Yarmouk University

Integration of sedimentology

Dr Graham Baines

PhD, University of Wyoming; MSc (Hons), University of Liverpool

Potential field geophysics

Cameron Bowker

BEng (Chemical)/BSc, University of Adelaide

Geothermics

Dr David Brautigan

PhD, BSc (Hon), University of Adelaide

Mineral replacement reactions in hydrothermal systems

Dr Maxwell Bull

PhD, University of South Hampton; BMechE (Hons), BSc (Hons), University of Melbourne

Fluid mechanics

Dr Mark Bunch

PhD, MSc, University of Birmingham; BSc (Hons), Durham University

Detection and quantitative modelling

Dr Themis Carageorgos

PhD, Imperial College-London University; MSc, COPPE-Rio de Janeiro Federal University; BEng (Chemical), Fluminense Federal University

Flow in porous media, laboratory studies and hydrometallurgy

Dr Cristiana Ciobanu

PhD, BSc, University of Bucharest

Mineralogy and geochemistry

Dr Robert Dart

PhD, University of Adelaide; BSc (Hons), University of South Australia

Regolith geology and geochemistry

Dr Robert Dickinson

PhD, University of Waterloo; MSc, University of Guelph; BEng, University of Melbourne

Systems design

Dr Barbara Etschmann

PhD, BSc (Hons), University of Western Australia

X-ray absorption spectroscopy

Simon Firth

Commercial Development Manager, Adelaide Research and Innovation

Dr Caroline Forbes

PhD, MSc, BSc, Monash University

Proterozoic tectonics

Dr Pascal Grundler

PhD, Ecole Polytechnique Federale de Lausanne; DChem, University of Lausanne

Coordination chemistry, physical chemistry and geochemistry

Dr Michael Hatch

PhD, University of Adelaide; MSc, University of Arizona; BA University of Pennsylvania

Fast-sampling electro-magnetic techniques for ground water

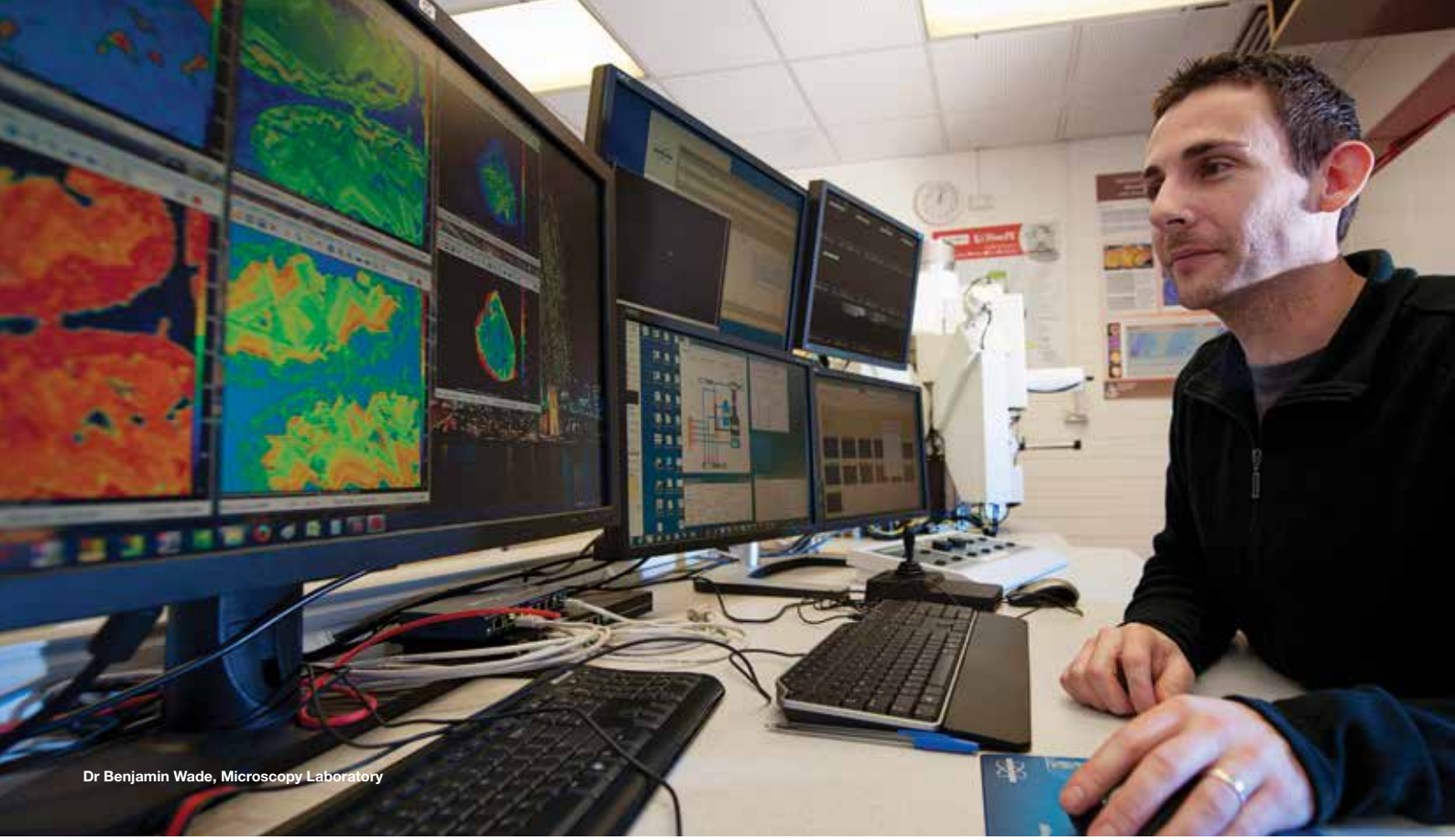
Dr Nathanial Jewell

PhD, BSc (Hons), University of Adelaide; BSc, Flinders University

Fluid mechanics, operations research and hydrology

Simon Ladd

Research Development Manager, Humanities and Social Sciences



Dr Benjamin Wade, Microscopy Laboratory

Dr Timothy Lau
PhD, BEng (Hons), University of Adelaide
Fluid dynamics

Chris Matthews
Research Officer, South Australian Centre for Geothermal Energy Research

Dr Rosemarie Mohais
PhD, MPhil, BSc, University of West Indies; DipEd, Valsayn Teachers' College
Fluid flow and heat transfer

Dr Danielle Moreau
PhD, MEng (Hons), University of Adelaide
Aeroacoustics, acoustics, active noise control and virtual sensing

Alexander Musson
Research Officer, South Australian Centre for Geothermal Energy Research

Dr Natarajan Narayanan
PhD, Indian Institute of Technology, Madras; ME, BE, Anna University
Modelling flow and transport in geothermal reservoirs

Dr Stephen Pahl
PhD, BEng (Hons), University of Adelaide
Industrial bioprocessing and biotechnology

Dr Zebb Prime
PhD, BE, BSc, University of Adelaide
Robust control theory

Myles Regan
BE, University of Adelaide
Enhanced oil recovery

Dr Frank Reith
PhD, Australian National University; MSc, BSc, BBA, University of Bayreuth
Geomicrobiology, metagenomics and transcriptomics

Dr Michael Rumsewicz
Business Development Manager, School of Civil, Environmental and Mining Engineering

Dr Sattar Seifollahi
PhD, Iran University of Science and Technology; MSc, BSc University of Tabriz
Fracture network modelling

Dr Kate Selway
PhD, BSc (Hons), University of Adelaide
Proterozoic collision

Lachlan Skuse
Research Assistant, Institute for Mineral and Energy Resources

John Terlet
Director, Adelaide Microscopy

Dr Stephan Thiel
PhD, BEng, University of Adelaide; MEng, Freiberg University of Mining and Technology
Electromagnetics and geothermal exploration

Dr Philip van Eyk
PhD, BE (Hons), BSc, University of Adelaide
Combustion and gasification of low-rank coals and biomass

Dr Matthew Welsh
PhD, BA (Hons), BSc (Hons), University of Adelaide
Psychology of decision-making

Dr Yunpeng Xue
PhD, University of Adelaide; BEng, Beijing University of Aeronautics and Astronautics
Vortex tube, windowless solar reactor, aerodynamic characteristics of heliostat field and fluidic seal

Dr Zhenjiang You
PhD, BEng, Zhejiang University
Fluid mechanics and heat transfer

Dr Carla Zammit
BSc, BA (Hons), Curtin University
Environmental microbiology and molecular genetics

Dr Manfred Zockel
PhD, MEng, University of Adelaide
Thermodynamics, engines, design and manufacturing

Postgraduate students

Current postgraduate students supervised by IMER members relevant to core IMER research areas and priorities during 2012.

Maqsood Ahmad
Coal bed methane and enhanced oil and gas recovery techniques

Md Shahabuddin Ahmmad
Investigation of a fluidised bed solar receiver

Homoud Raheel M Al Anzi
Sedimentology of the Murta Formation

Cristobal Gonzalez
Trailing edge noise

Mohammed Obid Alsawat
Composite nano-membranes for emerging applications - engineering, properties and applications

Tariq Altalhi
Development of multifunctional nanotubes

Alexander Altree-Williams
Reactive fluid flow: towards quantitative modelling through experiments and fundamental process understanding

Jason Alvino
Photo catalytic studies of size-selected metal clusters

Jade Anderson
Crustal evolution of Proterozoic Central Australia using an integrated isotopic, metamorphic and geochemical approach

Francesco Arboit
Tectonic geology - Indo/sinian orogeny in Thailand and Cambodia

Donnelly Archibald
The consumption of the Mozambique Ocean: Arcs in Madagascar

Elias Arcondoulis
Experimental study of low Reynolds number trailing edge noise

Vahid Atashbari
Petroleum geomechanics

Adam Bailey
The Australian structural permeability map

Elizabeth Baruch
Petrology of shale

Bita Bayatsarmadi
Carbon-based materials for energy storage and conversion

Kate Bradbury
A legal regime for ocean energy: an analysis of the legal issues associated with offshore renewable energy and the formulation of appropriate international and domestic legal mechanisms for its deployment

Andrew Bradley
Determination of the effectiveness of rolling dynamic compaction

Belinda Bruza
Investigating cognitive processes underlying decision-making biases

Gary Cai
Development and application of high-fidelity simulation tools for the combustion of petroleum and biofuels in advanced combustion engines

Lujie Chen
Power electronics for small-scale wind turbines

Xiao Chen
Integrating the solar energy system into existing infrastructure study of indirect evaporative cooling systems

Mei Chiin Cheong
Airfoil active circulation control

Amanullah Choudhry
Dynamic stall control on wind turbine blades

Scott Clafton
Conjugated polymer nanoparticles

Jesse Coombes
Hydrofoil flow induced noise

Alexander Corrick
Neoproterozoic carbon isotopes

John Counts
Outcrop analogues of the Flinders Ranges

Tess Dance
Reservoir characterisation for CO_2 storage

Thana Deawwanich
Non-Newtonian fluid mechanics

Rutraj Desai
Ocean current energy to generate electricity

Meridith-Maya Dharmarajah
Platinum, palladium and rhodium mobility in soils with application in ecotoxicology and mineral exploration

Yohannes Didana
Magnetotelluric characterisation of Australian and international geothermal plays

Nicole Ditty
Optimisation of multi-stage hydraulic stimulation design for unconventional reservoirs using geomechanical modelling

Quang Cong Doan
Determination of the fermentation potential of marine microalgal biomass for acetone butanol and ethanol production

Xue Dong
Modelling of algal biofuel production process

Jingjing Duan
Non-noble metal catalysts for energy-converting process

Blessing Elo-Oghene Eboibi
Renewable energy and bioenergy

Hamideh Behjati
Reconstructive models of nanoporous carbons

Mason Erkelens
Algae growth on digestate

Jack Evans
Synthesis and modelling of nano-functional materials

Younes Fadakar
Stochastic modelling of fractures in rock masses

Ahrufan Ghalba
Site investigation uncertainty on multilayered soil

Electrical Testing Laboratory

Farzin Ghanadi
Flow control techniques for drag reduction

Razieh Ghobadi
Factorial kriging analysis applied to environmental geology

Michael Gray
Seal evaluation for CO_2 containment in the Gippsland Basin

Dahe Gu
Solar gasification of particles, two phase flows and laser diagnostics

Peijun Guo
Solar gasification of carbonaceous fuels

Erwin Hamminga
Power density enhancement of wind farms using vertical axis wind turbines

Noorfaizah Hamzah
Geo-materials joint and bonding behaviour in tunnelling or underground excavation

Rowan Hansberry
Structural investigation of the mechanisms of shale detachments

Peter Hardy
Oscillating water column efficiency improvement through impedance matching and latching control techniques

Seyed Saeid Hashemi
Drilling and maintaining stable boreholes in unconsolidated rock formations

Peter James Hawke
Evaluation of petroleum systems on the Billiluna Shelf and adjacent structural regions, eastern Canning Basin

Xianqun He
Modelling of rock cutting by diamond impregnated bit

Bonnie Henderson
Global Hf cycle and the assembly of supercontinents in the Phanerozoic

Nicholas Henrys
Prediction and measurement of far-field wind turbine noise

Daniel Howlett
The sources of fluid during intercontinental reworking in Central Australia

Cheng Hu
Experimental and molecular modelling study of nanoporous carbons

Hao Huang
Intelligent control system

Kent Inverarity
Groundwater geophysics

Roniza Ismail
Trace element distributions in South Australian IOCG mineral deposits

Leslie Jenkinson
Image log analysis and geomechanical understanding of the Tangalooma sandstone and Juandah sandstone of the Surat Basin, QLD

Ashlyn Johnson
Palaeo landscape reconstruction of South Australia

Theo Kalaitzidis
Harvesting microalgae for biofuel feedstock from wastewater

Ashok Kaniyal
Energy pipelines

Ehtesham Ul Haq Karatela
Study on borehole failure mechanism in deep drilling conditions

Alireza Keshavarz
Enhanced oil recovery by nano and bio particles

Aditya Shankar Khanna
Enhanced oil/gas recovery

Melanie Kitchin
Porous aromatic organic and metalorganic frameworks

Kumphon Kumnerdsiri
Controls on structural and stratigraphic architecture of miocene succession, South Bongkot Gas Field, Gulf of Thailand: implication for hydrocarbon utilisation

Gideon Kuncoro
Geochemistry, corrosion & scaling in hot dry rock energy extraction systems

Daniel Lane
Thermal processing of marine microalgal biomass

Kathleen Lane
Tectonic evolution of the SE Gawler Craton

Tessa Lane
Evolution of the Mitchell River Delta (Geology)

Alex Laratro
Wake propagation of horizontal axis wind turbines

Kwong Shui Andrew Lee

Large scale harvesting and extraction of algal lipids for biofuels

Ryan Leknys
Investigation of dynamic stall on horizontal axis wind turbines

Ji Liang
Metal free catalysts for fuel cell applications

Jin Han Lim
Technical and economical assessments of SOCPR-combustion energy systems

David Loh
Chalcopyrite leaching by dissolution - reprecipitation reactions

Zhao Joe Lu
Aerodynamic design of a windowless solar receiver in a concentrated solar power system

Jake Macfarlane
Isotropic magnetotelluric modelling of the Australian continent

Edeltraud Macmillan
Mechanisms of uranium dissolution and reprecipitation at Olympic Dam

Saleh Mahmoud
Measurements in sooty flames (combustion)

Ben McGee
Tectonic evolution of the Paraguay Belt, Brazil

Stephanie McLennan
Geochemistry of a buried late miocene-pliocene landscape: geochemistry of the weathered Loxton-Parilla Sands Strandplain in the Western Murray Basin, Australia

Kieran Meaney
The structural and metamorphic evolution of the Barossa Complex, Mount Lofty Ranges, South Australia

Yuan Mei
Molecular dynamic simulation of metal speciation in ore fluids

Hoda Minoofar
Visualisation of transport and deposition of colloidal particles in porous media

Charlotte Mitchell
Regolith geochemistry of deep sediments on Mundi Mundi Plain, NSW

Zeeshan Mohiuddin
Flow visualization and pore network modeling of miscible displacement with gravity domination

Sara Polanco
Facies, architecture and connectivity of dryland fluvial deposits

Laura Morrissey
Mesoproterozoic global continental growth

Maung Thi Rein Myo
Bulk material flow study for robotic stockpile depositing/reclaiming trajectory optimisation

Moein Navvab Kashani
Computational study of microfluid flows

Verity Normington
Permian landscape reconstruction of South Australia

Matthew Penna
Molecular dynamics

Santiago Ospina
Acoustic monitoring of the rock cutting response of an impregnated diamond segment

Diana Plavsa
The role of the Southern Granulite Terrane of India in the amalgamation of Gondwana - A structural and geochronological perspective

Kunakorn Pokalai
Development of type curves for production data analysis in shale gas reservoir

Ric Porteous
Investigation of the sound produced by flow interaction with a wall mounted finite length cylinder

Jiyun Qin
Technical and economic assessment of geothermal assisted power generation

Angie Dongyuan Qu
Determining CO_2 storage reservoir potential of the Paaratte Formation, Otway Basin, by forward stratigraphic modelling

Md Habibur Rahman
Unconventional reservoir characterisation

Mojtaba Rajabi
The present day stress field of Australia

Jingrun Ran
Fabrication of novel nanomaterial for solar energy conversion

Tharanga Ranasinghe
Impact of rolling dynamic compaction

Damien Rankine
Synthesis of metal-organic frameworks for catalytic and gas storage applications

Nigel Rees
Time-lapse geophysical monitoring for energy and groundwater applications

Mehrdad Rezazadeh
Experimental and mathematical study of coal bed methane reservoirs

Lachlan Richards
Salt detachments in fold thrust belts

Aixa Maria Rivera-Rios
Three-dimensional magnetotelluric and controlled-source electromagnetic modelling and inversion in isotropic and anisotropic media with Gaussian quadrature frids

Kate Robertson
The use of electrical conductivity to constrain broad-scale lithospheric properties

Frank Robinson
Tectonic controls on igneous geochemistry and magma production

Nanang Rohadi
Global sensitivity analysis of impedance measurement algorithms implemented in intelligent electronic devices

Laura Rollison
Stratigraphy, sedimentology and chemistry of the Pandurra Formation

Nikan Rostamzadeh Torghabeh
An investigation into the effect of tubercles on aerodynamic performance

Manabendra Saha
Mild combustion of solid fuel

Ladan Sahafi
Intelligent control systems

Manuel Salazar
Vehicle power system architectures with energy management

Alireza Salmachi
Well testing in coolbed methane reservoirs

Isaac Saridakis
Analysis of particle clustering and radiative heat transfer in two-phase jet flows

Md Rabiul Islam Sarker
Investigation of the efficiency of concentrated solar heat systems

Mohammad Sayyafzadeh
Reservoir simulation

Tyler Schembri
Aerodynamic noise mitigation through active flow control

Sebastian Schnaidt
Joint inversion of MT and seismic data

David Scholten
Power electronic converters in microgrid systems

Karn Schumacher
Passive control of cavity flow noise using geometric modifications

Adam Schwartzkopff
Investigation into fracturing behaviour of rock masses under three-dimensional stress regimes subjected to internal hydraulic pressure

Saeid Sedghizeinolhajloo
Elucidation of nanoporous evolution during nanoporous carbon synthesis

Khalid Shamim
Mathematical modelling of integrated biosystems for operational control and management

Aabhash Shrestha
Re-use of residual heat and energy harvesting

Russell Smits
Testing models for continental growth

Paul Soeffky
The electrical heterogeneity of the crust: A vector to mineralisation?

Camilla Soerensen
Airborne electromagnetic methods for aquifer characterisation and groundwater and resource definition as part of the Flows Project

Sarwo Edhy Sofyan
Modelling geo-heat exchanger

Katherine Stoate
Geochemical signatures within landscapes and environments

Brenton Swansson
The study of the suitability of a low tin alloy for use in horizontal tubular positive plates and lead acid batteries

Ernest Swierczek
Old faults vs. new faults - comparing the mechanical behaviours of fault systems in different geodynamic settings and application to the geological storage of CO_2

Erfan Syamsuddin
Evaluating the influence of rolling dynamic compaction using geophysical techniques

Chun Tang
Electrical machines for small wind power generation

Patrick Tapping
Theoretical and spectroscopic studies of energy and charge transport in organic semiconductors

David Tassone
The neotechtonics of passive Southern Australian margin

Jesse Miah Teo
Synthesis and design of functional materials

Chia Xiong Thong
Enhanced mixing via lateral injection

Blake Tooth
Metal complexes in hydrothermal systems under high temperature & pressure

Jessica Trainor
Palynology, sedimentology and stratigraphy of the early Cretaceous to late Jurassic of the Northern Barrow Delta, Carnarvon Basin, Australia

Cuong Phuoc Tran
Solid waste minimisation and management for the alumina industry

Stephanie Wikan Tyiasning
Measuring geomechanical properties from 3D seismic data

Wynand Van den Berg
Biofuel from algae - anaerobic digestion processes

Benjamin Vanderhoek
Regolith and landscape evolution in South Australia

Josephine Varney
Optimisation in geothermal energy

Alec Walsh
Constraining the conditions and timing of orogeny in the Musgrave Province

Liying Wang
Modelling and analysis of large scale grid-connected wind turbine systems

Yanhan Wang
Heap leaching modelling

Andrew Ward
Anaerobic digestion of algal biomass

Christine Wawryk
A proposal to investigate the application of systematic variation in iron composition in the understanding of felsic magma systems with associated hydrothermal ore deposits: A potential exploration vector?

Keryn Wolff
Regolith bio-geochemistry of regional South Australia

Jiayi Xu
Finite element analysis of impregnated diamond drilling bits

Joe Yang
Optimisation of deep drilling in hard rocks by metaheuristic methods

Yulong Yang
Particle sizing in drilling fluid to minimize formation damage and filtrate losses

Kiang Meng Yeoh
Numerical analysis for tunnelling in urban areas

Guanran Zhang
Organic solar cells

Jing Zhao
Physical chemistry of the formation of copper iron sulphides under hydrothermal conditions

Shi Zhao
Study and development of 3D real-time stock pile management system

Higher degree graduates

During 2012 IMER researchers supervised 43 higher degree graduates in a wide range of research areas. Of this number 36 PhDs completed and a further seven completed Masters.

Here is a list of graduates and their research topics in areas relevant to IMER's focus.

Doctor of Philosophy

Yuen Yan Fong
Laser-based nanosoldering mechanisms and applications

Brad Gibson
Application of dielectric barrier discharge plasma flow augmentation for viscous drag reduction

Philip Hall
Neoproterozoic and early Cambrian petroleum systems of South Australia: their geochemical signatures and Paleoenviromental significance

Kristy Hansen
Effect of leading edge tubercles on airfoil performance

Chong Zhi Liaw
Wide speed range, inverterless, constant current mode alternator

Sanaz Orandi
Investigation of algal-microbial biofilms for acid mine drainage treatment

Mehanathan Pathmanathan
Innovative grid-connected, small-scale wind turbine generators offering low cost and wide operating speed range

Jared Peacock
Magnetotelluric methods and data processing

Bradley Visser
Photo-electron imaging spectroscopy of size-selected metal nanocrystals

Timothy Wiese
New developments in 3D electrical resistively imaging

Abbas Zeinijahromi
Laboratory and mathematical modelling of suspension/colloid flow in porous media

Masters

Setiawan Bambang
Modified evaluation of liquefaction potential of soils utilising in situ tests

Arash Mirahmadizoghi
Rock mechanics, rock behaviour under 3D state of stress, evaluating 3D failure criteria by comparing them with experimental data

Public seminars and events

IMER members shared key research findings, outcomes and benefits with business leaders, government and the wider community. Here is a selection of key public presentations by IMER members or hosted at IMER during 2012.

Mission promotes IMER in South America

New research and commercial opportunities in solar thermal, geothermal and renewable energy for mining and mineral processing were promoted during a visit to South America by key IMER personnel. The visit in April 2012 was organised in collaboration with the Australia Chile Chamber of Commerce and facilitated by the Australian embassies in Peru and Argentina and AMIRA International in Chile and Peru.

IMER representatives on the trip included Executive Director Professor Stephen Grano, SACGER Director Professor Martin Hand and CET Director Professor Gus Nathan. Other key participants included Maria Galatsanos, Director SA/Vice President Australia Chile Chamber of Commerce; Luis Urzua from Hot Rock Chile SA and Hot Rock Peru SA; and Juan Daniel Silva, AMIRA International Chile.

The visit created interest from a number of Chilean companies and research organisations in project investment, with several showing strong interest in an AMIRA International project in the field of geothermal energy. Visits by Chilean scientists to IMER were another key outcome of the trip.

The relationships developed during this visit built on the efforts of the State Government of South Australia who recently signed a significant memorandum of understanding with the Chilean government. The memorandum will allow the sharing of geosciences data and mineral exploration expertise between Australia and Chile, who share common imperatives in mining, particularly of copper, and energy. This will help to foster growth within both the Chilean and Australian mining industries.

Gondwana to Asia meeting

The 2012 Annual Convention of the International Association for Gondwana Research and 9th International Symposium on Gondwana to Asia was held in Adelaide in November 2012. Researchers from the School of Earth and Environmental Sciences and the Centre for Tectonics Resources and Exploration (TRaX) helped organise the highly successful conference, which was attended by over 130 delegates. Adelaide's location on the edge of Gondwana made it an ideal site for the gathering of geoscientists interested in Gondwanan geology and other supercontinents. Delegates enjoyed oral and poster presentations on Gondwana resources, break-up and amalgamation as well as a pre-conference field trip to the Adelaide Hills and Flinders Ranges to examine Cambrian arc initiation on the Gondwana margin and a post-conference field trip to Eyre Peninsula and southern Gawler Craton.

Australian School of Petroleum
Hosted the South Australia Unconventional Gas Roadmap Launch

Dr Kathryn Amos
Lecturer, Australian School of Petroleum

International Geological Congress Keynote Speaker
Continental depositional systems

Professor Steve Begg
Head of School, Australian School of Petroleum

The Petroleum Exploration Society of Australia Christmas Lunch guest speaker
Are you smarter than a pigeon?

Professor Mark Biggs
Head of School, School of Chemical Engineering

OzCarbon 2012 Meeting Chairman

Dr Mark Bunch
Research Fellow, Australian School of Petroleum

Formation Evaluation Society of Australia Technical Luncheon presentation
Evaluation of the Paaratte Formation, Otway Basin, for CO_2 injection

Master of Science in Energy and Resources Management class, International Energy Policy Institute, University College London, invited lecturer
Carbon capture and storage: what are the big issues and opportunities?

Professor Stephen Grano
Executive Director, IMER

South Australian Investment
Symposium & Panel Session
How do we use mining and energy sector growth to build other industries and enhance South Australia's competitive advantage?

Professor John Kaldi
Chief Scientist, CO2CRC

Technical Program Chair
The American Association of Petroleum Geologists International Conference and Exhibition
Asia Pacific resources: fuelling the future

Professor Gus Nathan
Director, CET

Adelaide City Council
Mining & Renewable Energy Seminar

Advantage SA, South Australian Research and Development Institute, National Media Tour, invited panellist
Renewable energy in South Australia

Australian Institute of Energy, invited seminar
Integrating renewable energy into fossil fuel systems

International Jubilee Conference in honour of Professor Mikko Hupa "From MoleCular Understanding to industrially relevant high-temperature processes" invited presentation
Probing molecular processes to enhance high-temperature industrial processes

Premier's Climate Change Council, invited presenter
Low carbon energy for South Australia

Maptek Users Conference, keynote speaker
Realising your potential

Clean Energy Congress and Expo, Buenos Aires
Generation of liquid fuels and electricity by hybrid solar gasification

FCT Combustion Course (AIE accredited)

Workshop spotlights energy management and storage

The Centre for Energy Technology (CET) and Regional Development Australia - Adelaide Metropolitan co-hosted a workshop on energy management and storage. Held in March, the workshop brought together key stakeholders in industry, academia and government to discuss the role that energy management and storage will play in meeting Australia's future energy needs at lowest cost and highest reliability.

The opportunity to increase penetration of intermittent renewable energy into the National Electricity Market (NEM) was a major discussion topic. South Australia leads the nation in the implementation of intermittent renewable energy and is a key player in the challenge of integrating the technology into a reliable energy supply and demand network.

The event was facilitated by Matt Herring, National Leader of Renewables and Partner, R&D Incentives from KPMG and Kenneth Taplin from Regional Development Australia.

As a result of the workshop, CET and RDA are working on a joint initiative to bring together industry, government and academic collaborators on energy storage research projects and infrastructure that will help South Australia become a world-leader in the area.

Co-hosts of the workshop Kenneth Taplin, Regional Development Australia (left) and Professor Gus Nathan, CET Director (right).

Dr Mark Tingay
Senior Lecturer, Australian School of Petroleum

First Australian Geoscience Teaching Workshop
Chief-Convenor

Professor Avner Vengosh

The Nicholas School of Environment,
Duke University, North Carolina
Environmental implications of hydraulic fracturing

Publications

During 2012 IMER researchers published over 300 journal articles and 50 conference papers.

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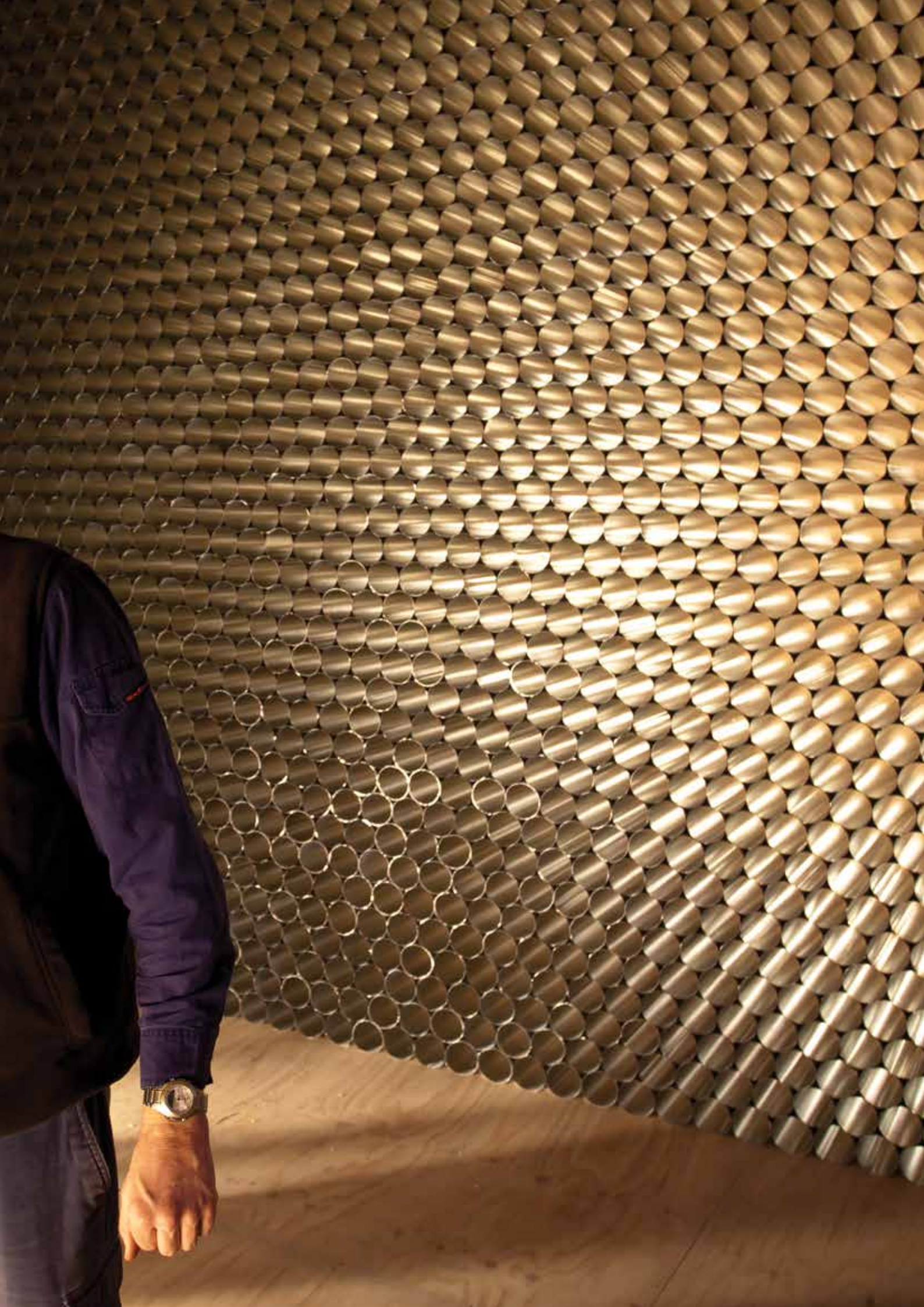

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