

Theo Murphy
High Flyers
Think Tank **2010**

Searching the Deep Earth:

The Future of Australian
Resource Discovery and
Utilisation

The Shine Dome, Canberra
19–20 August 2010

program



Foreword

Each year since 2002, the Australian Academy of Science has held a High Flyers Think Tank to bring together some of Australia's brightest young minds to consider a topic of national importance.

To a large extent, Australia has a minerals economy. However, the easy finds of mineral deposits have already been made and it is becoming increasingly difficult to find large new deposits that are economically viable. This does not mean that Australia has run out of undiscovered giant ore deposits, rather that we need new approaches to understanding the crust we live on and to locating the deposits that do exist. This is particularly difficult in Australia because of deep and extensive coverage by the regolith.

The 2010 Think Tank, *Searching the Deep Earth: The Future of Australian Resource Discovery and Utilisation*, will examine the contemporary challenges facing Australian science in delivering a better understanding of crustal processes and mineral systems, and thereby in delivering more effective exploration strategies. This Think Tank represents a valuable opportunity for some of Australia's leading early- and mid-career researchers to develop new understandings of our world and to identify new approaches that can be applied to this critical issue.

Think Tanks are generously supported by funds from the Theo Murphy (Australia) Fund, which is administered by the UK Royal Society. The Academy is pleased to have this funding available to enable some of Australia's outstanding young scientists to engage in fresh thinking about an area of great importance to the nation and to develop networks that will sustain their careers into the future.

A handwritten signature in black ink that reads "Phil McFadden". The signature is written in a cursive style with a horizontal line underneath the name.

Phil McFadden

FAA



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Day 1 Thursday 19 August 2010

7.30am Registration

8.00am Breakfast

Session 1: Introductory session

Chair: Dr Phil McFadden FAA

9.30am Welcome

Professor Suzanne Cory AC FAA FRS
President, Australian Academy of Science

9.35am Opening address

Dr Phil McFadden FAA
Chair, 2010 Theo Murphy High Flyers Think Tank Organising Committee

9.45am Keynote address

The challenge of discovering deeply buried ore deposits
Dr Neil Williams PSM FTSE
Immediate past CEO, Geoscience Australia

10.30am Morning tea

11.00am Computational, information management and modelling advances

Knowledge discovery via a virtual geological observatory
Professor Dietmar Müller
Professor of Geophysics and Australian Laureate Fellow, School of Geosciences,
University of Sydney

11.30am Giant ore deposits

Giant ore deposits: Why they are important!
Richard Schodde
Managing Director, MinEx Consulting
Adjunct Professor, University of Western Australia

Giant ore deposits: How do we get better at targeting them?
Dr Jon Hronsky
Director, Western Mining Services

12.10pm Innovation and new technology

*Current issues for the future of innovation and new technologies
in minerals exploration*
Dr Tom Whiting
Chairman, Deep Exploration Technologies Cooperative Research Centre

12.40pm Exploration policy – the way forward

Society and exploration: Considerations for now and in the future
Peta Ashworth
Science into Society Group Leader, CSIRO Earth Sciences and Resource Engineering

1.10pm Lunch

Session 2: Breakout groups

2.10pm Group A – Computational, information management and modelling advances

Chair: Professor Dietmar Müller

Rapporteur: Dr Thomas Landgrebe

Group B – Giant ore deposits

Co-chairs: Richard Schodde and Dr Jon Hronsky

Rapporteur: Dr Rob Hough

Group C – Innovation and new technology

Chair: Dr Tom Whiting

Rapporteur: Dr Katy Evans

Group D – Exploration policy – the way forward

Chair: Peta Ashworth

Rapporteur: Dr Chris Yeats

3.30pm Afternoon tea

4.00pm Return to breakout groups

5.40pm Close of session

6.45pm Buses to collect participants from University House

7.00pm Pre-dinner drinks at The Lobby

7.30pm Dinner at The Lobby

Day 2 Friday 20 August 2010

Session 3: Finalising breakout group presentations and reporting back

Chair: Dr Sue Meek FAICD FTSE

Reports from each group

Each rapporteur has been given 15 minutes, plus 10 minutes discussion

- 8.30am** **Return to breakout groups to finalise rapporteur presentations**
- 9.30am** **Group A – Computational, information management and modelling advances**
Rapporteur: Dr Thomas Landgrebe
- 9.55am** **Group B – Giant ore deposits**
Rapporteur: Dr Rob Hough
- 10.20am** **Morning tea**
- 10.50am** **Group C – Innovation and new technology**
Rapporteur: Dr Katy Evans
- 11.15am** **Group D – Exploration policy – the way forward**
Rapporteur: Dr Chris Yeats
- 11.40am** **Open discussion**
Chair: Dr Phil McFadden
- 12.40pm** **Summing up**
Speaker: Dr Neil Williams
- 1.00pm** **Lunch**
- 2.00pm** **Closed session: Outcomes and recommendations**
Organising Committee, speakers, rapporteurs and Academy secretariat
- 5.00pm** **End of Think Tank program**

Introduction

Purpose of Think Tanks

The purpose of the Theo Murphy High Flyers Think Tank series is to bring together early- and mid-career researchers from a broad range of relevant disciplines to engage in thinking about novel applications of existing science (including social science) and technology to issues of national significance, and to identify gaps in knowledge that should be addressed. These events are a unique opportunity for career development and network creation amongst the nation's next generation of research leaders and their institutions.

Think Tanks are one of the premier events of the Academy's calendar and this year is the eighth that the Academy has held since 2002.

Previous Think Tanks

Previous Think Tanks have culminated in reports to government that have been timely, well received and instrumental in influencing policy development. Past Think Tank topics (found at www.science.org.au/events/thinktanks.html) have been:

2002 – Australia's national research priorities

2003 – Safeguarding the nation

2004 – Emerging diseases – ready and waiting?

2005 – Biotechnology and the future of Australian agriculture

2006 – Innovative technical solutions for water management in Australia

2007 – Extreme natural hazards in Australia

2008 – Preventative health: Science and technology in the prevention and early detection of disease

2009 – Agricultural productivity and climate change

2010 Think Tank: *Searching the Deep Earth: The Future of Australian Resource Discovery and Utilisation*

Effective minerals exploration has been central to previous and current mining booms. Australia's future economic prosperity will, to a large degree, depend upon future resource discoveries. Those mineral deposits that were easy to discover have been found and it is becoming increasingly difficult to find large new ore deposits that are economically viable. To continue previous successes in mining requires identifying and resolving the key issues impeding effective minerals exploration in Australia. This will involve exploration of potential cross-discipline opportunities to integrate and extend existing data; foreshadowing the technologies necessary for the next generation of minerals exploration; and putting in place a policy framework that will encourage effective science and successful exploration.

The 2010 Think Tank, *Searching the Deep Earth: The Future of Australian Resource Discovery and Utilisation*, is a valuable opportunity for some of Australia's leading early- and mid-career researchers to identify and propose new approaches to Australian minerals exploration. Participants will focus on identifying new approaches, technologies, data management systems, and policy innovations to facilitate science in delivering a better understanding of the deep Earth and ultimately helping to maintain mining productivity into the future.

The process

The Think Tank theme is introduced with a keynote address and five brief presentations. These presentations are aimed at stimulating lateral thought in the discussions that form the remainder of the Think Tank, rather than providing comprehensive coverage of the theme or any of the four specialist topics.

The afternoon session of the first day of the Think Tank is dedicated to discussions in small breakout groups. Each participant has been assigned to one of four breakout groups and each group will be chaired by the relevant topic speaker(s). Each group comprises a mix of skills and experience in order to stimulate lateral thinking and to challenge the participants to extend themselves and think dynamically. Each Chair has pre-selected a participant to act as

Breakout groups

Group A	Name
Computational, information management and modelling advances Chair Professor Dietmar Müller Rapporteur Dr Thomas Landgrebe	Dr Graham Baines
	Dr Peter Graham Betts
	Tania Dhu
	Dr Weronika Gorczyk
	Dr Jane Hodgkinson
	Associate Professor Eun-Jung Holden
	Dr Margarete Jadamec
	Dr Thomas Landgrebe
	Dr Craig J O'Neill
	Dr Tim Rawling
	Dr Nicholas Rawlinson
	David Robinson
	Dr Gideon Rosenbaum
	Dr Nick Williams
Group B	Name
Giant ore deposits Co-chairs Richard Schodde and Dr Jon Hronsky Rapporteur Dr Rob Hough	Dr Tim Baker
	Christopher Chambers
	Dr James Cleverley
	Dr Robert Dart
	Assistant Professor Marco Fiorentini
	Associate Professor Klaus Gessner
	Dr Ian Graham
	Dr Anthony Harris
	Dr Rob Hough
	Dr Lawrence Leader
	Professor John McLeod Miller
	Thomas Poulet
	Dr Frank Reith
	Dr Simon Richards

the group's rapporteur. The role of the rapporteur is to collate the group's discussions and distil the discourse into a 15 minute presentation. The breakout groups are asked to examine and address their group's discussion questions (below) but are also encouraged to move beyond these questions to other topics identified during the discourse.

On the second day of the Think Tank, after a final review by the breakout groups, each of the four rapporteurs will present the findings of their breakout group. There will be an opportunity for questions and discussion after each presentation, during the general discussion, and in response to the final summing up.

Group C	Name
Innovation and new technology	Dr Benjamin Ackerman
Chair	Dr David Beck
Dr Tom Whiting	Dr Elena Belousova
Rapporteur	Laurie Callaghan
Dr Katy Evans	Dr Raj Das
	Dr Katy Evans
	Dr Ryan Fraser
	Dr Wojtek James Goscinski
	Dr Steven Micklethwaite
	Dr Anya Reading
	Dr Carl Spandler
	Dr Mark Symmons
	Dr Stephan Thiel
	Dr Mark Tingay
Group D	Name
Exploration policy – the way forward	Dr Graham Begg
Chair	Dr Stephen Beresford
Peta Ashworth	Dr Zhaoshan Chang
Rapporteur	Dean Collett
Dr Chris Yeats	Miles Davies
	Professor David Giles
	Aleksandra Kalinowski
	Dr Maxim Lebedev
	Professor T Campbell McCuaig
	Dr Kieren Moffat
	Professor Steven Reddy
	Dr Alanna Simpson
	Dr Hrvoje Tkalcic
	Dr Chris Yeats

Discussion questions

Group A – Computational, information management and modelling advances (specifically including geology, geophysical inversion, geochemistry and geochronology)

- With respect to minerals exploration, what is currently being well-achieved using information management, computational and modelling methodologies?
- What are the significant issues Australia's computational capability faces in becoming an effective tool for understanding crustal processes and identifying mineralisation niches? (Hardware, software, people?)
- Is there a need for a computational strategy to manage the increasing quantities of geological data? If yes, what shape should this strategy take?
- Ideally what systems (including software and hardware) need to be developed to advance this field in relation to minerals exploration?
- How can Australia's current and future computational capabilities be better integrated with the other topics of this Think Tank (Giant ore deposits; Innovation and new technology; and Exploration policy – the way forward)?

Group B – Giant ore deposits

- What successes have there been with regard to understanding the genesis of and exploration for giant ore deposits since the discovery of Olympic Dam, and what specifically supported these discoveries?
- What are the specific causes in Australia of poor progress in the discovery of giant ore deposits?
- How could a strategy be developed that better targeted available resources for future giant ore deposit discoveries?
- What additional resources are necessary to advance Australian minerals exploration, particularly for giant ore deposits?
- How can Australia's current and future mineral exploration capabilities be better integrated with the other topics of this Think Tank (Computational, information management and modelling advances; Innovation and new technology; and Exploration policy – the way forward)?

Group C – Innovation and new technology

- Where in Australia have innovation and/or new technologies been well-utilised to improve Australia's mineral exploration capability?
- What has impeded the innovation and development of new technologies that would improve and enable Australian minerals exploration?
- What key innovations or new technologies will be necessary to advance Australian minerals exploration in the near and distant futures?
- How can investments be strategically made to achieve these new innovations/technologies?
- How can Australia's current and future innovation and new technologies for minerals exploration be better integrated with the other topics of this Think Tank (Computational, information management and modelling advances; Giant ore deposits; and Exploration policy – the way forward)?

Group D – Exploration policy – the way forward (particularly the need for scientists to communicate effectively with politicians and the community at large regarding both the impact and value of searching the deep Earth)

- What is the current state of exploration policy in Australia, including engagement with key stakeholders?
- What policy impediments are there to minerals exploration in Australia?
- What type of strategy is necessary to integrate the views of the various key stakeholders (community, government, industry, academia/research)? How could such a strategy be implemented?
- What policy tools could be invoked to improve Australia's research capability in understanding the crust and in improving our exploration success? In particular, what policy levers could be used to drive more effective integration of the other topics of this Think Tank (Computational, information management and modelling advances; Giant ore deposits; and Innovation and new technology)?

Outputs

The proceedings will be taped, transcribed and made available on the Academy's website. This includes all presentations (verbal and PowerPoint slides), breakout group reports from the second day of the Think Tank, general discussions, and the final summing up. The event proceedings, available in electronic and print formats, will also provide contextual information, identify knowledge gaps and summarise the major outcomes from the Think Tank. These proceedings will offer options for a 'way forward' and subsequently can be used to underpin policy development and research prioritisation.

Organising committee

Chair



Dr Phil McFadden FAA

mcfadden@grapevine.com.au

Phil McFadden was a Chief Research Scientist from 1990 at Geoscience Australia and then Chief Scientist there from 1999 until his retirement in late 2008. He holds BSc honours degrees in physics and mathematics and a DPhil in geophysics. He is a past Chair of the Academy of Science's National Committee for Earth Sciences and in that role developed a national strategic plan for Australian geoscience. He has sat on many high-level government science committees, including the National Resource Infrastructure Taskforce and the National Collaborative Research Infrastructure Strategy committee. He has served as Treasurer of the Academy of Science and in that role served on both the Council and the Executive of the Academy. He was awarded the Gold Medal of the Geological Society of South Africa. He is a Fellow of the American Geophysical Union and a Fellow of the Academy of Science.

Committee members



Peta Ashworth

Science into Society Group Leader, CSIRO Earth Sciences and Resource Engineering
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Biographical details available on page 17.

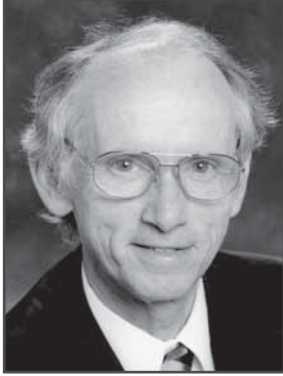


Professor Michael McWilliams

Chief, CSIRO Earth Science and Resource Engineering
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Mike McWilliams is Chief of CSIRO Earth Science and Resource Engineering (CESRE). Energy research in CESRE is focused on maximising the efficiency of petroleum exploration and production, new geothermal energy technologies and geological storage of CO₂. Minerals research in CESRE is enabling prediction and discovery of ore deposits with greater accuracy whilst improving safety, productivity and sustainability in mining.

Before joining CSIRO, Mike was Director of the John de Laeter Centre of Mass Spectrometry, a joint research venture between CSIRO, the University of Western Australia, Curtin University and the Geological Survey of Western Australia. He is Professor Emeritus at Stanford University in California, where he was a scientist and teacher from 1978 to 2006. He is author or co-author of more than 160 papers and has been a consultant to 38 companies, government organisations and universities engaged in minerals and energy exploration and production, electronics and aerospace technologies and science publishing.



Professor Robin Stanton FTSE

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Robin Stanton is Pro Vice-Chancellor (eStrategies) at ANU. Prior to that appointment, he was the inaugural Dean of the ANU Faculty of Engineering and Information Technology, head of the ANU Department of Computer Science and held various industry and academic appointments. He also served as Director of the Cooperative Research Centre – Advanced Computational Systems and the Centre for Information Science research.

Robin's background is in engineering, computer science, information systems and IT governance; developed largely through research, education and management roles in higher education. His academic interests have focused on artificial intelligence, high performance systems, information systems, knowledge management and IT governance. As PVC, he has carried portfolio responsibilities for information infrastructures, enterprise systems, libraries, e-research, e-learning and digital futures planning. Robin holds a PhD in computer science from the University of NSW and is a Fellow of the Australian Academy of Technological Sciences and Engineering.



Dr Neil Williams PSM FTSE

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Mr Roy Woodall AO FAA FTSE

Consultant, Earthsearch Consulting Pty Ltd
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Roy Woodall is a graduate of the University of Western Australia and Berkeley University, California. He joined Western Mining Corporation (WMC) in 1953 and spent his entire career with that company directing their mineral and petroleum exploration for nearly 40 years.

Through exploration success WMC became one of Australia's great mining companies. Discoveries were made in Western Australia; important gold deposits and a new previously unknown nickel province which is now a major world producer from nickel sulphide ores. In 1976 the company discovered the giant Olympic Dam copper, gold, uranium deposit in South Australia which transformed the area into one of the world's great mineral provinces. Oil fields were also discovered offshore Western Australia.

The WMC geological staff made important contributions to the understanding of ore deposits through careful scientific documentation. Roy is a Fellow of the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering and the Australasian Institute of Mining and Metallurgy. Honours and awards include Officer of the Order of Australia and the Academy of Science's Mueller and Haddon Forrester King medals.

Speakers



Dr Neil Williams PSM FTSE

Immediate past CEO, Geoscience Australia
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Neil was the Chief Executive Officer of the Australian Government's national geoscientific research and spatial information agency, Geoscience Australia, and two of its predecessor agencies for 17 years until his retirement in January 2010. He trained as an economic geologist and received his BSc (Hons) degree from the Australian National University and his PhD from Yale University. Upon completion of his PhD he returned to the ANU and worked there for five years as an academic specialising in the genesis of sediment-hosted base-metal deposits. In 1981 he joined the then Mt Isa Mines group of companies as a mineral explorer and remained with them for 10 years before joining one of Geoscience Australia's predecessors, the Bureau of Mineral Resources, in 1991. He was appointed CEO of the Australian Geological Survey Organisation in 1995 and oversaw the transformation of that agency into the present-day Geoscience Australia.

Neil received the Public Service Medal in the 2006 Australia Day National Honours List for outstanding public service in the provision of geoscientific advice to government, geoscience services, industry and the public. He is a Fellow of the Australian Academy of Technological Sciences and Engineering and was awarded the Society of Economic Geologists Lindgren Award in 1981 for his research on the McArthur River lead-zinc deposit in the Northern Territory. He was the President of the Society in 2008. He also led Oceania's successful bid for the 34th International Geological Congress to be held in Brisbane in August 2012, and is President of the 34th Congress.

The challenge of discovering deeply buried ore deposits

The world's hunger for mineral commodities is unlikely to lessen in the foreseeable future, given the twin drivers of global population growth and economic expansion.

During the 20th century, and particularly after World War 2, supplies of minerals were sustained by an unprecedented period of successful mineral exploration that was dominated by the discovery of a wide range of outcropping and near-to-surface ore deposits.

Factors contributing to this success included:

- the opening up of prospective terranes for exploration;
- comprehensive geological maps of these terranes;
- a revolution in surface geochemical exploration techniques;
- the development of a wide range of geophysical exploration tools – both ground-based and airborne; and
- advances in our understanding of the genesis of ore deposits and the geological environments in which particular ore types form.

However, discovery rates began to slow towards the end of the 20th century. This is attributed to the declining number of outcropping and near-surface, and hence easy-to-find, ore deposits that remain to be discovered.

The challenge now facing explorers is how to find more deeply buried ore deposits, both in regions of known mineralisation and in regions where terranes of unknown prospectivity are obscured by overlying barren rocks.

To meet the challenge many new activities will be needed. Some of these are:

- methods for producing accurate 3D and 4D geological maps to facilitate deep exploration in the same way that surface geology maps aided exploration in the 20th century (this will involve the integrated inversion-modelling of different geophysical datasets – an activity that will involve many mathematical and ITC challenges);
- the redefining of ore types in geophysical terms, rather than in geological, mineralogical, and geochemical terms as is the norm today; and
- the development of a new generation of genetic ore-deposit models that focus on *where* particular ore types form in time and space, rather than on *how* particular ore types form, as is the norm today.

Participants in this Think Tank have the opportunity of probing these challenges further, as well as coming up with other innovative ideas for improving our ability to successfully discover the world's future sources of minerals.



Professor Dietmar Müller

Professor of Geophysics and Australian Laureate Fellow, School of Geosciences, University of Sydney
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Dietmar received his undergraduate degree from the Christian-Albrechts University of Kiel in Germany, followed by a PhD in Earth Science from the Scripps Institution of Oceanography in San Diego/California in 1993. After joining the University of Sydney as a lecturer in geophysics in 1993, he established the University of Sydney Institute of Marine Science and built the EarthByte e-research group. The EarthByters are known for pursuing open innovation, involving the collaborative development of open-source software and global digital datasets, made available under a creative commons license.

One of the fundamental aims of the EarthByte group is geodata synthesis through space and time, assimilating the wealth of disparate geological and geophysical data into a 4D Earth model.

In 2000 Dietmar was awarded the Fresh Science Prize by the British Council and ScienceNOW, followed by the Carey Medal in 2004 for his contributions to the understanding of global tectonics. In 2006 he was elected Fellow of the American Geophysical Union and in 2009 he was awarded an Australian Laureate Fellowship. From January to July 2010 he was a visiting professor at the Ludwig-Maximilians-Universität München, Germany, funded by a Deutsche Forschungsgemeinschaft (German Research Foundation) Mercator Fellowship.

Knowledge discovery via a virtual geological observatory

Earth science has a history of being data-rich and information-poor, an imbalance that is growing year by year, due especially to a flood of remotely sensed data. A major problem now faced by geoscientists is how to amalgamate data and to connect them to analysis- and process-modelling tools. This is particularly relevant to the study of mineral

and petroleum resources, which typically form over time periods of hundreds of millions of years. In order to make digital Earth datasets suitable for resource exploration, one needs to be able to restore the geographic positions of all data back through geological time, and link data to models of the processes by which resources are formed. The Virtual Geological Observatory (VIRGO) project is designed to fill this fundamental technological gap. VIRGO is set up to develop a formal knowledge-discovery platform that connects testable ideas, concepts and models regarding plate tectonic and geodynamic processes with reconstructable digital geodata. A GIS-like framework with temporal awareness forms the core of the information model, interoperating with various GIS formats. It is able to reconstruct point, line, polygon and raster (gridded) data in accordance with past plate configurations, and model other time-dependent attributes in a coherent fashion. An important capability provided by VIRGO is the provision of quantitative spatio-temporal data analysis and data mining. Data co-registration considers spatial relationships over time and transforms disparate datasets into a homogenous data structure, which can then serve as an input to subsequent analysis- and data-mining tools, partitioned into supervised and unsupervised paradigms. Visual analysis tools in the form of interactive plots, charts and statistics will be an integral part of the process, helping to convey information from machine-learning tools such as cluster analyses, data projections and classifications.



Richard Schodde

Managing Director, MinEx Consulting
Adjunct Professor, University of Western Australia
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Richard has 30 years experience in a wide variety of project analysis and strategic planning roles within the international resources industry – including 15 years at Western Mining Corporation (in their Business Development Group and as Strategic Planning Manager for the Exploration Division) and, more recently, four years at BHP Billiton (as minerals economist in their Global Exploration Team). Two years ago he founded MinEx Consulting to provide strategic and economic advice to industry and government. From his work Richard has developed a deep understanding of the drivers

behind mineral exploration and assessing the various trade-offs between the geological, technical, economic and business risks of a given project. This underpins his work in helping companies identify how to make money out of exploration.

Richard has a first class honours degree in materials engineering and an MBA. Along the way he has learnt some geology. He serves on several industry committees, including the AusIMM and the Melbourne Mining Club. In 2009 he was appointed an Adjunct Professor at the School of Earth Sciences at the University of Western Australia and is a member of the AusIMM, SEG, SME and PDAC. He has published several papers on exploration discovery rates and industry performance and is internationally recognised by his peers as a world leader in mineral economics.

Giant ore deposits: Why they are important!

For obvious reasons, all explorers would like to find giant orebodies. However, what we really need to find is world-class mines (WCMs) – as not all giant accumulations of mineralisation are economic.

There are many benefits in finding WCMs. The geologist is keen to receive the kudos, the developer is keen to make money and have a 'company-making mine' that transforms their business. From society's perspective, WCMs create employment and enable major investments in infrastructure and downstream processing. Such mines often redefine the cost base of the industry, leading to cheaper materials and a better standard of living for everyone. Finally, they generate most of the industry's profits and taxes.

The challenge is that, for many commodities, it is progressively becoming more difficult to find WCMs. By definition they are extremely rare, but on the flip-side they tend to have large and obvious signatures. The problem for Australia is that all of the outcropping deposits have been found, and one now needs to look under deep cover and/or go to new search spaces. This requires:

- being innovative and creative in knowing where best to explore;
- being effective in testing the target; and
- developing new mining and processing technologies to best extract the ore.

Related issues are:

- Given the riskiness of exploration, what is the best way to manage your project portfolio?
- How do you measure the exploration effectiveness prior to discovery?
- What are the best tools, models and techniques for finding a WCM under deep cover?
- How to know whether a deposit has the makings of being world-class?
- Are WCMs made or found? Innovations in mining and processing can change what is economic ore.



Dr Jon Hronsky

Director, Western Mining Services
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Jon is currently a principal of Western Mining Services (WMS), a consultancy group with offices in Perth and Denver that provides services to the global mineral exploration industry. WMS specialises in the strategic management of mineral exploration and the exploration targeting process. Jon is also Chair of the Board for the Centre for Exploration Targeting, an industry-focused research group based at the University of Western Australia and Curtin University in Perth. In addition, he is a director of Encounter Resources, a Western Australian-focused uranium- and base-metals junior explorer. Prior to his current role, Jon was Manager of Strategy and Project Generation for BHP Billiton's

global mineral exploration group, and before that Global Geoscience Leader for Western Mining Corporation Resources.

Jon graduated from the Kalgoorlie School of Mines with a degree in mining geology in 1983 and then joined WMC Resources. He completed his PhD at the University of Western Australia in 1992. Subsequently his career focus has been on developing an understanding of the key business dynamics that drive mineral exploration and the interface between innovative geoscience and pragmatic exploration business outcomes, particularly as related to exploration targeting. His exploration targeting work led to the discovery in 2000 of the West Musgrave NiS province in WA. Jon was awarded the Gibb Maitland Medal in 2005, the highest award of the WA Division of the Geological Society of Australia. He was the 2009 Society of Economic Geology Distinguished Lecturer.

Giant ore deposits: How do we get better at targeting them?

Twentieth century economic geology failed to determine why some ore deposits were giants. However, recent advances now point the way towards a new paradigm for understanding ore formation and therefore a future in which predictive models for giant deposits may be developed.

The first key realisation is that ore deposits are the focal points of much larger systems of mass and energy flux. These 'mineral systems' are very large scale, commonly involving the entire lithosphere and subcontinental-size areas. The

other key advance is recognising that ore-forming systems are primarily physical systems. The critical element is a highly anomalous spatial concentration of mass flux (via the agency of advective fluid flow). Historical research was biased towards chemical aspects of ore formation, largely because these have been easier to study, and the more important (from a targeting perspective) physical processes were relatively neglected.

The above two fundamental concepts provide a powerful framework for unifying our understanding of ore-forming process. There are several important aspects that derive from these:

- lithosphere-scale architecture is a fundamental control on the location of giant ore systems;
- the importance of regional-scale pre-fertilisation of the upper mantle in many systems;
- ore systems, especially giant ore systems, require a high degree of self-organisation and therefore a major gradient barrier to ore fluid flow;
- only a small number of geodynamic scenarios have ore-forming capability; and
- the size of any deposit will depend on a combination of available advective fluid/energy flux and the degree of organisation of that flux.

Finally, we can now propose an explanatory hypothesis for the 'lineament concept', one of the earliest empirical concepts relating to the targeting of giant ore deposits: that they represent an emergent property of the complex interaction of the various elements of the long-lived orogens that host most major ore deposits.



Dr Tom Whiting

Chairman, Deep Exploration Technologies Cooperative Research Centre
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Tom has 32 years experience in global exploration project generation and management. He is currently a consultant, working in the minerals exploration and R&D fields. He is also currently the independent Chair of the newly formed Deep Exploration Technologies CRC.

Tom held numerous senior exploration management roles within BHP Billiton, including vice president of Minerals Exploration from 2000-2004. In this role, he was responsible for BHP Billiton's global minerals exploration program whilst based in Melbourne. He has a successful exploration discovery record. Prior to joining BHP Billiton, he worked for CRA Exploration Pty Ltd and Geoterrex Pty Ltd, an international geophysical contractor, in Australia and Canada. He started his career with Delhi Oil, based in Adelaide.

Tom has a history of involvement in industry-led research developments. This includes Falcon, the world's first airborne gravity gradiometer, and helping develop and instigate the Deep Exploration Technologies CRC. His current interests revolve around helping various organisations solve the problem of lifting exploration investment and improving current declining discovery rates in Australia.

Current issues for the future of innovation and new technologies in minerals exploration

Although its national benefits have been overwhelmingly positive, one issue resulting from the recent minerals boom has been an acceleration in the decline of resource quality due to the interplay of rapidly increasing commodity production rates and the longer term decline of discovery rates of world-class mines.

One solution to this challenge is new innovative technologies and exploration methods aimed at expanding the effective search space within which these world-class mines may be found. In Australia that is both within the deeper sections of existing terranes of known high prospectivity and within poorly understood terranes generally covered by unconsolidated cover.

New technologies would seek to improve targeting through exploration tools that enable improved detection and discrimination of ore deposits and improved testing technologies (eg, drilling). Innovative methodologies may include the way information is bundled or visualised to create knowledge leading to discovery.

Australia's minerals industry R&D capability is amongst the best in the world. There are several important initiatives under way that are a carefully researched response to the national issue outlined above. These include CSIRO's Minerals Down Under Flagship, the National Collaborative Research Infrastructure Strategy/AuScope initiative and the new Deep Exploration Technologies CRC. Many university groups are also in this research space (eg, Centre for Exploration Targeting, University of Western Australia; ARC Centre of Excellence in Ore Deposits (CODES)) and there is much relevant research outside the minerals industry (eg, petroleum, defense and medical industries).

So will this ensure success in the future?

One could pose the question of how we draw these various research initiatives together to maximise our chances of success. Some key issues for consideration include the following:

- Ensuring a flow of information and results across the various organisations involved in minerals research initiatives in a systematic and strategic way.
- Research capacity appears tight as most researchers are fully engaged on existing programs. This makes it difficult to free up capability to identify new transformational innovations and technologies outside of what has currently been identified.
- Success will require early and aggressive adoption of innovations by industry. For this to occur, the link between mining houses/explorers, their industry service providers and R&D providers needs to be transparent and efficient.



Peta Ashworth

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Peta Ashworth brings over 20 years of experience working in a range of senior management and research roles. She is currently group leader of the Science into Society Group within CSIRO's Division of Earth Sciences and Resource Engineering, leading a team of social researchers examining stakeholder perceptions to areas of national significance to Australia. Peta's main research interest is how to deliver information to best effect. She has gained an international reputation as a leading researcher in understanding stakeholder perceptions to climate change and low emission energy technologies, in particular carbon capture and storage. This research

is critical because although much of the effort to address climate change will be led by industry and government, energy users at the community level will also play a critical role both in technology acceptance and behaviour change. Peta believes it is important to educate and empower them to engage with this issue and work towards environmental sustainability. She co-authored *The CSIRO Home Energy Saving Handbook – How to save energy, save money and reduce your carbon footprint*, which was released late 2009, and is currently chair of the International Energy Agency Greenhouse Gas Social Research Network.

Society and exploration: Considerations for now and in the future

The worlds of industry, society and governance are intertwined. Changes in one will affect the others and influence the rate of change and the acceptance of the industry, technology or process. A key issue for whether an industry is accepted by society is how the industry, and the risks associated with it, is perceived. If society perceives the risks to be too great it can delay or cease a project.

The Australian minerals and exploration domain face similar challenges of this interconnectedness. Declining ore grades, increasingly difficult operational conditions, accelerating constraints around water and energy use and changing policy contexts are impacting on the way business is done. Each of the challenges has societal implications that also impact on those involved in exploration.

When projects are delayed, as a result of public opposition, in most cases government will be brought in to decide whether to overrule or allow the local opposition to stand. Reasons most often cited for opposition include concerns around environmental impacts, subsidence, impacts on local housing prices, effects on local agriculture and local water supplies. Many of these concerns can arise through a lack of knowledge about the processes involved, a lack of adequate regulatory frameworks, or competing priorities between stakeholder groups.

This paper will explore the role that social sciences can play to enhance societal acceptance of minerals and exploration. It will draw on a number of case studies to highlight potential issues and present some considerations of what may constitute a positive way forward, and identify ways to think about these in relation to minerals and exploration in the next 20 to 30 years.'



Dr Phil McFadden FAA

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Phil was a Chief Research Scientist from 1990 at Geoscience Australia and then Chief Scientist there from 1999 until his retirement in late 2008. He holds BSc honours degrees in physics and mathematics and a DPhil in geophysics. He is a past Chair of the Academy of Science's National Committee for Earth Sciences and in that role developed a national strategic plan for Australian geoscience. He has sat on many high-level government science committees, including the National Resource Infrastructure Taskforce and the National Collaborative Research Infrastructure Strategy committee. He has served as Treasurer of the Academy of Science and in that role served on both the Council and the Executive of the Academy. He was awarded the Gold Medal of the Geological Society of South Africa. He is a Fellow of the American Geophysical Union and a Fellow of the Academy of Science.



Dr Sue Meek FAICD FTSE

Chief Executive, Australian Academy of Science

Sue has 25 years experience working in a variety of capacities at the interface of industry, academia and government. Her particular interests are in promoting awareness and understanding of science and technology, and the formulation of policies and programs to stimulate the conduct and application of research and development. Sue held the position as Australia's inaugural Gene Technology Regulator from December 2001. This statutory appointment was established to administer the national regulatory system for the development and use of genetically modified organisms. Immediately prior to that, she was Executive Director, Science and Technology in the Western Australian Department of Commerce and Trade. In this role she was responsible for the development and implementation of state policies on science and technology and public sector intellectual property management and the administration of grant programs to support innovation and the development of research infrastructure.

Sue has a PhD in marine biology; a Masters in oceanography; and an honours degree in microbiology. She is a Fellow of the Australian Institute of Company Directors and of the Australian Academy of Technological Sciences and Engineering. She is a member of the Centre for Environmental Risk Assessment Advisory Council and was one of 14 inaugural recipients of James Cook University's Outstanding Alumni award.



Dr Thomas Landgrebe

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Tom is a data-mining specialist, having obtained Bachelors and Masters degrees in electrical engineering at the University of the Witwatersrand in Johannesburg, South Africa, and a doctorate in the area of statistical pattern recognition at Delft Technical University, The Netherlands. He spent around seven years performing R&D at De Beers, focusing on image-processing and pattern-recognition related technology. Hyperspectral-based mineral sorting and image-based diamond population analyses for diamond exploration were two significant projects where he played a primary role, including project management. Tom joined the EarthByte group in 2010. His research interests span several areas of computational intelligence, ranging from the design of practical machine-learning systems, the formal incorporation of expert knowledge into learning machines, and image, video, GIS and hyperspectral data processing. Recently his research focus has shifted towards developing a coherent spatio-temporal data-mining framework for paleo-GIS data analysis.

Tom's research is directly related to the Think Tank theme, especially regarding new technology and data management. He is developing a data-mining infrastructure integrated into the GPlates tectonic plate simulation software to identify complex relationships between diverse geographical data sources. The technology will be in a unique position to coherently analyse data both spatially and temporally, thus exposing important dynamics related to deep Earth time. Studies with large potential impact for Australian exploration will be made possible, such as the relationships between plate tectonics and ore deposit formation, and explicitly showing associations between pre-competitive data and late-stage exploration outcomes.



Dr Rob Hough

**Research Stream Leader in the Discovery Theme of the Minerals Down Under
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Rob is a geologist and senior research scientist in CSIRO whose major research is in the properties of natural gold and how it is deposited within the Earth. He is the author of publications in *Nature*, *Geology* and *Science*. He has received research funds in the form of fellowships from the Robert Blair Fellowship and the Royal Society. He received the Western Australian Premier's Award for Early Career Achievement in Science in 2004, the Perth Convention Bureau Scholarship in 2006 and the CSIRO Julius Career Award recognising mid-career excellence in 2009. He has been invited to edit a special issue on nanominerals in ore deposit processes in *Ore Geology Reviews* in 2011; he was editor of *Elements'* special issue on gold in 2009; and he won the Geological Society of Australia's AB Edwards Medal in 2008 for the best paper in economic geology. He has been an invited plenary speaker at 15 international conferences and was a convenor at the Goldschmidt Conference in Knoxville, USA, in June.

Rob has worked for eight years at the interface between regolith (surface) and hypogene (deep crust) exploration geochemistry, with specific emphasis on gold exploration and targeting. He is a research leader in gold mineralogy and geochemistry in ore deposits and exploration samples. His work has focused on developing innovative new avenues in research on gold at all scales, from nanoplates to nuggets. Rob partners very closely with university collaborators on research across Australia and internationally and is renowned for his ability to develop a collaboration and to communicate his results widely. He works very closely with the gold exploration and mining industry in Australia and leads several research projects heavily funded by industry and is a co-investigator on several others. He has already begun to develop a group of young researchers to work on these projects and as such can be seen as a future leader in exploration geochemistry in Australia. His ability to integrate across disciplines (gold in plants, gold with bacteria, metallography of gold, gold colloid chemistry) in order to pursue new research directions for the Australian gold industry is well-recognised as necessary to promote new exploration in Australia and to foster the discovery of new gold deposits.



Dr Katy Evans

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Katy was awarded a PhD on metamorphic fluid flow by Cambridge University in 1999. Subsequent postdoctoral work on mineral dissolution and precipitation in mine spoil was followed by a move to Australia in 2002 to CSIRO Exploration and Mining to work on gold deposits and the thermodynamic characteristics of sulfur-bearing, high ionic strength, mixed solvent fluids. In 2005 she was awarded an Australian Synchrotron Research Fellowship and moved to the Australian National University, where she performed experiments on CO₂-bearing solutions, with applications to the formation of gold deposits from CO₂-rich fluids. She began a Research and Teaching Fellowship at Curtin University in 2007.

Katy's research focuses on fluid-rock interaction, particularly open-system interactions that redistribute redox-sensitive elements such as Fe, S and C. These systems have tremendous relevance to ore formation, as redox reactions in open systems are a key factor in the formation of a range of ore deposit types.



Dr Chris Yeats

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Chris received his PhD in 1996 and is a mid-career ore systems geologist. He has 20 years experience in base- and precious-metal exploration and research in terranes ranging in age from the Archaean to modern active seafloor hydrothermal systems. His current research focuses on exploration for and the geochemistry, mineralogy and petrology of volcanic-hosted massive sulfide mineralisation in ancient and modern terranes. He has played a leading role in 14 research cruises on a range of vessels; the highlights include a manned submersible dive on the PACMANUS hydrothermal field, the first attempt to drill an active felsic-hosted hydrothermal system during Ocean

Drilling Program Leg 193 (where he led the crucial hydrothermal alteration study) and the first commercial exploration drilling for seafloor sulfides on the Kermadec Ridge in December 2005. As a member of the Seafloor Hydrothermal Systems Team, in 2002 he received the CSIRO Chairman's Medal for Research Excellence. He is the Western Australian Divisional Chair of the Geological Society of Australia.

In his role as Research Program Leader for Mineral System Science, Chris leads 90 staff who represent Australia's largest multidisciplinary mineral-exploration focused research group. His position provides him with a broad perspective of emerging trends and technologies in the Earth sciences, while CSIRO's unique role within the National Innovation System requires that he is cognisant of the issues that impact on the minerals industry. Chris has also had significant involvement with the nascent seafloor exploration and mining industry in the South Pacific region and is able to speak on the benefits and barriers to this potentially major new opportunity for the minerals industry in Australia.

Early- and mid-career researchers



Dr Benjamin Ackerman

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Ben has spent ten years in minerals exploration as a geologist, both in industry and research roles. During this time he gained experience in gold and base-metal exploration in New South Wales, Victoria, Western Australia and Fiji, where he has managed exploration programs for porphyry copper-gold, epithermal gold deposits and industrial metals. He obtained his PhD in geology from the University of Wollongong for work on the geochemical exploration of the Girilambone region of New South Wales and continues to further his interest in mineral exploration in his current appointment as District Geologist with Newcrest Mining Limited in Fiji.

Ben will contribute to the theme of the Think Tank through experiences gained in mineral exploration in Australian and Fiji, which have included deep diamond drilling, exploration under more recent cover sequences and successful discovery and advancement of copper-gold deposits. He has designed and managed all aspects of mineral exploration in regions ranging from arid to tropical, and has stayed abreast of new technologies in mineral exploration and exploration drilling both in Australia and internationally. Having practiced mineral exploration in several physical, political and social settings, Ben has developed a broad understanding of the challenges in further resource discovery in Australia.



Dr Graham Baines

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Graham is a geophysicist whose research integrates geological observations with geophysical data, primarily magnetic and gravity surveys, in order to understand the geodynamic evolution of Earth's lithosphere. Having completed undergraduate studies in geology and geophysics at the University of Liverpool, he undertook PhD research in geophysics at the University of Wyoming. His PhD research used bathymetric, magnetic and gravity data, together with geochronologic dating and numerical models, to determine the tectonic evolution of >130,000 km² of oceanic lithosphere at the Southwest Indian Mid-Ocean Ridge. Since completing his PhD he has moved to Adelaide to take up a postdoctoral research position at the South Australian Centre for Mineral Exploration Under Cover (CMXUC), where his research integrates seismic,

magnetic, gravity and sparsely distributed drillhole constraints to determine the basement architecture and evolution of the Archean-Mesoproterozoic Northern Gawler Craton, where it is buried beneath sediments of the Eastern Officer Basin.

Mineral exploration in Australia is increasingly focusing on exploration for deposits that are buried beneath or within layers of sedimentary cover. Locating such deposits requires the use of geophysical techniques to remotely sense and locate prospects. Graham's work at CMXUC has primarily focused on the integration of geophysical datasets with known geology to image the geology of basement in areas of significant cover. Integration of expertise and development of methodologies to accomplish this more efficiently have the potential to greatly assist in the next generation of minerals exploration in Australia.



Dr Tim Baker

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Tim has been the Manager of the Geological Survey of South Australia since 2009. Prior to this he held positions as Exploration Manager for Sovereign Metals Ltd (2007-2009) and lecturer/senior lecturer in mineral deposit geology at James Cook University (1999-2007). He has published over 100 scientific articles in mineral deposit geology and presented at numerous national and international meetings. He has received international awards for this work, including the Lindgren Award from the Society of Economic Geologists. This prestigious cited international honour is presented to a researcher under the age of 37 who has made an outstanding contribution to the discipline. He received a BSc (Hons) degree from the University of Wales, College of

Cardiff in 1992 and a PhD from James Cook University in 1996. He carried out postdoctoral research at the Mineral Deposit Research Unit, University of British Columbia between 1996 and 1999.

Tim has an international reputation in economic geology, developed through the past 14 years in academia, industry and government. He has carried out multidisciplinary research, exploration and consulting on a wide range of mineral deposit types in geographically diverse regions. His research activities have involved a wide range of partners including junior to major exploration and mining companies, universities, government surveys and competitive research funding agencies. His roles as an exploration and government survey manager have provided a cross-disciplinary perspective on industry and government. This includes experience in managing and executing exploration programs, interacting with diverse stakeholders, and developing a practical understanding of exploration, mining, infrastructure and environmental and social sustainability issues within the minerals sector.



Dr David Beck

Principal Engineer, Managing Director, Beck Arndt Engineering Pty Ltd
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David is a mining engineer working in the field of rock mechanics and mine design for complex and difficult geotechnical environments. Since forming Beck Arndt Engineering (BAE) in 2005, David has led and provided advice to geotechnical studies for some of the largest and deepest open pit and underground mines in Australia, South Africa, Indonesia, the USA and Canada. In many cases, BAE's work involves the conceptual development and optimisation of projects in deep or difficult geotechnical environments at the limits of current industry experience. BAE has developed tools and techniques for better integrating geophysical and geological data to better forecast risk in these uncertain environments and continues research in deep mine

design, forecasting mine stability, and seismicity and hydromechanical simulation. Before forming BAE, David worked as a consultant and prior to that as a rock mechanics engineer for Mt Isa Mines, where he completed a PhD in the engineering management of induced seismicity in deep level hard rock mines.

Over the past decades the global mining industry has achieved continuous improvement in productivity through technical innovation. The most significant technical improvements have been in mechanisation and processing. In the fields of rock mechanics, deep orebody exploration and mass mining, innovation has struggled to keep pace with the needs of industry and society. Only pits and block caves have deepened or grown in size quickly and anecdotal evidence suggests current methods are nearing physical limits. Incremental improvements to old techniques will not keep pace with the challenges and problems of increasing heat, rock stress, seismicity, transport costs and difficulties in gaining orebody knowledge. These vulnerabilities will need to be addressed with step-change innovations. Current models for risk management applied during the design and operation of mines will also need to change. In the future, mines will need surer- and higher-resolution geological and geotechnical information and more robust designs. David's experiences in working on mines facing these challenges over the past 15 years will provide valuable input into discussions on resource policy, exploration, geophysical programs and mine planning.



Dr Graham Begg

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Graham has a BSc from Melbourne University and a PhD on epithermal gold systems and tectonics from Monash University. During 22 years with Western Mining Corporation and BHP Billiton he gained experience in exploration for a variety of commodities and from 2002-2007 was responsible for the global targeting framework for project generation. For the past eight years he has also been a principal investigator in a (WMC/BHP Billiton) collaborative research project with the ARC National Key Centre for Geochemical Evolution and Metallogeny of Continents (GEMOC) group at Macquarie University, Sydney. This project aims to create the first detailed map of the global continental mantle lithosphere, to facilitate a breakthrough in both understanding the controls on giant ore-forming

systems and, by extension, greenfields mineral discovery. In 2007 he formed his own consulting company Minerals Targeting International Pty Ltd. He was the 2009 International Exchange Lecturer for the Society of Economic Geologists.

Graham will contribute to the Think Tank in several ways. Firstly, through his world-leading expertise in the 3D structure of continents, the relationship between crust, mantle lithosphere, tectonic setting and geodynamic processes. Secondly, through his understanding of how this provides the context for the spatial and temporal development of ore systems and giant ore deposits. Thirdly, through his broad understanding of the many scientific disciplines required to enable integration of the diverse information types. Finally, through his familiarity with the minerals industry; the exploration process; and the tools available to explorers, government bodies and research institutions.



Dr Elena Belousova

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Elena graduated with a BSc (Hons) degree in geology from Kiev University, Ukraine in 1988. She obtained her PhD degree from Macquarie University in 2000, studying the trace-element signatures of zircon and apatite in a wide range of rock types and mineral deposits. Research interests include the timing and nature of the growth of Earth's continental crust; essential knowledge for a robust framework for resource assessment and exploration. Her ARC-APD (2003-2006) work has shown a new approach to crustal evolution studies and contributed to the development of the TerraneChron® methodology, which is now a powerful technique for the Australian (and international)

mineral exploration industry. The competitive Vice-Chancellor's Innovation Fellowship was awarded to Elena in 2006, and represented further recognition of the potential of TerraneChron®. This mixture of fundamental and applied research has resulted in her publications appearing both in high-impact journals and in those that reach the exploration-oriented end-users.

Elena's research, since her PhD, has been instrumental in developing leading-edge geochemical methodologies, based mainly on zircon geochemistry, in providing a tool for geochemical and tectonic remote sensing of inaccessible regions on the Earth's surface and in the deep crust. Her diverse research expertise in geochronology, geochemistry, analytical methodologies and field expertise, directed to understanding the evolution of the Earth's crust, provides the ideal background for further innovative ideas and developments that could be inspired through interaction with research from a broad range of relevant disciplines as well as professionals from industry attending this Think Tank.



Dr Stephen Beresford

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Steve's career is a mix of academia and industry, including tenured faculty at Monash University; professor at University of Western Australia; principal exploration geologist in nickel at Western Mining Corporation; manager of project generation (ASA) at BHP Billiton; and commodity specialist. His current positions include Chief Geologist of Minerals and Metals Group and Adjunct Professor at the University of Western Australia and Monash University. Steve continues to supervise students, publish papers and give over 10 workshops per year on exploration. In academia he has published over 50 papers, supervised over ten postgraduate students and five postdocs, and received competitive ARC grants and industry funding worth more than \$4 million. In industry he

has been involved in, and led, exploration groups in 32 countries, on all continents except Antarctica.

Steve's speciality is at the earliest stage of exploration – that is, area selection or project generation. His career has been uncommon, holding senior positions in research and exploration while still mid-career. He believes that the unique perspective gained through his various positions and his speciality in one portion of the exploration value chain will be his main contribution to the Think Tank.



Dr Peter Betts

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Peter is a senior lecturer in the School of Geosciences at Monash University and a senior partner in a small consulting firm, PGN Geosciences, which specialises in geophysical interpretation and modelling for the resource sector. His primary research interest is the integration of structural geology, aeromagnetic and gravity interpretations to understand geological structures and their signatures in large-scale magnetic and gravity datasets, with an emphasis on continental evolution and controls of mineral systems. Peter has an international reputation for developing plate tectonic models for the evolution of the Australian lithosphere during the Proterozoic era and has published 55 peer-reviewed papers in international journals. He is the chair of the Geological Society of Australia Specialist Group in Tectonics and Structural Geology.

He also consults widely to international exploration and mining companies; including geophysical interpretation and modelling for terrane analysis, mineral targeting, and construction of 3D models.

Peter's research skills are in direct alignment with the theme of the Think Tank. His current research activities include mapping deep Earth structures in the Australian continent using the Earth's magnetic and gravity fields and he is one of Australia's leading geoscientists in constraining the tectonic evolution of the Australian plate, so he can provide geological context for the discussions. Furthermore, he has undertaken research in understanding Proterozoic mineral systems in north and south Australian terrains and regularly consults for Australia's mineral explorers, so has an understanding of the applied difficulties associated with mineral exploration.



Laurie Callaghan

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Laurie has worked for over ten years as a software developer at various large and small enterprises, in both the public and private sector. He has been with Intrepid Geophysics, a leading company in geophysical processing software development, for the past five years. He is interested in processes for improving software development practices, enhancing the usability of complex software systems, and extracting better performance from recent and future computer hardware advances. Laurie holds a BSc in computer science from the University of Queensland.

Effective use of information technology is a critical part of our resources industry. Future developments such as the proposed National Broadband Network will increase its capacity. We must devise strategies to use this increased capacity to increase our capabilities. Laurie combines a broad interest in many areas of science with a strong focus in IT as a practical tool to help solve real problems.



Chris Chambers

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Chris holds a BSc (Hons) from Flinders University of South Australia and has 15 years of continuous industry experience as a mine geologist, exploration geologist and property-generation geologist, in four countries. He has had exposure to eight styles of gold and base-metal mineralisation but specialises in low-sulfidation epithermal gold mineralisation. During his career, Chris has worked closely with Earth science students and researchers from the ARC Centre of Excellence in Ore Deposits (CODES) at the University of Tasmania, the Economic Geology Research Unit at James Cook University, the WH Bryan Mining Geology Research Centre at the University of Queensland, and a variety of industry consultants and experts.

In his role as an explorer, Chris has two main research areas:

- the zonation and gradation of host structure characteristics, vein textures and multi-element geochemistry in relation to gold enrichment; and
- the role of far-field and near-field stresses on the enrichment of gold.

Much of Australia has been tested for mineral deposits but only to relatively shallow depths. Chris sees the recognition of zones that are peripheral to mineralisation as a key driver of future ore discovery at depth.



Dr Zhaoshan Chang

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Zhaoshan obtained his first PhD from Peking University, one of the best universities in China, in 1997, and worked there as an assistant professor for three years. In 2000, he entered another PhD program at Washington State University and obtained his second PhD degree in 2003. Both degrees were on mineral deposits. In early 2004, he worked as a postdoctoral research associate at WSU. From June 2004, he started working at CODES as a Research Fellow in economic geology. In 2008 he was promoted to Senior Research Fellow. Zhaoshan has studied a wide range of deposits, including skarns, porphyry deposits, epithermal deposits and sediment-hosted gold deposits, in 12 countries (Australia, Indonesia, Philippines, Mongolia, USA, Mexico, Peru, Chile, Canada,

Russia, Serbia, Bulgaria and China). He has undertaken research on diverse topics, from exploration tools to state-of-the-art laboratory techniques (eg, U-Pb dating using LA-ICP-MS methods) and fundamental ore-forming processes.

Zhaoshan can contribute to the Think Tank by presenting research results on new exploration tools for undercover mineral deposits and new ideas on the future direction of mineral exploration, and by participating in such discussions. He has published research results in leading international journals and presented at international meetings in each of the past 10 years (including several presentations that won awards). Exploration tools that Zhaoshan and his colleagues devised have been applied in exploration for porphyry and high-sulfidation epithermal deposits. Some of the targets he generated have been or will be drill-tested. His research has been recognised by colleagues and the mineral industry; he has been invited to deliver speeches, to chair at international meetings, to teach in international workshops and to provide training to exploration staff of international companies. Zhaoshan has served as a reviewer for international journals and national science foundations and in 2009 was awarded a Guest Professorship by China University of Geosciences, Beijing.



Dr James Cleverley

Stream Leader, Mineral Systems and Targeting, CSIRO Minerals Down Under Research Flagship
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James is a senior geochemist and leader of the Mineral Systems and Targeting research stream at CSIRO in Perth, Western Australia. After completing his BSc at Plymouth University, MSc at Leicester University and a PhD at the University of Leeds in 2002, he moved to Australia to take up a postdoctoral position in the Economic Geology Research Unit at James Cook University. James moved to CSIRO in Perth in 2006, where he has been helping to develop the understanding and application of hydrothermal geochemistry, simulation science and micro-chemical characterisation to the understanding of fluids and dynamics in ore systems. He has worked closely with

industry on several ore deposit types, including Fe-oxide copper-gold, copper, Archean gold, uranium and sediment-hosted base-metal systems, and firmly believes they have common ingredients that will revolutionise the way we explore for new ore deposits.

In his current role leading research in the CSIRO Minerals Down Under Flagship, James has interfaced between academic technique and knowledge development and application of minerals exploration science in industry. This gives him good insight into the current and future trends in Earth science research and practical application to the resource and energy industry. He takes a science leadership role in CSIRO and the research community in hydrothermal geochemistry, and is involved in developing world-leading micro-analytical techniques including through the Australian Synchrotron. He has been involved in setting strategic directions for research and for communication with stakeholders in the government and private sectors. This ability to bring together science strategy with sector knowledge sets him in good stead for this Think Tank.



Dean Collett

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Dean has worked as a geologist and senior geoscience manager in Australia and the Asia Pacific region for 25 years. He has the uncommon combination of experience in open-pit and underground mining, feasibility studies and exploration, as well as research and development portfolio management. He has worked for BHP Minerals, Sons of Gwalia, Placer Pacific, Mt Isa Mines Ltd and is currently Group Manager (Minerals) for Newcrest Mining. He holds appointments on the Science Steering Committees for the Deep Exploration Technologies CRC, AMIRA P843a Geometallurgy project, and the CODES Centre of Excellence at the University of Tasmania. Dean has held positions in the recent past on various other industry professional groups and mining industry community consultation committees. Dean holds a BSc and an MSc from James Cook University and has published and presented his work at local and international conferences on a variety of exploration-deposit models, mining geology, geostatistics, mining management, mining environmental and exploration method topics.

The four key challenges for the Australian mining industry are: an increasingly disguised footprint of mineral deposits; an increasingly longer time between discovery and development; decreasing economics; and community acceptance. All of these challenges are linked by the solutions presented by superior ore-deposit knowledge and improved cross-functional collaboration along the value chain from exploration through to operation and mine closure. Dean will contribute to the Think Tank on the research gaps contributing to all of these challenges.



Dr Robert Dart

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Robert is presently employed as a postdoctoral research fellow at the University of Adelaide, and is soon to commence as a postdoctoral research fellow with the Deep Exploration Technologies Cooperative Research Centre (DET CRC). His research interests are in the fields of regolith geology and landscape processes and their implications for mineral exploration. More specifically he is presently investigating landscape controls on the dispersion of mineralisation indicators within the regolith and the improvement of geochemical data interpretation by considering the impact of landscape processes. Following a successful career in computing, Robert completed a BAppSc (Hons) in geology at the University of South Australia in 2004. He then completed a PhD at the University of Adelaide in 2009. His PhD research investigated the relationship of regolith carbonates with gold and associated elements, and the landscape and pedological processes controlling this relationship.

A key impediment for Australian mineral exploration is that most of the continent is blanketed by regolith. Geochemical sampling of the regolith can identify anomalous zones and buried mineralisation. Robert's PhD research of Au-in-calcrete was about minimising exploration risk through innovative interpretation of the landscape. He will contribute to the Think Tank as one of the country's researchers fluent in the importance of regolith and landscape processes on the expression of buried mineralisation. Outcomes of the Think Tank will contribute to his postdoctoral research with DET CRC where regolith research will translate to cost-effective mineral exploration in areas of deep cover.



Dr Raj Das

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Raj is a senior research scientist in CSIRO's division of Mathematics, Informatics and Statistics. He completed his PhD at Monash University in the field of structural failure analysis and optimisation. During his PhD he developed a range of durability-based optimisation tools for structural design of aircraft and rail components, which have been adopted by aerospace and rail industries. He was then appointed as a research associate at the University of Manchester in 2005 and worked on the structural response and collapse of joints in steel-framed structures in fire. Raj's current research interests involve the application of mesh-free numerical methods to modelling

deformation and failure in large-scale geomechanical applications. He has established strong linkages with mining and material processing industries and academic institutes and has active research collaboration with Monash University, the University of Quebec and Pennsylvania State University.

Raj has extensive knowledge and expertise in the computational modelling and structural analysis in geomechanical applications. In the Think Tank he would like to emphasise the significance of computational geomechanics in mineral exploration in Australia. The primary focus of his input will be how computational modelling can be effectively combined with experiments and field data to devise efficient and cost-effective mineral exploration strategies. Raj will highlight the areas where lack of understanding of the behaviour of rock mass leads to ineffective mineral exploration and extraction plans, often resulting in lower productivity and/or quality of ores than those expected during mapping the regions. The role of accurate geological field data as input to the numerical models and its sensitivity on the reliability of computational simulations as a predictive tool will be highlighted. His overall contribution will be to identify the key directions of research in the area of computational geomechanics necessary to develop cost-effective and efficient mineral exploration technologies.



Dr Miles Davies

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Miles's research interests focus on palaeoenvironmental interpretations of geological terranes. More broadly, his academic research work integrates with practical applications encountered within the geological survey of South Australia, such as the search for and description of heavy mineral sand and sedimentary uranium systems. His PhD research at Adelaide University included consulting work with Western Mining on the identification of palaeochannels for alluvial diamond exploration – a project developed to utilise low-cost sampling and analysis for the delineation of possible target zones for further exploration. As an exploration geologist in the minerals industry

his work focused on the search for a range of mineral commodities such as gold, copper, base-metals and iron in both South Australia and Queensland. Miles's current position PACE Manager with the Minerals and Energy Resources Division (MER) demands a high level of collaboration with the exploration industry and an understanding of the issues faced when moving through the prospect to mine pipeline. Programs currently in development include the up-scaling of the PACE initiative and the implementation of projects such as the streamlining of government processes for the granting of mineral leases, the development of best practice guidelines for community consultation and the expansion of functionality of MER's online systems.

Miles has spent several years as a researcher in geoscience, as an exploration geologist within the minerals industry and as a member of the South Australian state government focused on developing strategies to improve exploration within the state. His contributions to the Think Tank would be sourced from his range of experience gained from all of these arenas, namely academic, industry and government. Miles's current role in particular requires a strong focus on collaboration with the minerals industry as well as within government and academia. This unique position allows comment on the strengths (and weaknesses) of each, as well as potential avenues of opportunity.



Tania Dhu

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Tania attended the University of Adelaide majoring in geology and geophysics and graduated with an Honours degree in geophysics in 2002. She currently works with the Mineral and Resources Group, PIRSA, as a geophysicist. Her work involves the integration of different geophysical datasets from potential fields to electrical methods as an aid to exploration within a state whose resources are predominantly under cover. She is also undertaking a PhD at the University of Adelaide, investigating the spatial variation of the Earth's electrical response and attempting to link this with geological variation.

Tania's work covers areas such as the synthesis of geophysical depth estimates with geological knowledge to accurately map basement and the development of inputs to predictive modelling. She also has experience with scaling issues in electrical data through her PhD studies. An understanding of how these techniques are applied within South Australia, where cover is a major obstacle to resource discovery, will effectively contribute to the Think Tank.



Assistant Professor Marco Fiorentini

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Marco received his PhD from the University of Western Australia in 2005. He has subsequently become a world-recognised authority on the genesis of Ni-Cu-PGE deposits. The implications of his studies for understanding the evolution of the early Earth's mantle, lithosphere, and hydrosphere-atmosphere, have been recognised and published in prestigious international journals, such as *Nature* and *Science*. Since 2005, he has had an enviable record in terms of integrated research activity within and across groups in academia and industry, successfully attracting external funding from state and federal governments. In 2008 he was awarded an APDI fellowship and was instrumental in designing and implementing the largest nickel project initiative ever undertaken in

Australia. Marco balances high-calibre pure science with applied research, as evidenced by his multiple industry-sponsored projects and his selection in 2009 as Nickel Theme Leader in the Centre for Exploration Targeting.

Marco ranks as one of Australia's brightest young Earth scientists. The keys to his research success are his infectious enthusiasm and his capacity to collaborate with the best national and international researchers in several fields, creating the necessary synergy to achieve ambitious research goals. He is internationally recognised in both industry and academia as a researcher who can think holistically and work efficiently. In his research, a non-conventional 'out of the box' approach is successfully coupled with cutting-edge analytical techniques to generate new working hypotheses in highly controversial fields of both fundamental and applied research.



Dr Ryan Fraser

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Ryan is a project leader within CSIRO's Minerals Down Under Flagship. He leads three large projects dealing with the exchange and delivery of geoscientific information. These projects focus on enabling the delivery of data in an interoperable manner to the various communities – in particular the geoscience community. He has a software engineering background with particular expertise in high-performance data and computational technologies. He has primarily been involved in the design and execution of systems to deliver geoscientific information and the provision of data and computing services to the research community and industry. Ryan leads a large team to

deliver technologies to enable data exchange and orchestrate change within the community.

To achieve better understanding of the Earth and address the challenges of future requirements of deep exploration, easy access to streamlined and standardised data is essential. This will aid informed and timely decisions to make exploration more accessible. Through Ryan's experience on various data delivery and interoperability projects he can bring relevant expertise and knowledge to this Think Tank on what is required to provide data information systems to the geoscience community, to have impact and assist in decision-making processes.



Associate Professor Klaus Gessner

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Klaus graduated with a Diplom from the University of Frankfurt and then a PhD from Johannes Gutenberg Mainz in 2000. He joined CSIRO in 2001, before moving to the University of Western Australia. His research interests lie in structural geology with an emphasis on the processes that produce giant ore deposits. He has recently completed a major study of the structure of the Mt Isa copper deposits and linked that to numerical modelling of the control of deformation on the fluid pathways responsible for mineralisation. His interests extend to large-scale deformation of the crust and much of his work is centred on crustal deformation in Turkey. His strong international reputation is built on understanding the development of 'core complexes' in the Turkish part of the

Alpine tectonic chain. Klaus is presently working on gold mineralisation in the Yilgarn of Western Australia, and on links between faults, ore deposits and geothermal systems in Australia, Turkey and New Zealand. He has 22 highly cited fully refereed papers.

Klaus is an internationally acclaimed structural geologist with a strong interest in mineralising systems. He has worked with industry to apply his observations and numerical modelling expertise to exploration for new mineralisation in the Mt Isa region and the Yilgarn of Western Australia. He brings this practical hands-on experience to the Think Tank, which will benefit from his wide field experience on the mineral targeting problem. In particular, he has experience in communicating and transferring his results to industry. He is enthusiastic and anxious to develop a new approach to mineral exploration.



Professor David Giles

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After four years in the minerals industry (1992-1996: Billiton, Great Central Mines) David returned to postgraduate study at Monash University. His PhD project (1996-2000) was based at the Cannington deposit and involved intimate collaboration with BHP Billiton. This was followed by a series of postdoctoral appointments, including an APDI (2003-2006) as part of an ARC Linkage Grant addressing exploration for Proterozoic base metal deposits, again in collaboration with BHP Billiton. In 2006 he was appointed the inaugural State of South Australia Chair of Mineral Exploration and Director of the Centre for Mineral Exploration Under Cover (CMXUC) at the University of Adelaide. David's roles are to facilitate mineral exploration beneath the veneer of recent sediments and weathered rock that covers much of South Australia, and to address the skills shortage in the minerals sector by training the next generation of minerals industry professionals. He teaches undergraduate programs in geology and mineral exploration at the University of Adelaide and manages a group of researchers and students with projects (including two current ARC Linkage projects) embedded in the mineral exploration industry. In 2009 he was part of a team of researchers and industry collaborators responsible for the successful proposal 'Deep Exploration Technologies CRC', in which his continuing role will be as Program Leader – Deep Targeting.

David has a mix of industry and academic experience particularly relevant to this Think Tank. Indeed, in many ways the subject of the Think Tank is a summary of his roles as a researcher and educator at the University of Adelaide.



Dr Weronika Gorczyk

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Weronika graduated with a PhD from the Geological Institute, ETH-Zurich, Switzerland in December 2007 after completing an MSc in geology at Jagiellonian University, Krakow, Poland in 2003. She joined CSIRO in 2008. Her research interest is the numerical modelling of processes that produce giant ore deposits. The computer codes she uses model the interaction of metamorphism, melting and fluid flow with deformation behaviour within the entire lithosphere. The computer codes are fully coupled in the sense that changes in physical properties arising from the above processes and the associated feedback effects are updated continuously during the computer calculations. Weronika's strong international reputation is built on the modelling of subduction processes and her emphasis has moved to considering the formation of giant orebodies arising from instabilities at old cratonic margins due to metasomatic processes. She is presently extending the codes to operate in 3D. She has six highly cited fully refereed papers.

Weronika is continuously developing new concepts that enable mineralisation in the Earth's crust to be modelled in a quantitative manner. Her goal is to develop criteria that enable targeting of mineralisation during exploration to be better focused. She brings this quantitative modelling expertise to the Think Tank, which will benefit from integrating her approach with different approaches to the targeting problem. Everyone will benefit from her understanding of lithospheric processes and their influence on localising mineralisation. Weronika brings an air of enthusiasm and enquiry that will drive active discussion and her influence on the outcomes of the workshop will be substantial.



Dr Wojtek Goscinski

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Wojtek is the coordinator of the Multimodal Australian ScienceS Imaging and Visualisation Environment (MASSIVE), a specialised Australian high-performance computing facility for imaging and visualisation. Since late 2008 he has been the Advanced Technology Analyst at the Monash e-Research Centre, a role in which he promotes effective and creative applications of technology in research. He has completed a Bachelor of Computing at Deakin University (2001), a PhD in high-performance computing at Monash University (2006), and most recently a Bachelor of Architectural Design at RMIT (2009). Wojtek is also a part-time Research Fellow at the Spatial Information Architecture Laboratory in the School of Architecture and Design

at RMIT and was formerly a lecturer in the Faculty of Information Technology at Monash University. His research interests include high-performance computing, scientific visualisation and advanced architectural design techniques.

Wojtek has strong technical expertise in parallel computing and its application to large-scale simulation and modelling. He has a multidisciplinary background that helps him to engage across a wide range of scientific domains. He assisted with the development of the 3D-Alive facility in the Geoscience Department at Monash University – a facility that helps geoscientists to better view their 3D data. His position as coordinator of MASSIVE provides him with an appreciation of the importance of computational infrastructure to underpin Australian science and he can provide insight into the technical requirements of current- and next-generation simulation, modelling and visualisation, in the geosciences, resource discovery and resource management.



Dr Ian Graham

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Ian graduated from the University of Technology, Sydney with a PhD in geology in 2000 ('Tectonic significance of chromitite-bearing serpentinite belts, Tumut Serpentinite Province, southern NSW, Australia') then took up a postdoctoral fellowship at the University of Pretoria, South Africa, working on the sub-Rustenburg layered suite dioritic sills of the Bushveld Complex. He was then a research scientist within the geology section of the Australian Museum in Sydney, before taking up his current position as a senior lecturer in geology at the University of New South Wales in 2007. He is currently the first vice-president of the International Association on the Genesis of Ore Deposits (IAGOD), associate editor of *Ore Geology Reviews*, chair of the NSW Division and committee member of the specialist group in geochemistry, mineralogy

and petrology of the Geological Society of Australia, and an ARC Reader. His research interests include the genesis of magmatic-related ore deposits, epithermal gold deposits, gem deposits, and applied mineralogy.

Ian can contribute to the Think Tank's theme because of his strong background in economic geology, including four current industry-sponsored honours projects in Western Australia (Archaean VMS), Papua New Guinea (epithermal gold) and Indonesia (epithermal gold) and last year had two other industry-sponsored honours projects in Papua New Guinea (epithermal gold) and Indonesia (placer gold and platinum). Earlier this year he was secretary of the local organising committee and chair of the scientific committee for the 13th Quadrennial IAGOD Symposium in Adelaide. Ian has strong contacts throughout the university sector, government agencies (such as the various state geological surveys and Geoscience Australia), professional societies and industry.



Dr Anthony Harris

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Anthony is a Senior Research Fellow at CODES, investigating aspects of porphyry ore deposits. After graduating from the University of Queensland he worked briefly for Rio Tinto Exploration. He returned to the University of Queensland to undertake his PhD, which sought to further constrain the evolution of porphyry ore systems. Since starting at CODES in October 2002, Anthony has been involved with basic and applied studies of porphyry ore deposits throughout Australasia, China, North and South America. Using advanced microbeam techniques (including laser ablation, PIXE and synchrotron radiation) he has studied micron-sized fluid inclusions that help elucidate fundamental ore-forming processes. His work is published in leading international journals, including

Science. He currently manages a 100 per cent industry-funded research project that seeks to better describe the chemical and physical environments of porphyry ore deposits. Anthony received the Society of Economic Geologists Waldemar Lindgren Award for 2004. This award is offered annually to a young scientist whose published research represents an outstanding contribution to economic geology.

Anthony works closely with exploration and mining professionals to undertake strategic science that provides new exploration opportunities through advancing an understanding of ore systems and exploration models. His research investigating aspects of porphyry ore deposits (some of the largest bulk minable Cu and Au resources known) sees him embedded in Newcrest Mining Ltd. This opportunity has afforded him new insight into the requirements of industry. Anthony's role is to enhance the skills of industry professionals via a training program underpinned by targeted research activities designed to advance conceptual models and exploration techniques.



Dr Jane Hodgkinson

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Jane is a geologist in the Mining and Exploration Division of the CSIRO. She gained her BSc (Hons) in geology at Birkbeck College, University of London in 2003 and her PhD in 2009 at the Queensland University of Technology. Her research at CSIRO has involved analysis of vast and complex minerals-exploration datasets using self-organising map (SOM) analysis for improved mineral targeting, reduction of sulfur in coal for environmental protection, 3D coal-mine modelling, geosequestration targeting for international clients investing in Australia and the adaptation requirements for the mining industry in the face of climate change. Jane has published and co-authored work in international journals and conferences and is additionally interested in

geological hazards including earthquakes and landslips.

Since joining CSIRO in 2007, Jane's experience in the mining industry has been broad and she has developed and performed new projects and liaised with industry. She has been involved in future strategic planning meetings where knowledge gaps and industry requirements are identified. Working for gold, iron ore, diamond and coal mining companies for example, Jane has worked on mineral targeting techniques and 3D modelling of ore and deposit bodies. She is presently engaged with industry and social scientists to assess climate change implications in the mining industry to ensure the future of mining in Australia under new climatic conditions.



Associate Professor Eun-Jung Holden

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Eun-Jung gained a BSc, an MSc and a PhD in computer science from the University of Western Australia, and is currently a Research Associate Professor at the Centre for Exploration Targeting (CET) within UWA. Her research expertise is in image analysis and pattern recognition with 15 years experience. Previously working on human motion analysis and visualisation, she started working at CET in 2006 with a specific aim to bring in advanced image analysis technology to geoscientific data processing. By working closely with the mineral exploration industry, she has been developing cross-disciplinary projects to address the data-processing challenges facing the industry. Eun-Jung's achievements include the development of award-winning human motion visualisation

software and commercial geophysics data-processing software that provides efficient and effective data discontinuity detection, namely the CET Grid Analysis Extension for Geosoft Oasis montaj, which was released and marketed by Geosoft in April 2010.

Eun-Jung's contribution to the Think Tank will be her expertise in extending geoscientists' capacity to extract and integrate information from existing data by utilising effective visualisation and automatic processing tools. Discovering resources from deep Earth will require better ability to understand patterns in remote sensing data. Her research focus has been on addressing this issue by applying advanced image enhancement, automatic feature detection and pattern recognition techniques to provide effective, fast and non-subjective processing with reproducible outcomes. In addition she will be bringing extensive hands-on experience in designing and developing multidisciplinary research crossing the areas of computer science and geoscience.



Dr Margarete Jadamec

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Margarete received her BSc (Hons) in geology and geophysics from the University of Connecticut in 1999, an MSc in structural geology from the University of Alaska in 2003, and a PhD in geophysics from the University of California, Davis in 2008. In 2008 she joined the computational geodynamics group at Monash University as a postdoctoral research fellow. She is Project Leader (2008-present) of 3D-ALIVE (3D-Applied Laboratory for Immersive Visualisation Environments) at Monash University and designed the facility in collaboration with Monash Schools of Geosciences and Mathematical Sciences, Monash e-Research Centre, AuScope, and CSIRO Advanced Scientific Computing. Her research interests include continental deformation,

subduction dynamics, 3D visualisation, and numerical modelling. An important scientific contribution from her PhD work is the prediction of fast, localised mantle velocities (80 cm/yr) in models also satisfying surface plate motions and seismic anisotropy observations (Jadamec and Billen, 2010, *Nature*).

Margarete will contribute to the Think Tank in three ways. First, she is familiar with both geological and geophysical datasets and in incorporating those observations into 3D numerical simulations of geodynamic processes. Second, she has experience in using new technology such as 3D immersive visualisation and massive passive parallel computing in the analysis of complex 3D geologic structures, and is now manager of a visualisation facility in Australia. Thirdly, through her research she has demonstrated the ability to work collaboratively to deliver practical, innovative, and paradigm shifting results.



Aleksandra Kalinowski

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Aleks is a geologist currently working on geological storage of carbon dioxide at Geoscience Australia (GA), where she is also undertaking postgraduate study with the University of New South Wales in this dynamic and topical field. After completing her undergraduate degree at the Australian National University in 2002, she worked in the minerals exploration area at GA before participating in GA's graduate recruitment program in 2004. She then moved into the carbon capture and storage (CCS) team in 2005, where she worked on assessing the potential of some of Australia's sedimentary basins for CO₂ storage. In 2006 Aleks and her husband moved to Boston where she was fortunate to work on CCS at the Laboratory for Energy and the Environment at MIT as

well as energy policy-related issues at the Kennedy School of Government at Harvard University. She is currently leading the international CCS project at GA.

Working at GA in both minerals exploration and carbon capture and storage has given Aleks a broad perspective about the technical, economic, skills gaps, social and other issues facing these industries. Throughout her career she has had experience working on technical, policy, capacity building and public outreach activities in CCS. Finding new geological resources and attempting to fill knowledge gaps as well as building technical capacity and public confidence in these areas, locally and internationally, is exciting and challenging. Aleks warmly welcomes the opportunity to contribute to this Think Tank and to engage with other researchers on these issues.



Dr Lawrence Leader

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Lawrence is a research assistant in the School of Earth Sciences at the University of Melbourne. His interests include structural geology, tectonics, mineralisation and numerical modelling of deformation and fluid flow. Since the completion of his PhD degree at the University of Melbourne in 2008, Lawrence has been working on regional- and mine-scale studies that focus on the structural control of gold mineralisation in western and central Victoria.

Through his research, Lawrence has worked closely with academic, government and industry groups associated with the gold exploration and mining industry in Victoria, and thus has significant knowledge of how applied research can be used by the industry for effective minerals exploration.



Dr Maxim Lebedev

Senior Research Fellow, Department of Exploration Geophysics, Curtin University of Technology

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Maxim gained a Masters in physics and engineering from the Moscow Institute of Physics and Technology in 1986 and his PhD in physics from the same university in 1990. He worked for a decade as a physicist at the High Energy Research Centre in Russia, and for approximately eight years as a material scientist at the Japanese National Institute of Advanced Industrial Science and Technology. In 2007, he joined Curtin University and became the leader of an experimental group in rock physics. His research is focused on the properties of subsurface reservoir rocks and minerals.

He is author and co-author of over 100 scientific papers, and has been granted five international patents. He holds a current ARC Discovery grant and is recognised widely as a national and international leader in the field.

Maxim will contribute to the Think Tank through his experience in a broad range of disciplines, including geophysics, physics, material science and engineering. He will add to discussions about the challenges and opportunities in the Australian resources sector associated with developing new technologies for the exploration of resources. Networking with national research leaders will allow Maxim to share his knowledge and enable him to contribute to strategies for developing deep Earth resources as a national priority. In all, he will benefit greatly, both personally and professionally, through his involvement in this exciting Think Tank.



Professor T Campbell McCuaig

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Campbell received his PhD in geology from the University of Saskatchewan in 1996. Subsequently with SRK Consulting, he rose to the position of director, garnering 10 years experience in providing solutions to the mineral exploration industry. His experience spans six continents and numerous commodities in geological terranes ranging from Archaean to Eocene in age, including gold, nickel, iron, copper, uranium and zinc, amongst others. Since August 2005, Campbell has been Director of the Centre for Exploration Targeting (CET), a joint venture between the University of Western Australia, Curtin University, and the minerals industry that is focused on advancing the science of exploration targeting. His leadership has resulted in a world-recognised sustainable research centre with more than 25 staff, 30 research PhD/MSc students, a

turnover of more than \$4 million a year and research outcomes that are impacting on exploration industry practice, yet also being recognised at the highest academic levels by publications in journals such as *Nature* and *Science*.

Campbell is internationally recognised in both industry and academia as a visionary in exploration geoscience. He has a remarkable track record of engaging industry and academia to identify challenges hampering mineral discovery and then designing and implementing research programs to overcome those challenges. The success of CET attests to this ability, where in five years he has personally attracted more than \$10 million in research funding and built a sustainable research centre with over 70 corporate members. Campbell is also recognised as a talented communicator, constantly in demand to speak and provide courses on exploration geoscience and industry-academia collaborative research.



Professor John McLeod Miller

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John is a Research Professor at the Centre for Exploration Targeting at the University of Western Australia. He received his PhD in 1999 and his expertise is in the fields of structural geology, tectonics and mineralisation. He has done extensive research programs in gold, nickel, uranium, copper, lead and zinc mineral systems in Australia and internationally. He has over 30 international publications and is currently a chief investigator on four active ARC Linkage Grants. He was awarded the prestigious Joe Harms medal in 2004 by the Geological Society of Australia for excellence in mineral exploration and ore deposit research. This was awarded for research that led to a gold discovery that extended the Stawell gold mine's life by at least five years; it is one of the

largest employers in the rural Stawell community and provides community stability.

John has expertise relevant to the Think Tank theme, having done numerous applied research studies at both mine- and regional-scales resulting in the development of new geological models to generate exploration targets and to aid resource extraction at existing deposits. A core focus has been integrating field observations with 3D software to rapidly model, visualise and interpret data. His research was used as a case study of technological innovation in the geosciences in a 2005 submission to an Australian Federal Government House of Representatives Standing Committee by the Australian Geoscience Council.



Dr Steven Micklethwaite

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Steve completed his PhD in 2002 at Leeds University. From 2002-2008 he was a research fellow at the Australian National University. While at ANU he developed, with Professor Stephen Cox, a novel software technology for blind, deep-Earth minerals exploration, based on the mechanics of earthquakes and how they influence fluid flow and mineralisation within the crust. In 2009 he was awarded the UTAS Business Commercialisation Prize, worth \$25,000, for an idea centred on the commercialisation of this application. Steve is currently researching the development and predictability of mineralised epithermal structures, working on the Gosowong epithermal goldfield in Indonesia. Over the past seven years he has built extensive links with the minerals exploration industry, working with nine different companies and carrying out research

with industry exploration teams on eleven different mining sites from four different nations. He also has a growing international recognition, with invitations as keynote speaker to scientific meetings in the USA and UK. He has international and national collaborative links with the Australian National University, Sydney University, CSIRO, Glasgow University and the University of British Columbia, which have led to the publication of a number of journal articles. Steve investigates processes of deformation and fluid flow and their application to mineral deposit formation. This research is cross-disciplinary, uniquely combining the disciplines of earthquake mechanics, structural geology and economic geology to generate creative and new outcomes for the exploration industry. He is particularly interested in the impact of pore-fluid pressure, and earthquake-related stress changes on the enhancement of permeability in the crust, plus the application of fractal concepts to develop new tools useful for predicting the spacing and location of mineralised structures.

Steve is concerned about developing new field-based and numerical techniques, to create tools that enable greater predictability in exploration. He is in the process of commercialising an application that has been successful at this in mesothermal and Carlin-type gold deposits. He also has several research projects currently under development, which participants of the Think Tank may be able to collaborate on.



Dr Kieren Moffat

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Kieren is a social scientist at CSIRO. He completed a PhD in social and organisational psychology at the University of Queensland in 2008. He leads a team of social scientists in the Earth Sciences and Resource Engineering Division, and is responsible for social science research delivery into several minerals-related portfolios in CSIRO, including the Mineral Futures initiative. His research interests include analysis of the drivers of future development in the Australian minerals industry and their implications for sustainability, particularly with respect to the role of societal expectations. He is also leading research to explore the future conditions under which the minerals industry will need to operate to hold a social licence to operate in both onshore and offshore resource sectors. Prior

to joining CSIRO, Kieren worked as a management consultant in the mining and health sectors. His PhD research explored diversity management issues in the Australian Defence Force.

Kieren's social science training and research interests provide him with different and critical perspectives on deep Earth exploration and utilisation of Australian resource commodities. His knowledge of global and domestic foresighting activities exploring the future drivers of the industry and in particular the role that societal expectations will play, may offer valuable contributions to the Think Tank. Similarly, his research into the nature of trade-offs that society is willing to make with respect to the industry in the future, and the intersection between technology development and the social risk inherent in its deployment, may also provide useful inputs for discussions about future deep Earth mining activities.



Dr Joshu Mountjoy

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Joshu is an early-career scientist in the field of marine geology and geophysics. Experience in terrestrial geology, including as a consultant in ground engineering and mining, in combination with science research in the offshore environment, has enabled him to develop a well-rounded skill set with a strong ability to visualise 3D problems and to see the global picture while understanding the necessity for detailed analysis. Offshore research involvement has included active tectonic processes, canyon development, submarine landslide processes, submarine hazards, habitat mapping, seafloor gas hydrates, and seafloor mineral deposits. Joshu has experience with the collection and analysis of marine geophysical and geological datasets, including high-

resolution multibeam bathymetry, multi-channel seismic data, sediment cores and rock samples. His current research topics and principal interests are submarine landslide hazards, canyon development on active tectonic margins, and characterisation of active faults in high-resolution seismic reflection data.

A broad background in Earth science, including exposure to onshore mining and environmental impact assessment, offshore petroleum exploration, and undeveloped offshore resources such as gas hydrates and massive sulfide deposits, puts Joshu in a strong position to critically analyse issues that are key to the mineral industry's future. A reductionist approach to problem analysis, in a framework of holistic understanding of the Earth system, knowledge of environmental impacts, and broad understanding of social and cultural issues will be critical to streamlining the challenges that Australia faces to maintain its success as an economic power in the developed world.



Dr Craig J O'Neill

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Craig is a young geodynamicist working on simulation of tectonic processes and integrating numerical simulations with geological and geochemical constraints on the evolution of the Australian continent. He graduated from the University of Sydney in 2004 with a PhD in geophysics and has had postdoctoral appointments in Australia and the USA. Currently an ARC-funded Australian Postdoctoral Fellow and lecturer based at Macquarie University, his current research interests include the earliest evolution of the Earth from its primordial state to one capable of supporting life, and the origin and conditions for plate tectonics.

Craig's research delves into the mechanics of plate-boundary processes, the same processes that are ultimately responsible for Australia's mineral wealth. He also collaborates extensively with the minerals and petroleum industries, bringing sophisticated numerical modelling techniques to bear on resource-related science problems. He brings to the Think Tank a detailed knowledge of Australia's mineral wealth, a working knowledge of cutting-edge resource-related technologies, a cross-disciplinary research ethos and an appreciation of the integration of knowledge and technology to an exploration framework.



Thomas Poulet

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Thomas graduated in 2000 from the Ecole Polytechnique, the top level multidisciplinary engineering school in France. He also undertook an application curriculum in signal processing at the National School of Telecommunications until 2002. Since joining CSIRO in 2003, Thomas has been working on various projects aimed at transforming our understanding of the formation of mineral deposits from a qualitative to a quantitative and predictive science. His areas of expertise include numerical modelling, signal processing, mathematical optimisation and visualisation of high-dimensional model parameters, software engineering, e-Research, grid services and high-performance computing. Thomas's current research activities centre on reactive transport in porous media and the thermodynamics of dissipative processes. It is part of a wider effort to

provide a common multi-scale framework to couple all processes involved in ore-deposit formation, including mechanical deformation, heat and mass transport, as well as reactive fluid flow in porous media.

Thomas can bring to the Think Tank a wide expertise in numerical modelling and applied mathematics, with seven years experience developing numerical tools targeted at helping the minerals exploration industry. He can also bring a multidisciplinary background and team-playing interest, which have already made him a catalyst in many research projects and equipped him with competences at all levels of the numerical workflow. He believes that more realistic numerical models require a tight coupling of all processes involved at all scales and is excited by the opportunities that the Think Tank provides in this respect.



Dr Tim Rawling

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Tim is a structural geologist with research interests in 3D geological modelling, numerical simulation of Earth systems and structural geophysics. He currently works for GeoScience Victoria, managing the 3D Victoria modelling program. Prior to this he was the MCA Lecturer at the University of Melbourne and project leader for the predictive mineral discovery CRC (pmd*CRC) Tasmanides Project. He has also worked as a consultant geologist to both the minerals and energy exploration industries, both in Australia and overseas. Specifically, Tim's research is focused on the application of new technologies to geological analysis, exploration and resource development-related problems. This includes the integration of structural geology, geophysics, 3D modelling

and numerical simulation to investigate the geodynamic evolution of complex systems and the nature and influence of geometrical and mechanical controls on fluid flow in basins and hard rock environments. He is also interested in the development of exploration techniques and workflows incorporating these new technologies.

Tim can contribute to the theme of the Think Tank in several ways. The research that he has been involved in for 10 years is directly applicable to exploration of the deep crust. In addition he has a very good understanding of industry, the current and developing technologies, and also brings experience in state government and science leadership to the table. He is passionate about the application of new technologies to solving difficult exploration problems and believes in the predictive capability of many techniques currently in development.



Dr Nicholas Rawlinson

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After completing his PhD at Monash University in 2001, Nicholas began his academic career at the Research School of Earth Sciences at the Australian National University as a postdoctoral fellow in seismology. In the past 10 years, he has carried out research into seismic wave propagation in the solid Earth, geophysical inversion techniques, and observational seismology using seismic array data. He has also been responsible for the development of the WOMBAT seismic array project, which uses a transportable array to progressively cover southeast Australia with passive seismic stations at spacings of no more than 50 kilometres. To date, over 550 stations have been deployed, making it one

of the largest programs of its type in the world.

Much of Nicholas's research involves imaging crustal structure using a variety of seismic techniques. He has done collaborative work with Mineral Resources Tasmania on the generation of a high-resolution 3D crustal model of Tasmania, and currently has a project with the NSW Geological Survey on imaging deep structure beneath the Macquarie Arc, a highly mineralised porphyry copper-gold province. He has another current project on using seismic tomography to identify favourable locations for hot rock geothermal energy production. With this background, he can bring new ideas on how to contribute to predictive frameworks for mineral exploration to the Think Tank.



Dr Anya Reading

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Following undergraduate study at the University of Edinburgh (BSc in geophysics) and postgraduate research at the University of Leeds (PhD in seismology), Anya began her career in Earth sciences with the British Antarctic Survey. She participated in major geophysical data collection expeditions on land and at sea. After time as a lecturer back at the University of Edinburgh, Anya moved to Australia to take up a research fellowship with the Australian National University in the Research School of Earth Sciences, where she continued to carry out challenging observational geophysics in Antarctica and also in the Australian outback. In 2007, she took up her current position as a senior lecturer in geophysics at the University of Tasmania, which she holds jointly with a research role in the ARC Centre of Excellence for Ore Deposits (CODES). She now divides her time between teaching and research into innovative and computational geophysics.

Anya is a research seismologist of international standing with experience of working in challenging environments and use of innovative techniques. She combines this background with a practical perspective and has current applied research interests in deep crustal investigations for geothermal and ore deposit exploration. Her teaching expertise spans other geophysical techniques including innovations in electrical methods in minerals and environmental applications. This area of expertise is well-suited to the theme of the Think Tank. Anya brings a thoughtful, lively and constructive approach to committee and community roles and will contribute significantly to the Think Tank.



Professor Steven Reddy

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Having completed his PhD in 1990, Steven has gone on to become a geologist with research interests ranging from sub-micron scale deformation of minerals to global-scale plate tectonics. Over the past five years his research has concentrated on the development and application of quantitative microstructural analysis to Earth sciences, including the characterisation of microstructure in minerals used for geochronology; the deformation of mantle rocks and subducted tectonic plates and implications for geodynamics; and the formation and evolution of ore minerals and deposits. In 2009 he published a comprehensive review of secular variations in the Earth, from the core to the atmosphere, from 3.0 to 1.2 billion years ago. He currently leads a project to provide a geological assessment of the geothermal potential of the Perth Basin.

Steven has a broad expertise in 'Deep Earth' research and the practical problems associated with such studies. He has experience of technical issues related to the geological assessment of ore deposits, and a working knowledge of the state-of-the-art analytical techniques that will lead to greater understanding of the processes controlling their formation. He is currently the deputy Dean of Research for Science and Engineering at Curtin University and has a broad appreciation for other disciplines and their potential application to the Australian resources sector. Steven considers himself to have a strategic approach to research and development issues and believes these skills will allow him to make a significant contribution to the theme of the Think Tank.



Dr Frank Reith

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Frank holds an ARC Research Fellowship in geomicrobiology, shared between the University of Adelaide and CSIRO Land and Water. His research is aimed at investigating the fundamental processes underlying the geomicrobial cycling of noble metals in Earth surface environments with respect to the potential of utilising microorganisms for geochemical exploration and ore-processing applications. He combines the use of state-of-the-art molecular microbial methods (eg, transcriptomics and eco-(meta)-genomics) and micro-analysis techniques (eg, Synchrotron-XAFS, FIB-SEM-EDS/EBSD, EPMA and HR-TEM), with field-based exploration approaches to understand the environmental cycling of gold and platinum and find novel microbially-based approaches for exploration

and processing. After his MSc (Diplom) at the University of Bayreuth, Germany, he moved to Australia in 2002, where he received his PhD from the Australian National University in 2006. Since then he has held postdoctoral appointments at CSIRO Exploration and Mining and the University of Adelaide.

With multidisciplinary skills encompassing (bio)-geochemistry, synchrotron spectroscopy, electron microscopy, soil science, regolith geoscience and geology as well as classical and molecular biology, Frank is a leading expert on the geomicrobiology of noble metals. His excellent public-speaking skills will add to his exciting contribution on the development of bioindicators and biosensors for gold exploration. A highlight of his research is the discovery of a gold-specific genetic operon in the bacterium *Cupriavidus metallidurans*. This knowledge, for which a patent application has been submitted, can now be used to construct the first biosensor for gold exploration.



Dr Simon Richards

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Key to finding new mineral deposits and advancing mineral exploration is understanding when, where and why deposits form. Simon's current research is unique because it combines established micro-analytical chemical analysis of mineralised and non-mineralised intrusives with newly developed 3D geological maps of the Earth's interior. These detailed 3D maps are being combined with lithosphere- and asthenosphere-scale plate tectonic reconstructions and mineral deposit information (eg, age, location and chemical fingerprint) to build unprecedented interactive 4D models of how Earth's mineral forming systems are linked to mantle-scale structures and processes. Simon believes that developing new methods to compile, visualise and

interpret geological data, using cutting-edge technologies, is key to advancing the science of mineral exploration. Current research is focused in the highly prospective south-west Pacific, where the plate tectonic controls on mineralisation are being revealed. Simon also has major projects with industry partners in the south-west Pacific.

Simon will make a significant and invaluable addition to the Think Tank, especially given the themes to be discussed. His fields of research, involving high-volume, geospatial data analysis and unique forms of visualisation, and his relationship with industry place him in an ideal position to contribute. He will undoubtedly provide a positive contribution on topics ranging from data compilation, analysis and presentation to expected future developments in the way in which geoscientists present geological models (ie, information transfer) to industry and the general public and how industry can work with academia to achieve useful techniques and technologies.



Dr David Robinson

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David has 10 years experience providing advice and conducting research from within Geoscience Australia. As a graduate recruit he worked in diverse fields, ranging from geomagnetism research through to policy development in the petroleum resource exploration area of the Department of Industry, Tourism and Resources. In 2002 he joined the Natural Hazard Impacts Project, where he has led the development of Australia's earthquake hazard and risk-modelling capability, designing and building tools that are used widely within Australia and south-east Asia for emergency management planning and forecasting earthquake hazard and risk. David has a university medal and BSc (Hons) with majors in geophysics and mathematics from Flinders University of South Australia. He recently submitted a PhD thesis entitled 'Studies on earthquake location and source determination using coda waves' and in 2007 was awarded the Robert Hill Memorial Prize for scientific communication by the Australian National University's Research School of Earth Sciences.

David's background spans marine and exploration geophysics, seismology and mathematics. He has served on the ACT branch of the Australian Society for Exploration Geophysicists, both as president and treasurer, and is aware of issues facing the exploration and geoscience industries. In particular, he is interested in securing an educated geoscience workforce to face future challenges as well as ensuring a strong, vibrant, growing Australian economy that utilises our natural resources in a socially and environmentally responsible manner. David has extensive experience working with multidisciplinary teams and is committed to engaging the expertise of economists, engineers, business leaders and policy makers.



Dr Gideon Rosenbaum

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Gideon is a graduate of the Hebrew University (Jerusalem) and Monash University. Prior to his appointment as senior lecturer with the University of Queensland's School of Earth Sciences, he was a research fellow at the Johannes Gutenberg Universitat (Mainz). Gideon's research history includes collaboration with Australian, New Zealand, French, Italian, Swiss and Israeli geoscientists. He has authored a significant number of peer-reviewed papers, has received two active ARC Discovery grants and is associate editor of the *Journal of Geophysical Research*. He is an active member of the academic life of the School of Earth Sciences and displays a strong and cooperative interest in the research projects of his colleagues.

Geodynamics and the reconstruction of Earth dynamics through time are Gideon's particular areas of expertise. His skills will contribute to the theme of the Think Tank by providing a necessary focus upon the tectonic history of the Australian continent and its relationship to the occurrence of mineral deposits. Presently, mineral exploration benefits from a 3D visualisation of mineralisation zones. However, the key to future mineral discoveries is that refinement of insight to be provided by a full 4D understanding of the tectonic jigsaw puzzle, that is, of the evolution of physical mineral location across a geologic time span.



Dr Alanna Simpson

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Since joining Geoscience Australia in 2007, Alanna has undertaken research into natural hazards in the Asia-Pacific region, particularly the risks to communities from volcanic eruptions. This research is a key part of AusAID's efforts to reduce disaster risks. In this time, Alanna has also supported the Australian government to improve linkages between science development and policy delivery, specifically in the field of disaster risk reduction but more broadly across climate change and water resource issues. Alanna currently leads Geoscience Australia's Regional Risk program, which aims to build the capacity of scientists in the Asia-Pacific region to independently develop and deliver natural hazard risk information. As a graduate recruit at Geoscience Australia, Alanna

worked on carbon capture and storage research, risk analysis, and policy development in AusAID. She has a PhD in geology from the University of Queensland (2007), with her research utilising mineralogy, geochemistry and geochronology to understand magmatic processes.

Alanna's research covers fields directly related to mineral exploration, with skills and knowledge developed during her PhD and MSc theses just as applicable to mineral exploration as they are to crustal magmatism. She currently plays an active role in Australian government policy development and has a clear understanding of the influence of policy on scientific research. Alanna has significant experience working with people from diverse professional and cultural backgrounds. She is also passionate about the sustainable use of resources to ensure that while we grow the economy now, we also secure resource wealth and a healthy environment for future generations.



Dr Carl Spandler

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Carl is an academic geologist with a strong track record of research into geological processes, including plate tectonics, crustal genesis, magma generation and ore-deposit formation. He has been at the forefront of development of new experimental and micro-scale geochemical techniques and has applied these techniques to achieve innovative results in several Earth science research fields. Since completing his PhD at the Australian National University in 2005, he has held an Australian Postdoctoral Fellowship at the ANU (2005-2006) and a postdoctoral fellowship at the University of Bern, Switzerland (2006-2008). He is currently a lecturer at James Cook University, Townsville. Carl has published over 20 papers (most as first author) in high-ranking

international journals, including *Nature* and *Geology*; with many of these papers subsequently achieving a high number of citations. He has presented research results at more than a dozen international conferences and workshops, including numerous keynote presentations.

Throughout his academic career, Carl has invested in the development of geochemical methods to advance our understanding of geological systems, including ore deposits. His research has led to the discovery of platinum mineralisation in New Zealand and a new model for the genesis of chromium ore deposits. He is currently supervising student research projects on gold and molybdenum mineralisation in northern Queensland. Carl sees great potential in applying advanced geochemical techniques and ore deposit petrology to improving our understanding of how and where ore deposits form (and hence, exploration models) and how best to process ores once extracted from the ground.



Dr Mark Symmons

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Mark is a senior lecturer in psychology at Monash University. He received his PhD in 2005 and has since co-authored 34 peer-reviewed publications and won over \$1.2 million in grants, competitive tenders and industry research contracts. He pursues research in two fields: road safety and haptics (haptics relates to the sense of touch, including sensations that arise from contact between the skin and surfaces, and perception of movement). Of particular relevance to the mining field, Mark's team is currently undertaking contract research developing and testing new interfaces to enable touch interaction in virtual reality to remotely control mining machinery. The intention of the project is to reduce the need for fly-in/fly-out and to improve productivity and safety. The work is also

relevant to operator training.

With a psychology background and a research interest in human factors, safety and behaviour, Mark's work spans multiple disciplines. He can thus contribute to discussions that are highly technical in engineering-focused areas such as automation, remote control, machinery safety and workplace environment, as well as to fields that are more social and focused on the individual, including teams, motivation, leadership, the environment and communities. Mark teaches and publishes in a range of these areas. Accordingly he can provide a bridge between what can be very disparate areas.



Dr Stephan Thiel

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Stephan is a research associate at the Centre of Tectonics, Resources and Exploration (TraX) at the University of Adelaide. He completed his Masters at the Freiberg University of Mining and Technology, Germany and was an IPRS scholarship recipient for his PhD dissertation ('Modelling and inversion of magnetotelluric data for 2-D and 3-D lithospheric structure, with application to obducted and subducted terranes') at the University of Adelaide from 2004-2008. His specialty is the analysis, modelling and interpretation of electromagnetic data to define large-scale lithospheric structures, mineral systems and geothermal areas. His current research interests involve imaging

the electric signature of continental lithosphere and mantle from the perspective of mineral exploration potential. Recently, he obtained an IMER grant to monitor fluid injection into enhanced geothermal systems using time-lapse magnetotellurics (MT).

Deep-sounding electromagnetic methods, such as MT, are a relatively low-cost alternative to conventional exploration tools and are susceptible to the bulk electrical conductivity of the host rocks, minerals and aqueous phases of the subsurface. The MT method is able to image features from the near-surface to mantle depths. It can delineate a mineral system with highly conducting orebodies and establish a potential connection to deeper parts of the crust and mantle, to aid in understanding its genesis. Hot fluids in conventional and enhanced geothermal systems are also a primary target for MT, providing an imaging tool in the renewable energy sector.



Dr Mark Tingay

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Mark is a senior lecturer and Australian Postdoctoral Fellow at the Australian School of Petroleum, where he examines the tectonic evolution of sedimentary basins in south-east Asia and Australia. His primary field of research is in petroleum and geothermal geology and geophysics, particularly the development of delta systems and formation of basins. He also specialises in drilling technologies and the mechanics of fluid flow in high-pressure systems, such as in geothermal energy production, oil-field blowouts and mud volcanoes. Mark has undertaken collaborative projects with over 20 petroleum companies in more than a dozen countries, including Azerbaijan, Egypt, Oman, Thailand and Malaysia. He has 40 refereed publications, consulted on numerous

petroleum geomechanics projects and has provided over 40 media interviews on geoscience and resources issues.

Mark will contribute his broad and extensive knowledge of the challenges facing the petroleum and geothermal industries in Australia. Furthermore, he is strongly engaged in raising awareness and understanding of geosciences within the general public and thus will be able to contribute his experiences with the social and environment aspects of exploration and production. In particular, Mark can contribute his knowledge of man-made geological disasters such as oil-field blowouts and induced seismicity, and approaches for avoiding such environmentally and socially destructive accidents in Australia.



Dr Hrvoje Tkalic

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Hrvoje is a Fellow in Seismology at the Research School of Earth Sciences, Australian National University. He received his Diploma in physics from the University of Zagreb, Croatia, and a PhD in geophysics from the University of California, Berkeley. He was a postdoctoral fellow at the University of California, San Diego (SCRIPPS) and Lawrence Livermore National Laboratory, prior to accepting an academic position in observational seismology at the ANU in 2007. His research interests include global observational seismology, Earth's structure and seismic sources. His publications include work on the Earth's core and the lowermost mantle, lithospheric structure, strong-motion prediction in populated areas, and physics of seismic sources in volcanic

environment. He is responsible for the operation of the Warramunga seismic and infrasonic array in the Northern Territory, which is designated as a primary monitoring station for the Comprehensive Nuclear Test Ban Treaty.

As a geophysicist, Hrvoje looks at earthquake waveforms and uses various seismological techniques (and develops his own) to infer Earth's properties based on observations. The focus of his research is on answering fundamental questions about the dynamics and properties of Earth's inner and outer core, the lowermost mantle and lithosphere (including the Earth's crust). Hrvoje has an understanding of how surface observations could be linked to structures and processes within the Earth's interior. He could readily contribute to the general discussion on novel applications and identify important issues that this Think Tank aims to address.



Dr Nick Williams

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With a background in ore deposit geology and geochemistry, Nick completed a PhD in geophysics at the University of British Columbia in 2008. Working with UBC's Geophysical Inversion Facility and Mineral Deposit Research Unit he investigated ways to recover predictive maps of the subsurface by integrating geology, physical property data and geophysical modelling techniques. He completed Honours in geology at the University of Tasmania in 2000, and a BSc in Earth science at Monash University in 1999, after undertaking most of the coursework at the University of California, Santa Cruz. Since 2001 he has worked at Geoscience Australia on the challenge of promoting exploration in Australia despite the continuing decline in discovery of new ore deposits

due to the dwindling number of unexplored outcropping rocks. Future exploration success demands novel subsurface exploration techniques. With experience in geology, geochemistry and exploration geophysics, he understands that no single technique will improve exploration effectiveness. Instead, he specialises in ensuring that all available geological and geophysical information is interpreted together in a holistic way. The process of geophysical inversion provides a rigorous numerical framework for achieving this. Inversion facilitates recovery of 3D models of subsurface rocks or properties required to explain remotely measured geophysical data, while also satisfying available geological observations. For seven years his primary work role has been investigating and testing ways of using inversion methods to derive predictive 3D maps, at regional to deposit scales, using gravity, magnetic, and electromagnetic datasets together with available mapping and drilling observations.

Nick is particularly excited to be involved in this Think Tank as it is so closely aligned with his primary research activities. With a background in both geology and geophysics he brings a unique insight into how multiple geological and geophysical datasets can be combined to support deep exploration. He has developed several new techniques to support this approach and generate more predictive exploration targeting models. These efforts were recognised with an award for best presentation at the 2009 Australian Society of Exploration Geophysicists Conference, and invitations to give talks and a keynote address at several major conferences.



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