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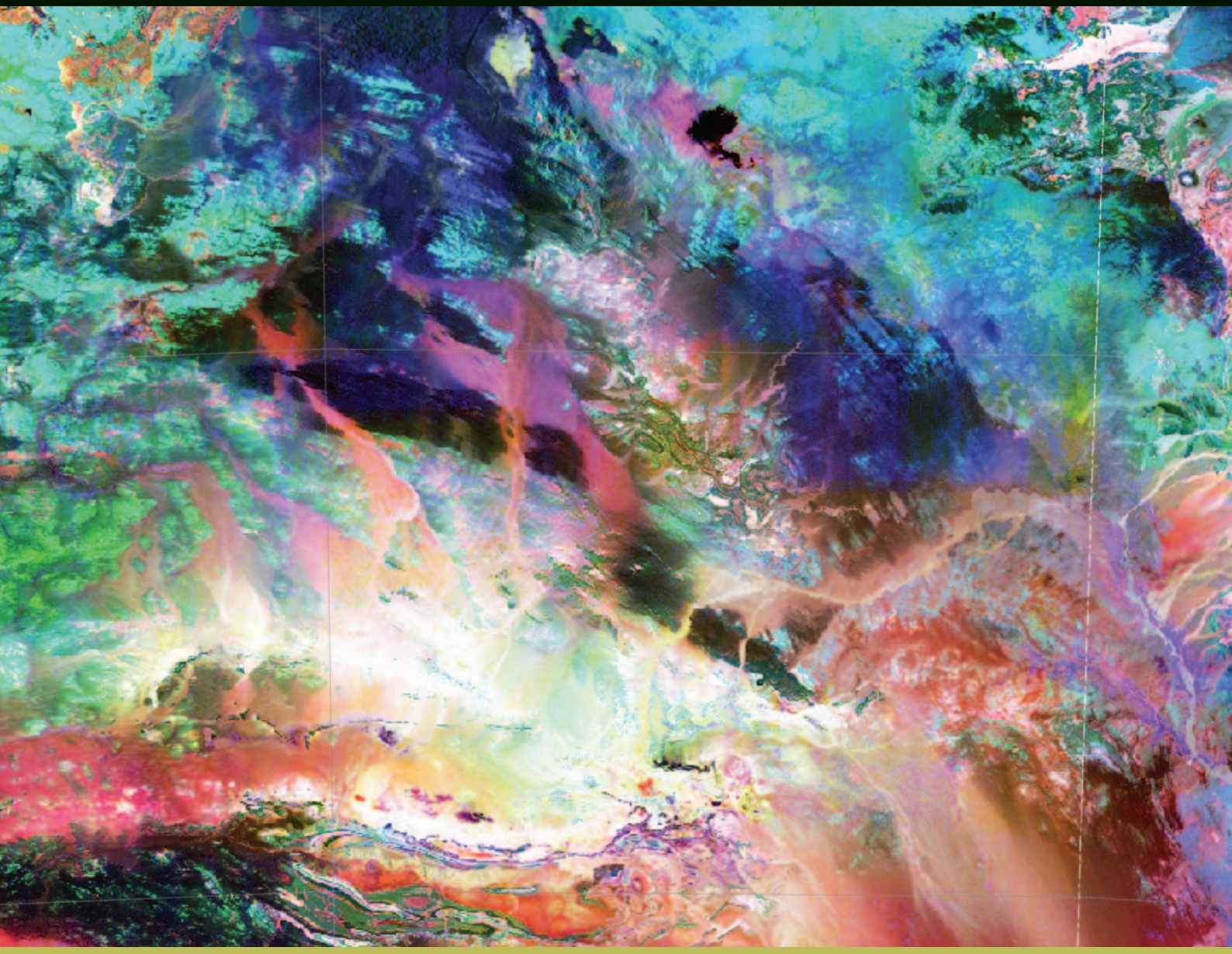
PREVIEW

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS



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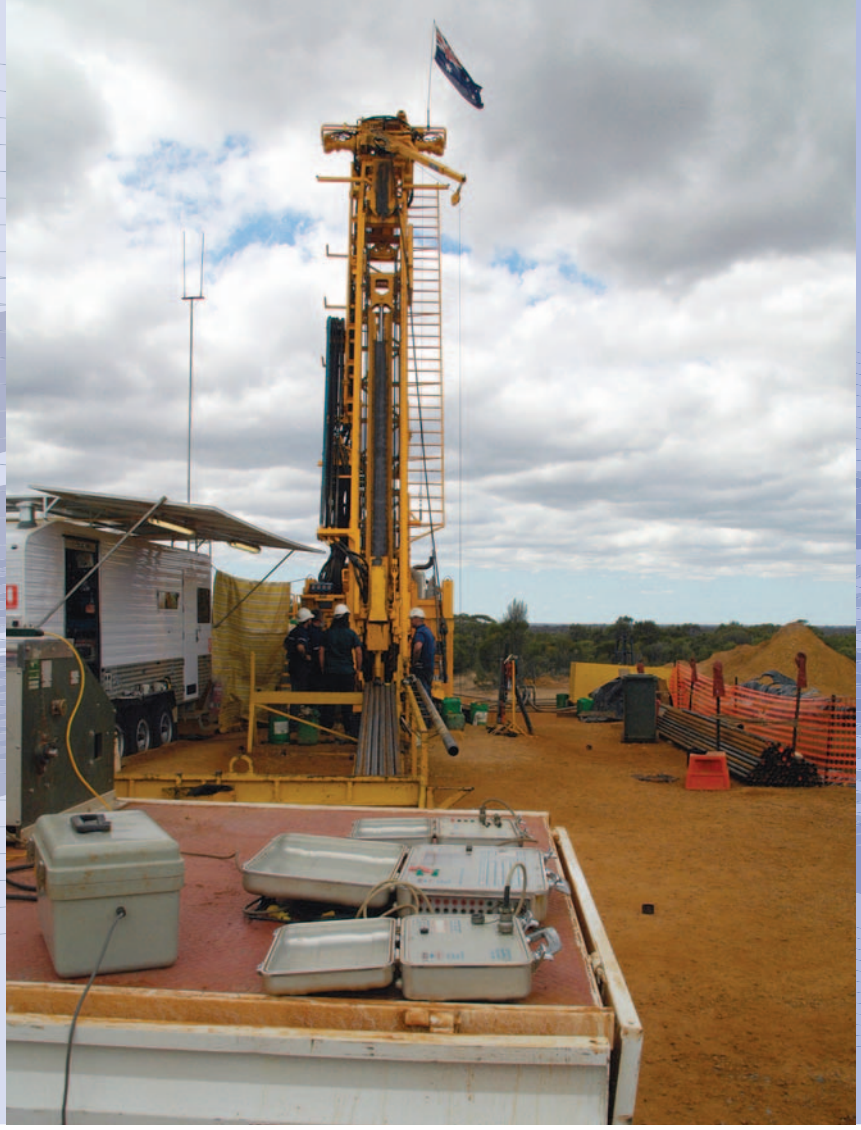
FEATURE ARTICLES



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PREVIEW

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FRONT COVER

Image from the new radiometric map of Australia, produced by Geoscience Australia (see p. 31 for details).

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P

CONTENTS

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David Denham

We live in interesting times and April 2009 is no exception. The economic bubble has finally burst and although mainstream economists and politicians are calling for measures to return to a growth environment, I think we need something new. Even a 1% continual annual growth across the planet is unsustainable. So we need to look differently at our socioeconomic behavioural patterns.

As long ago as 1867 Karl Marx said:

> *Owners of capital will stimulate the working class to buy more and more of expensive goods, houses and technology, pushing them to take more and more expensive credits, until their debt becomes unbearable. The unpaid debt will lead to bankruptcy of banks, which will have to be nationalized, and the State will have to take the road which will eventually lead to communism.*

Apart from the road leading to communism, which we have fortunately dispensed with, we don't seem to have learnt a lot in the last 150 years.

The cash handouts from government that Eristicus discusses in this issue are really more of the same and the total new spending package from the government is already up to $8800 per person!

As Clive Hamilton said in 2006:

> *We are constantly being urged to spend money we don't have to buy things we don't want to impress people we don't like.*

Nothing has changed and we are still living beyond our means.

A key problem is that we need to borrow money to do anything that is significant. On a personal scale, to buy a house or a car we mostly need to borrow. On a national scale to build new roads, hospitals and schools, governments need to borrow. And the system works fine until the big guys borrow too much and then like Samson, bring the temple crashing down.

Somehow we have to get the balance right and more importantly make sure that the system is more stable than it has been. That might not be too difficult to achieve, but to change the idea that growth is good might be impossible, nevertheless, we have to try.

The good thing going for us is that although the stocks, real estate and commodities have fallen, they will recover. People will still need homes to live in, food to eat and energy to travel and keep warm (or cool). The global population will not be declining for another 100 years or more, unless there are major global disasters like epidemics, volcanic eruptions, meteor strikes or massive solar storms, so we have time to change direction.

And if we don't Nature may do it for us and that could be nasty!

The other good thing is that we are going to need talented geoscientists to help manage the earth's resources. And this is where the ASEG has a role to play. Our members have helped discover mineral and petroleum resources and are playing an increasingly important role in managing our land and water resources. We should not be discouraged by having our voice heard more clearly on major issues like education and research, climate change, energy supplies and resource management.

The intellectual and management talent on display at the Adelaide Convention in February was impressive. We should use this as effectively as we can to make a difference on a bigger stage and forge a better future.

And with those words I will sign off with my last Editor's Desk.

Ann-Marie Anderson-Mayes will be in charge of *Preview* from now on, and I would like to encourage all members to provide her with the same great support that I have received over the last ten years.

As someone said to me in Adelaide: 'The good thing about *Preview* is that you can actually hold it and read it (*rather than having to download it*).'

Let's keep it that way.

In February, we had a very successful 20th Conference and Exhibition in Adelaide that attracted some 800 delegates from Australia and overseas. The conference had a well rounded selection of papers from most areas of geophysics but with the majority of papers coming from the oil and minerals industries. The exhibition was well presented and had some 140 exhibitors participating. CGG Veritas took out the prize this year for the most elaborate exhibit. The Convention Centre in Adelaide was an excellent venue for this size conference and there were sufficient hotels within walking distance of the Convention Centre to house visiting delegates. I congratulate the Chairman of the Conference Organizing Committee (COC), Andrew Shearer, and the PESA Co-Chair, Tony Hill, as well as members of the COC for a well organized and well run conference. Mike Hatch in particular deserves a mention for his enormous input into the COC.

In the December issue of *Preview* I mentioned the results of a Business Review that had been organized for the ASEG last year and some of the actions the Federal Executive Committee was taking in regard to the Review. One of the items highlighted is the possible employment of an Executive Officer (EO) full or part time. The ASEG is currently run by a group of volunteers who also have demanding day jobs. With the growth in the society over the last few years as well as the increasing complexity of accounting and legal requirements I see it as essential we look for a full time EO to take the pressure off the Executive Committee and one who is loyal to the ASEG. The Fedex Committee is moving closer to making a decision on this possibility. There will be more on this in the next issue of *Preview*.

This year is likely to be a difficult year for some of our members who may have lost their jobs or are in a difficult position financially. By the time this article goes to print the AIG will have run a seminar on 'Surviving the Downturn', which will include presentations from industry, universities, and government on how best to weather the downturn in our industries, caused by the global financial meltdown. The AusIMM Geoscience Committee is also looking at ways of assisting members through information on how to weather the financial storm. There may be room for the ASEG to provide a similar service to our members so if anyone reading this article has any brilliant suggestions please forward them to our Secretary for consideration (secretary@aseg.org.au).

Due to robust membership renewals and a successful 20th Conference and Exhibition in Adelaide, the ASEG starts 2009 in a strong financial position. We now have six active State Branches, which provide regular technical meetings and social functions, where members can meet and enjoy being part of the geophysical fraternity. I recommend to our members to make an effort to get out this year and attend as many of these functions as possible. The ASEG is your society.

Peter Elliott
elliottgeophysic@aol.com

ASEG Publications go Online and International

Our journals *Exploration Geophysics*, *Preview* and Special Publications are now online with **CSIRO** Publishing, and are available for full search and free download for members via the 'Publications' tab of the ASEG website (www.aseg.org.au).

The material is also being indexed and becoming searchable in the SEG Digital Cumulative Index which covers SEG, EAGE and EEGS (Environmental and Engineering Geophysical Society) journals simultaneously; SEG President-Elect Steve Hill received an update on progress during his visit to our Adelaide Conference, and has assured us of ongoing efforts to complete integration of this resource.

As a service to colleagues in our sister societies overseas, and as an aid to lifting the profile of our publications, the ASEG Federal Executive has approved extending the free access and download capability from our website for a year to members of the SEG, EAGE, NSG and EEGS. In addition we are making available one-year free online library access to overseas universities that teach geophysics but do not currently subscribe to *Exploration Geophysics*.

President-Elect Michael Asten recently presented the AGH University of Science and Technology (Cracow, Poland) with a one-year free library subscription, in appreciation for their efforts in hosting the Near Surface Geophysics meeting of the EAGE last September.

The FedEx would be pleased to receive suggestions from members, with names of other universities with teaching programs in geophysics which may benefit from similar access to our publications.

Further information contact: Phil Schmidt ASEG Publications Chairman on (02) 9949 8873, or at phil.schmidt@csiro.au.s

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New Members

The ASEG welcomes the following 15 members to the Society. Their Membership was approved at the Federal Executive meetings held on 27 November 2008 and 29 January 2009.

Name	Affiliation	State	Membership Category
Cara Danis	Macquarie University	NSW	Student
Richard Davis	Conquest Seismic Services Inc	USA	Active
Susannah Gallagher	Santos	SA	Active
Edward Gerner	Geoscience Australia	ACT	Associate
Slawomir Gras	University of WA	WA	Student
David Grybowski	Santos	SA	Active
Cameron Hamilton	Origin Energy	Qld	Associate
Paul Hammel	Terrex Seismic	Qld	Active
Matthew Hutchens	Asls International, AMG Surveys	SA	Active
Alan King	Vale	Canada	Active
Darren Kyi	Macquarie University	NSW	Student
Ben Oostermeyer	Fugro Ground Geophysics	WA	Associate
Kevin Ralph	Crone Geophysics & Exploration Ltd	Canada	Active
Stephan Thid	University of Adelaide	SA	Associate
Brian Traeger	Dept. Water, Land & Biodiversity Conservation	SA	Associate

New Editors for *Exploration Geophysics* and *Preview*

Mark Lackie and Ann-Marie Anderson-Mayes are the new editors of *Exploration Geophysics* and *Preview*. They take over from Lindsay Thomas, who has been in charge of *EG* since 2002, and David Denham, who has been editor of *Preview* since 1999.

Mark is looking forward to the challenge of being editor of *Exploration Geophysics*. He feels that the journal's value is that papers on the application of geophysics, as well as papers investigating our basic understanding of geophysics, can be published together and read by both commercial and academic geophysicists.

He completed his geophysics degree at Melbourne University decades ago and his PhD last century at Macquarie University. He currently teaches Geophysics at Macquarie University and sees that his primary role as an academic is to produce the next crop of geophysicists and he enjoys this immensely. His research interests include palaeomagnetism, magnetics and gravity with the general aim of understanding geological problems. Through his teaching and research supervision he is also involved in the application of geophysics in understanding environmental and exploration problems. He is also a member of the GSA (Aust), AGU and GSA (USA).

And of course encourages all of you to submit papers. His email is: mlackie@els.mq.edu.au.

Ann-Marie has developed a passion for excellence in science communication and is looking forward to her new role as Editor of *Preview* magazine.

Her first contact with geophysics was undertaking some FORTRAN programming for Aerodata in Perth, Western Australia in the summer holidays of 1988/89. This led to an Honours project in 1989 on digital image processing of airborne magnetic gradiometer data. After graduating with 1st Class Honours in Physics, Ann-Marie continued to work with Aerodata/World Geoscience in areas that included digital image processing, analysis and marketing of SALTMAP AEM data. She also enjoyed working briefly in the Houston and Ontario offices of WGC. Between August 1993 and December 1995, she took a break from geophysics to coordinate the WISE project (Women in Science and Engineering) at UWA in Perth.

But eventually geophysics lured her back to work on an industry sponsored PhD project, once again with WGC. Being married to a geophysicist who likes to travel (Keith Mayes) meant that the PhD was commenced in Brisbane, at UQ, but then completed remotely whilst residing in Sweden and then England. In October 2000, Ann-Marie's PhD was awarded for a thesis entitled 'Enhancing Interpretation of Multivariate Airborne Geophysical Data for Dryland Salinity Studies'. In recent years, Ann-Marie has taken on small independent consulting roles in between the joys of having two children. This has included working as special editor with Greg Street on Volume 33, No. 2 of *Exploration Geophysics – Special Issues on Salinity and Land Management*. Her email is: ann-marie@mayes.com.au.

Mark Lackie

Ann-Marie Anderson-Mayes

Andrew Long is SEG's 2009 Honorary Lecturer

Congratulations to Andrew Long of Petroleum Geo-Services. He has been appointed as SEG's 2009 Honorary Lecturer, for The Pacific South.

The Honorary Lecture Program, previously known as the Regional Lecture Program, is a companion program to the long-established SEG Distinguished Lecture Program. The goals are similar:

1. Recognize an individual's contributions to advancing the science and technology of geophysics.
2. Foster a sense of community amongst geophysicists by providing opportunities for local meetings and exchange of ideas.
3. Encourage students by providing the opportunity to discuss scientific and career issues with a leading expert.

For 2009 program is presented by Shell.

Andrew's lecture is entitled 'Multi-azimuth and Wide-azimuth Seismic: Foundations, Challenges and Opportunities'.

His Australian itinerary is:

City	Country	Date	Lecture Time
Yogyakarta	Indonesia	2 May	9:00 am
Bandung	Indonesia	9 May	9:00 or 10:00 am
Wellington	New Zealand	18 May	Evening/Dinner
Melbourne	Australia	21 May	Lunch
Melbourne	Australia	21 May	4:30 pm
Perth	Australia	18 Jun	12:00 noon
Brisbane	Australia	7 Jul	Noon/Luncheon
Sydney	Australia	8 Jul	Evening/Dinner
Canberra	Australia	9 Jul	12 noon
Ballarat	Australia	10 Jul	Evening/Dinner
Hobart	Australia	13 Jul	Evening/Dinner
Melbourne	Australia	14 Jul	1:00 pm
Adelaide	Australia	15 Jul	5:30 pm
Manila	Philippines	24 Jul	6:00 pm
Kuala Lumpur	Malaysia	9 Sep	Evening/Dinner
Singapore	Singapore	9 Oct	To be arranged

For more details, including the abstract of his talk, visit: http://www.seg.org/hl or contact Koya Suto at koyasuto@optusnet.com.au. Koya is organizing the Australian leg of his tour.

Andrew Long

ASEG News

Australian Capital Territory

On March 18th, the ACT Branch held its AGM. Michael Morse from GA kicked off proceedings with a presentation, repeated from the ASEG conference in Adelaide by popular demand, on his ideas for enhancing geology from aeromagnetic data. The AGM followed the talk. The new committee elected for 2009 comprises Ron Hackney (President), Marina Costelloe (Secretary), Leonie Jones (Treasurer), Paul Sutherland (Student Rep.), Jonathan Griffin, Matt Purss, Nick Rawlinson, Malcolm Sambridge and Ned Stolz. The meeting also acknowledged the efforts of retiring committee members, Adrian Hitchman and David Robinson, who have made significant contributions at both branch and federal level over many years. ACT member David Denham was also recognised for his considerable efforts as *Preview* Editor.

2008 ended on a successful note with a well-attended Christmas barbeque held jointly with the local GSA and AusIMM Branches. Prior to that, several further technical meetings were held. These included presentations from Thomas Bodin (RSES, ANU) on a partition modelling approach to seismic tomography and Dhananjay (Tiku) Ravat (University of Kentucky) on his work on full-spectrum mapping of magnetic anomalies. The local Branch was also involved in organising the event to mark 50 years of the paleomagnetic hut at ANU in October (see Ted Lilley's report in *Preview* 137).

Canberra looks to be on the map in 2009. The Branch will host two SEG speakers: Jack Bouska (Spring Distinguished Lecturer) on May 11th and Andrew Long (South Pacific Lecturer) on July 9th. The program of technical talks for the first half of the year is also looking healthy with talks by Horst Holstein (currently visiting Intrepid Geophysics) and Denis Shephard (former curator of a collection of geophysical instruments at the National Museum) planned for April 15th and June 17th, respectively. A focus of efforts during 2009 will be on continuing joint meetings with PESA and the GSA, particularly for the prestigious SEG lecturers. Based on branch reports at the recent Federal Council meeting in Adelaide, efforts to boost meeting attendance by combining with other societies seem to be widespread. This was certainly a successful approach in 2008 for the ACT Branch – we managed three joint meetings and these were the best-attended events.

In 2009, we also aim to promote more student involvement and to encourage interaction between practising geophysicists and students who are beginning to discover the wonders of geophysics. Paul Sutherland has joined the 2009 committee as student representative. His enthusiasm will go a long way towards achieving this goal.

Ron Hackney

New South Wales

The NSW Branch held the first meeting of the year and it's AGM in February. Mark Lackie was elected as President, Bin Guo was elected as Secretary and Roger Henderson was elected as Treasurer and Peter Gidley continues as Webmaster. I am sure I have seen that lot before. The 2008 President's and Treasurer's Reports are available from the Branch website.

The President wishes to thank the Secretary Bin Guo, the Treasurer Roger Henderson and the Webmaster Peter Gidley for the effort they made in 2008; it makes life a lot easier.

In February, Clive Foss from Pitney Bowes Business Insight spoke about strategies to invert a suite of magnetic field anomalies due to remanent magnetization. Clive presented results from a study of magnetic field anomalies due to remanent magnetization in the Georgetown area of Queensland. Clive illustrated the inversion and magnetic moment analysis of simple and complex anomalies, and established the importance of isolating anomalies from superimposed background fields. Most if not all the potential field interpreters in Sydney were at this meeting and much discussion resulted from Clive's presentation, it was enjoyed by all.

An invitation to attend NSW Branch meetings is extended to interstate and international visitors who happen to be in town at that time. Meetings are held on the third Wednesday of each month from 5:30 pm at the Rugby Club in the Sydney CBD. Meeting notices, addresses and relevant contact details can be found at the NSW Branch website.

Mark Lackie

Queensland

The Queensland Branch held their first meeting of the year; combining the branch AGM with a preview of Mathew Dorling's ASEG conference talk 'Low impact seismic reflection-trialling Envirovibes in the Surat Basin'. The AGM was relatively quick with the re-election of Wayne Mogg as President, Shaun Strong as Secretary and election of Henk van Paridon as Treasurer. Congratulations must go to those Queensland branch members who presented papers at the ASEG conference in Adelaide. We hope to get the chance to revisit these talks in some form at branch meetings in the coming months.

Wayne Mogg

Developing geophysical skills in Australia – what are the opportunities and future prospects?

A forum with this title was held in Adelaide on Sunday, 22 February 2009, as a part of the ASEG/PESA 20th International Geophysical Conference and Exhibition. Approximately 40 participants met to discuss the current skills-development opportunities in Australia, to decide if there were gaps between these opportunities and the requirements of industry and other employers, and to formulate actions to address these gaps (if present). Topics discussed included the following:

- Undergraduate courses
- Postgraduate studies
- Continuing education for the existing workforce
- Geophysics research (e.g. Universities, industrial, CRCs, AMIRA, AuScope)
- Links between employers and educational institutions
- Attracting and retaining students to geophysics
- Linking with overseas institutions
- Geophysics career development (e.g. career pathway, mentoring)
- The role of the ASEG and SEG (e.g. conferences, journals, scholarships)
- The role of industry and governments

(In the following, comments supplied by participants and from other sources are enclosed in quotes, indented and italicized.)

Michael Asten (Monash University) (Figure 1) kicked off the formal presentations by providing a summary of the 'Survey of Geophysics Capability in Australian Universities' carried out in 2008 on behalf of the Minerals Council of Australia and the ASEG (see report link at http://www.minerals.org.au/mtec/what_we_do/education_policy). The ASEG and the MCA will be able to take forward the recommendations arising from this survey, namely:

1. Universities should collaborate to provide industry in-service and professional development courses in geophysics and/or a minerals industry oriented MSc program, to be offered nationally.
2. Universities should collaborate to build national teaching capacity in numerical and physics-based geophysics by encouraging collaborative undergraduate and postgraduate teaching initiatives.
3. The Commonwealth Government should fund the development of collaborative educational capabilities using state-of-the-art ICT systems.
4. Undergraduate students in designated faculties or technologies, who are recipients of industry scholarships, should have their core-funding contribution to the university paid at a higher level than that for non-scholarship students.

There was broad agreement that we should update annually the profile of geophysics in tertiary institutions as set out in the report prepared by Michael Asten in 2008. This would provide an accurate foundation when lobbying for change and for monitoring trends over the long term. This was one of four recommendations made to the ASEG Education Committee as a result of the discussions at this forum, namely:

1. That the ASEG Education Committee coordinates an annual update of the survey material presented in the 'Survey of Geophysics Capability in Australian Universities' (prepared by Michael Asten, Report 0808/1 for The Minerals Council of Australia, available from the MCA website http://www.minerals.org.au/mtec/what_we_do/education_policy). This would result in an increasingly valuable set of primary data, which could be used to analyse trends and changes over time.
2. That the ASEG Education Committee makes the cumulative survey information from the original report (without the analysis and recommendations that are part of the MCA report) and the subsequent updates available to the public via the MCA (http://www.minerals.org.au/) and/or ASEG websites (http://www.aseg.org.au/). This information would be useful to a wide range of people, including ASEG members.
3. That the ASEG Education Committee adds moderated, concise footnotes to the survey information. These would be obtained from a range of sources (e.g. the original author – Michael Asten, the universities, the ASEG Education Committee). Forum participants felt that it was important to clarify or draw attention to different aspects of the survey information (e.g. notable exceptions, anomalies, exclusions, restrictions) so that the public could properly comprehend the survey information.
4. That the ASEG Education Committee establishes and regularly updates a webpage on the ASEG website that provides links to the public information available for the geophysics courses offered by Australian universities (http://www.aseg.org.au/Education/default.aspx). Both ASEG members and the general public have indicated that this facility would be very useful to alleviate the present situation where it is frustrating and time-consuming to search through all of the university websites to find geophysics-related course information.

Fig. 1. *Michael Asten presenting a summary of the 'Survey of Geophysics Capability in Australian Universities' at the forum held in Adelaide on 22 February 2009.*

'The presentation by Mike Asten on his collation of the status of geophysical training is a valuable contribution – I found it very enlightening.'

'The benefit of Mike Asten's work will only be fully realised if the statistics/data are collected on a continuous basis. And the idea that the ASEG website act as a starting point for finding information on

geophysical studies is useful and important.'

'What interested me most was the idea of setting up some sort of Masters by coursework (or some degree/means for continuing education). I am not generally a fan of remote education by video lecture, etc. But having recently become acquainted with a number of highly motivated people, with demonstrated ability to work outside of the traditional classroom environment, I think it could work.'

'(I would like to) learn more about geophysics courses offered at Australian and overseas universities.'

'As a result of attending the conference, I have found a number of good courses that my colleagues and I will be attending in the next few months.'

Ken Witherly (Condor Consulting) and Richard Smith (Fugro Airborne Surveys) followed this up with some observations and outcomes from the 'Mentoring geophysicists in the mining industry' forum held at the 2008 SEG conference. Anecdotally, mentoring has always played an important role in the skills development of geophysicists and as a key ingredient of employee retention.

'The theme of mentoring came up in a couple of the talks. I plan to take a suggestion to the local ASEG branch that we try to set up some kind of mentoring for students at ANU that are interested in pursuing geophysics as a career.'

'People don't leave organizations; people leave leaders. What keeps your top talent motivated in these times of change? Good leadership. According to the Saratoga Institute, almost 90 per cent of leaders believe that employees leave for more money, whereas in reality 90 per cent of employees say they leave for other reasons, fundamentally stemming from poor leadership.' (Ian Hutchinson, The Weekend Australian, 21–22 February 2009)

Barry Bourne (Barrick Gold of Australia), Bob Whiteley (Griffith University, Coffey Geotechnics), Nick Fitzgerald (Woodside Energy Ltd), and Ned Stolz (Geoscience Australia) provided some fascinating insights into the graduate intake, skill requirements, training and career development aspects of employers in the minerals, geotechnical, petroleum and government sectors respectively. Approaches adopted by these employers to meet their geophysics skill requirements included sourcing employees from non-traditional sources, having good induction programs, and working hard to keep existing employees happy in their jobs (i.e. making employee retention a priority for managers). This last point goes beyond consideration of pay. Job satisfaction, work–life balance and career planning are also important. Recent events have served to highlight that the cyclic nature of the minerals and petroleum industries continues to be a challenge for all concerned (i.e. both employers and teaching staff at universities).

'Fundamental knowledge expectations of employers are not always being met by graduates.'

'The absence of industry-ready training courses as an adjunct to basic geoscience/geophysics degree courses is a notable omission from the available skills development opportunities.'

'The industry lays-off people periodically and this discourages people. If they leave or are asked to leave, they are unlikely to come back.'

'I will use the forum to try to justify changes in corporate behaviour (with respect to periodic layoffs).'

Having heard from the 'clients' of tertiary education services, the 'suppliers' in the form of Anton Kepic (Curtin University of Technology), Jim Macnae (RMIT University), and Mike Dentith (University of Western Australia) described some of the issues confronting those providing graduate and postgraduate geophysics education at the tertiary level.

'I found it useful to hear the academic's perspective in this subject.'

'Whilst I was aware that universities have funding issues, hearing it from the people who struggle with it on a daily basis was valuable.'

'Alas, I have to concentrate effort to keep one small specialist geophysics education option going, rather than putting effort into a better countrywide solution.'

'Academics need to be proactive in promoting geophysics across their institution – a convenient pool of students and nice little standalone geophysics department away from physicists, geologists, engineers etc. is not going to fall into their laps.'

'I (intend) to communicate more with the other geophysics teaching staff to see if we can liaise at all on equipment, short courses etc.'

Joe Cucuzza (AMIRA) ventured deep into the AMIRA archives to compile statistics to highlight the 'role of syndicated collaborative R&D in support of research institutions and the development of graduates'.

'(I will) try to develop research projects that will enhance the geophysical toolbox and thus provide avenues for more postgraduate students.'

Stepping further back along the supply chain for future geoscientists, Karin Barovich (University of Adelaide) provided results of student surveys used to gauge reasons for enrolment in an entry level university geology course. This survey suggested that the attitude and perception of secondary students towards the geosciences is an important factor in their decision to pursue geology (and by inference, geophysics) at the tertiary level. To this end, Graham Heinson (University of Adelaide) outlined the events that had been organised at the conference and exhibition for secondary level students.

'I suggest that we need to focus on outreach at schools... Our challenge is to enthuse (and attract) students at a young age to study science and to highlight geophysics as a viable career path.'

Reflecting on the presentations and discussions, it could be concluded that the issues could be tackled at three different levels.

1. Examples of fundamental impediments to the supply of 'suitably skilled geophysicists' that can be sensibly tackled head-on at a national level by high profile science groups such as the Australian Academy of Sciences include a reduction in the interest in maths and physics by students at secondary and tertiary levels and the obstacles imposed by the basic framework within which university teaching staff operate.
2. The ASEG, PESA and the industry umbrella groups such as the MCA can

work with universities, government organisations and industry to develop and promote more specific geophysics education and training initiatives, primarily at the tertiary and postgraduate level.

3. However, every single geophysicist can help by taking personal responsibility to promote geophysics as a discipline to the community and thereby raise public awareness and improve the image of geophysics. They can also provide support for other geophysicists within their organisations and local region through mentoring and technical discussions.

'The geosciences and mineral exploration in particular, have a poor public reputation based on perceptions (foundered in reality or otherwise) of cyclic demand, long periods of field work, and poor environmental and social records.'

'(There is a) lack of visibility and attractiveness to students of a career in geoscience (science generally), (and we) need more people encouraged into the sciences to produce more graduates.'

'A very interesting US-centered study was just released by the American Geological Institute (relevant section is at http://www.agiweb.org/workforce/reports/2009-EmploymentSectors.pdf). Only 20% of recent MSc graduates and 10% of PhD graduates have favourable opinions with respect to working for the mining industry." (A comment made in response to the SEG mentoring forum)

'We will pursue further community engagement in conjunction with the ASEG as it is important for the public to know our good work and to see that we as an industry are also proud of being what we are.'

'In 2008, the Geoscience Australia Education Centre has again had a very busy year…hosting visits from more than 150 groups, totalling more than 6000 students (approximately 4000 primary age students and 2000 secondary age students).' (Extract from the Geoscience Australia Education Centre Annual Report 2008)

'Although numbers vary from year-to-year, the Geoscience Australia Open Day in Canberra is a popular event attracting around 2000 visitors.'

The participants unanimously agreed that attending the forum had been beneficial because they now had a greater awareness of the many different issues that are involved and had been provided with an opportunity to discuss common and contrasting views.

In conclusion, I would like to thank both the speakers and the audience for contributing their time and their thoughts to the event. I encourage everyone to follow through with their actions. The sponsorship provided by the ASEG and Geoscience Australia for this event is gratefully acknowledged.

Richard Lane
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Successful Adelaide Conference, despite industry downturn

ASEG Conferences are the life-blood of the society. They provide opportunities to learn about new developments, to explore the exhibition and discover what new things the resource service companies are doing, to network with friends and colleagues and to discuss future plans for the ASEG. On all these issues, Andrew Shearer and his team delivered, by providing an excellent program at a fine venue (Figure 1).

The Conference statistics speak for themselves: 752 delegates from 32 countries attended and the number of overseas delegates gave the Conference a truly international flavour. A total of 143 papers were presented, of which 72 were in the minerals streams, 44 in the petroleum streams and 27 in the near surface/environmental categories. In addition there were 16 posters displayed throughout the Conference, nine workshops attended by approximately 200 people and of course the magnificent exhibition where 76 companies filled the Exhibition Centre.

The Conference dinner was a great success with 350 attendees. 120 secondary students visited the Conference and 140 attendees attended the one day 2009 SEG Distinguished Instructor Short Course on Petroleum Engineering: Integration of Static and Dynamic Models, presented by Patrick Corbett, Heriot-Watt University.

With minerals papers dominating the program, it is clear that this sector of the exploration industry remains the main strength of the ASEG. At the 2007 Perth Conference, there were 77 petroleum papers and 73 from the minerals sector, so the ratio of minerals/petroleum has changed significantly in the past eighteen months.

Fig. 1. *The Adelaide Conference venue (on the right) by the River Torrens in Adelaide.*

Opening session

The Conference was opened by the Premier of South Australia, Mike Rann, who gave an upbeat speech that highlighted the importance of the Resource Sector to South Australia and also described the government/industry cooperation taking place in that State to boost the industry (Figure 2).

As the Premier said:

'Even though the financial crisis will result in some weakening of exploration activity in the short term, the outlook for our resources sector remains positive due to the fact that our known resources are long-life and very competitive.

Last week's impressive profit result recorded by Santos provided a potent and timely symbol as to the ongoing health of the resources sector in South Australia.

And the success of the State Government's Program for Accelerated Exploration, or PACE program as it's known, has played an integral part in fuelling the resurgence of our mining industry. It has resulted in record expenditure of $355.2 million in minerals exploration last financial year, which represents a 10-fold increase in the space of five years.

When our Government came to office in 2002, South Australia had just four operating mines.

Now, we have 11 mines either operating or in construction, and another 20 to 30 more in various stages of planning and development.

But we are not resting on our laurels, and earlier this month the State Government announced that bidding has opened for five new petroleum exploration licenses in our Cooper Basin; the first major release of multiple Cooper Basin blocks in a decade.

The resources sector is crucial to South Australia's economic future, and we are committed to investing in the industry, as well as in education and training to sustain its skilled workforce.

That's why the State Government has secured an agreement with the prestigious University College London to establish a campus here in Adelaide that will offer a two-year Masters Degree in Energy and Resources. This is the first time that

Fig. 2. *The Premier of South Australia, Mike Rann, addressing the Opening Ceremony. At the table from left to right are Peter Elliott, President of the ASEG, and Tony Hill and Andrew Shearer, the Co-Chairs of the Conference Organising Committee.*

UCL has offered a degree program outside of Britain.

I'm delighted that Santos is backing this outstanding coup for South Australia by making a $10 million contribution to the UCL School of Energy and Resources through funds for scholarships, research and the sponsorship of a professional chair.

And just last week, the State Government announced a $100 000 grant to the University of Adelaide to support the training of mining engineers, and the University's involvement in the development of a common curriculum through Mining Education Australia.'

The Premier also highlighted the State's green credentials stating:

'We are now home to 58 per cent of Australia's installed wind power, and 32 per cent of the nation's grid-connected solar power capacity.

South Australia also boasts significant advantages in naturally occurring geothermal energy. Those resources, combined with the State Government's supportive investment framework, has enabled SA to attract more than 80 per cent of Australia's total investment in the research, exploration and development of this truly emissions-free "hot rocks" power source. That investment is worth more than $680 million, and the South Australian Government is strongly committed to its ongoing partnership with the geothermal industry, as part of the broader resources sector.'

And with these encouraging words he declared the Conference open.

ASEG Awards in Adelaide

Conferences are excellent opportunities for Awards to be given to members who have made special contributions to the ASEG and the community in general. The following awards were presented during the Conference.

Honorary membership

For distinguished contributions by a member to the profession of exploration geophysics and to the ASEG.

John Hughes
During a career that has spanned a decade in the UK and almost three decades in Australia, John Hughes has been almost constantly at the forefront of his field. John's work in the acquisition and processing of seismic data during his Santos years in the Cooper and Eromanga Basins in the 80s and 90s resulted in a number of seminal papers and world class standards of both technical and environmental nature. Many of these findings have been presented at ASEG conferences.

This work included early research into the problematic subject of static control. Later productivity improvements followed testing of 2D Seismic acquisition parameters. Many of these parameters are still being used now, both by operators within the Cooper and Eromanga Basins and service companies worldwide. John was also instrumental in instigating the testing and application of 3D Seismic in the Cooper and Eromanga Basins in 1992. This has subsequently resulted in a substantially enhanced discovery rate for exploratory and development drilling in the basin.

John has been heavily involved in ASEG technical standards committees over many years and has represented the geophysical industry on similar APPEA committees. He has been an active member in the ASEG for many years, at Branch, Federal and Conference levels since joining in 1984.

Well known within the oil and gas industries for his push for better environmental practice, John was heavily involved in a joint government and industry initiative to develop a system for environmentally sensitive seismic line preparation and rehabilitation within the Cooper Basin in the mid-1980s. The subsequent techniques and reporting procedures are considered by many to be industry's best practice, not only within Australia, but worldwide.

This environmental inclination took a different route in 2002, when he accepted an invitation to work with Deakin and Curtin Universities on cetacean monitoring and research. It is this more recent work that John is arguably most known for, specifically monitoring the influence of marine seismic acquisition on whale behaviour.

Since then, John has been presenting the results of this research in a variety of forums, both nationally and worldwide. He also is a representative on the International Joint Industry Program into E&P Sound and Marine Life. Largely thanks to John's work in this field, Santos was awarded the APPEA 2006 Environmental Award.

John has managed to balance a career-long commitment to environmentally sound practices with technical excellence and high productivity. John Hughes' career and accomplishments embody every aspect of the theme of this conference: Deeper, Brighter, Greener and it is fitting that his contributions are recognised with ASEG Honorary Membership.

Early Achievement Award

For significant contributions to the profession by way of publications in Exploration Geophysics *or similar reputable journals by a member under 36 years of age.*

Mark Tingay
Mark has eight years of experience in petroleum geomechanics and tectonics. He completed his PhD at the University of Adelaide in 2003, submitting a thesis titled *In Situ Stress and Overpressures of Brunei Darussalam*. This award-winning thesis revealed major insights into the present-day stresses and tectonics of deltaic systems deposited on active margins. His thesis was awarded the Harold Woolhouse Prize for the best scientific PhD Thesis at the University of Adelaide for 2003/2004 (in fact the first such award presented to a geoscientist at the University of Adelaide).

From 2003–2006, Mark was responsible for all petroleum industry aspects of the World Stress Map (WSM) Project, the world's foremost project on present-day stresses (he was based at the University of Karlsruhe in Germany). While at the WSM Project, he created the successful 'Present-day Stress in Sedimentary Basins' initiative, undertaking 15 collaborative projects with 18 petroleum companies worldwide. During this time he analysed stress orientations in over 400 boreholes, adding more petroleum industry data to the WSM than any other person in the project's 21 year history. His impact while leading the petroleum component of the WSM is further evidenced by his being invited to give a plenary paper at the 2006 American Rock Mechanics Association conference.

Mark started a four year Australian Post-Doctoral fellowship in mid-2006 investigating the 'Crustal Stress

Field of SE Asia'. This project aims to examine the state and origin of the present-day stress field in SE Asia and to investigate the changes in the stress field and tectonics in SE Asia throughout the Cenozoic. As part of this project, Mark has already instigated collaborative projects with petroleum companies in Thailand, Malaysia and India.

He has 12 refereed publications, given over 25 conference presentations and been invited to speak to over 35 companies, societies or universities on his PhD and WSM research. This record, we feel, is truly remarkable for a researcher of any experience. We feel that Mark embodies the spirit of the Young Achievers Award.

Conference Awards in Adelaide

Best Presentation

Nicholas Williams – *An automated sparse constraint model builder for UBC–GIF gravity and magnetic inversions*

Honourable Mentions

Petroleum: Natasha Hendrick – *Towards cost-effective permanent seismic reservoir monitoring*

Minerals: David Pratt – *Maximising geological information recovery from different magnetic instruments through the application of joint inversion*

Best Poster

Jonathan Ross and Graham Heinson – *Viva La Resistance! The utility of cross-hole electrical resistivity tomography to image resistive pathways*

Honourable Mention

Carlos Cevallos – *Defining a hypothetical boundary between two phases of the Braidwood Granodiorite*

Best Written Paper

Richard Chopping and Simon van der Wielen – *Querying potential field inversions for signatures of chemical alteration: an example from Cobar, NSW*

Honourable Mention

Tony Meixner and Fiona Holgate – *In search of hot buried granites: a 3D map of sub-sediment granitic bodies in the Cooper Basin region of Australia, generated from inversions of gravity data*

Best Small Booth Exhibit

DownUnder GeoSolutions Pty Ltd

Best Large Booth Exhibit

CGG Veritas

Laric Hawkins Award

For the most innovative use of geophysics in a paper presented at the Conference.

Maxim Lebedev, B Gurevich, B Clenell, M Pervukhina, V Shulakova and T Muller – *Velocity-saturation relation transition during rocks saturation: direct laboratory observation by computer tomography and ultrasonic technique'.*

Honourable Mention

Ross Brodie and Malcolm Sambridge – *Holistic inversion of time domain AEM.*

ASEG Research Foundation

Another big winner in Adelaide was the ASEG's Research Foundation. A total of $11 600 was donated at the Conference to enable the Research Foundation to support student research projects.

The Foundation was established in 1988 to encourage the study of exploration geophysics by providing students with support for research projects. Funds are specifically targeted at field or laboratory work carried out as part of study for an honours or postgraduate degree.

Since 1991 the Research Foundation has spent a total of more than $50 000 supporting 80 research projects. This has contributed to the completion of at least 47 honours, 13 masters and 20 PhD degrees at 11 tertiary institutions.

The $11 600 was raised through the generosity of individual conference participants and a number of companies. In addition each of the Corporate-Plus Sponsors contributes $2000 per year. The chief catalysts in the fund raising in Adelaide were Barry Long and Nick Sheard, who helped people donate at the Conference Dinner (Figure 3), and Louise Middleton who organised the very successful ***Grange*** raffle. A big thank you to Barry, Louise, Nick and our Corporate-Plus Sponsors.

Members of the Foundation are formally nominated and go through an approval process and registration involving the CSIRO legal department. This allows the Foundation to be registered so that all donations qualify for tax deductibility in Australia.

So if anyone would like to add to the Research Foundation please contact the Secretariat at secretary@aseg.org.au.

Fig. 3. *Members of the Order of the White Jacket, who have attended every ASEG Conference, at the Adelaide Conference Dinner. From left to right we have Nick Sheard, Barry Long (almost in disguise), Steve Collins (really in disguise), Peter Gidley, Bob Smith, Doug Roberts and John Denham.*

Welcome to Sydney in 2010

The 21st International Geophysical Conference and Exhibition will be held in Sydney at Darling Harbour from 22–26 August 2010. This will be an ASEG–PESA joint meeting and Figure 1 shows Mark Lackie the Co-Chair inviting members to Sydney in 2010.

The Conference Organising Committee for 2010 will be:

Co-Chairs
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mlackie@els.mq.edu.au

Phil Cooney (PESA) (02) 9948 6293
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Workshops
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Finance
Max Williamson (02) 9894 1886
wiltaxconsulting@bigpond.com

International Links
Bin Guo (02) 9024 8800
bguo@srk.com.au

Officers for Student Liaison, Publicity and Social Functions
Still to be appointed

Others
Keeva Vozoff (02) 9960 1499
kvozoff@iinet.net.au

Advice
Roger Henderson & Barry Smith

And just to whet your appetite here is an image of the Sydney Convention Centre, Darling Harbour.

Fig. 1. *Mark Lackie invites delegates to Sydney in 2010 while Andrew Shearer looks on after a job well done.*

Pictures from Adelaide 2009

Cash and Carbon

The government's economic stimulus package and its emissions trading scheme (ETS) have dominated Canberra. Everything else, apart from the Victorian bushfires and maybe the alcopop tax and the bikies, were just noise on the political landscape.

Cash

$84 billion to boost the economy

To minimise the effects of the 'Global Recession' the government is trying to stimulate the economy by pumping cash into peoples' pockets and strengthening national infra-structure. Whether this will work, or just produce an ephemeral blip on the GDP trends, only time will tell.

But let's summarise what is being spent. The stimulus packages so far, total $84 billion.

In 2008 the government pumped $10.4 billion into the economy, including $8.8 billion for pensioners and families and $1.5 billion for first home buyers. Then there was a $6.2 billion New Car Plan for a Green Future; a $0.3 billion Regional and Local Community Infrastructure Program, to boost local economic development by building local community infrastructure; $15.1 billion in a national reform package, focused primarily on improving schools and hospitals, and training more quality teachers, nurses and doctors; a $10 billion investment into rail, road, education & research and business and finally in 2009 a $42 billion stimulus package, which includes a $28.8 billion package for schools, housing and roads, and a $12.7 billion handout to low- and middle-income earners (everyone who earns less than $100 000 should get something).

Several of these packages involve commitments over the next three or four years but there is still an outlay in this financial year (2008–09) of about $26 billion and about $23 billion of this will be in cash hand outs.

To put these numbers into perspective, the government revenue for 2008–09 was estimated, in May 2008, to be $319.5 billion (~26% GDP) with expenses of $292.5 billion, leading to a surplus of $27 billion.

So the stimulus packages amount to about 7% of GDP – and will cause a deficit at the end of June 2009, because the revenue side of the budget will be smaller than the May 2008 forecast – a rapid $50 billion turnaround.

Will the stimulus work?

I don't think anyone will argue over the infrastructure components of the packages, but there is a big question mark over the value of the cash handouts. Will they contribute to long term job growth or will they be short term one-offs with no lasting effects? I suspect the latter. Too many people have spent their handouts on things like golf clubs, television sets and overseas holidays. So the main beneficiaries will be outside Australia and the boost to our economy will only be temporary.

Furthermore, the infrastructure projects mainly comprise bricks and mortar, roads, railway lines and bridges, very little towards the people involved in education, research and innovation.

Senator Carr, the Minister for Innovation, Industry, Science and Research, emphasised the importance of Science on 11 March 2009 in his speech to the National Press Club entitled The Science of Recovery: Research, Innovation and the Global Crisis.

He talked about *'Mobilising science against the global recession and enlisting it in the service of recovery.'* And pointed out that: *'The European Union has called on all member states to stimulate growth and productivity by increasing their investment in research, innovation and education.*'

Fine words, but the actions of the government in the stimulus package leave a lot to be desired.

For example nothing extra was given to the Australian Research Council; even though the $363 million for new research projects awarded under the National Competitive Grants Program in October 2008 is less than the Howard government's $370 million in 2005. Furthermore, the success rate is still only about 20% for Discovery Projects and a lot of good projects have to be rejected.

It is interesting to compare the Rudd package with Obama's stimulus plan, which amounts to US$838 billion. In terms of the per capita stimulus, there is ~A$3800 for Australia and ~A$3900 for the US – very similar levels of funding. However, the focus is different. In the US$15.8 billion was provided to conduct more federal R&D and $2.0 billion for R&D facilities and capital equipment. Whereas in Australia $452 million will be spent on university buildings and apparently nothing extra on research programs funded by the ARC.

Parkinson had a chapter in his book, *Parkinson's Law*, about the folly of constructing special purpose buildings. He argued that if you can afford to build new buildings it may well detract from what you should be actually doing. Let's hope this does not happen here.

Priority on jobs but not in government – GA and ABS face major cuts

One consequence of spending $84 billion is that it will eventually have to be paid for. The government's plan for this appears to be to cut its own expenditure. However, when the priorities are jobs, innovation, education and research, it seems counter-productive to cut institutions like Geoscience Australia and the Australian Bureau of Statistics.

According to the Canberra Times (20/3 and 21/3) up to 180 jobs could go in the ABS and 150 in GA. In a 'Clever Country' we should surely be striving for better statistics on the state of the nation not less. And as we still rely heavily on our resource industries we should be aiming to be smarter than our competitors in discovering and developing our natural resources – apparently the government does not think so. Or will it have a change of direction in the May budget?

Emissions Trading Scheme

The Carbon Pollution Reduction Scheme Legislation (http://www.climatechange.gov.au/emissionstrading/legislation/index.html) was introduced to the Australian Parliament on 10 March 2009. It comprises about 550 pages of legislation and 450 pages of commentary, so it has been a major drafting task for the bureaucrats, because the 820 page White Paper (http://www.climatechange.gov.au/whitepaper/report/index.html), on which the legislation is based, was only tabled on 15 December 2008. Makes you wonder if anyone has read all the pages.

Anyway, the plan is to reduce emissions by 5–15% below 2000 levels by 2020 and

Table 1.

Country	2020 targets	2020 per capita reduction	2050 targets
Australia	5–15% below 2000 levels (4–14% below 1990 levels)	27–34% below 2000 levels (34–41% below 1990 levels)	60% below 2000 levels (60% below 1990 levels)
European Union	20–30% below 1990 levels	24–34% below 1990 levels	60–80% below 1990 levels
United Kingdom	26–32% below 1990 levels	33–39% below 1990 levels	80% below 1990 levels
US (proposal of President-elect Obama)	Return to 1990 levels	25% below 1990 levels	80% below 1990 levels

by 60% in 2050. The scheme is scheduled to start on 1 July 2010, not very far away, and the easy part seems to be the first 12 years when the emissions will only have to be reduced by 5%. Table 1 shows how we compare to other regimes.

The important point to notice is that the Australian per capita reduction by 2020 is really quite large because of the significant population increase expected in the next 12 years.

In the Cap and Trade scheme being proposed, aggregate emissions are capped at a level that is consistent with the environmental objective and the government auctions permits to pollute.

The number of tradeable carbon pollution permits will be equal to the Scheme Cap – if the cap were to limit emissions to 100 million tonnes of carbon dioxide equivalent (CO_2-e) in a particular year, 100 million emissions permits would be issued for that year.

The Scheme will cover around 75% of Australia's emissions and involve mandatory obligations for around 1000 entities. There are around 7.6 million registered businesses in Australia: the overwhelming majority will not, therefore, face any direct obligations under the Scheme.

There will be initial rates of assistance of 90% for activities with an emissions intensity of at least 2000t CO_2-e/$m revenue or 6000t CO_2-e/$m value-added. The government has confirmed that only coal-fired electricity generation will receive support as a strongly affected industry. Needless to say the Greens and the LNG industry are not happy with this situation.

There will also be a huge raft of support for pensioners and other disadvantaged people to cope with the cost increase in electricity. But space precludes a discussion on this.

The White paper is strong words on renewable energy: *'Renewable generation will play a key role in the future of Australia's energy supplies. The Renewable Energy Target requires 20% of Australia's electricity to be sourced from renewable generators by 2020.'*

However, how we get to the 20% target is not articulated.

Needless to say, the Coalition and several industry groups want the whole scheme deferred until the global economic crisis has abated – even though the emission reductions are only 5% by 2020. I find the argument that the economic crisis should be used as an excuse to delay the scheme rather strange because the current downturn in global emissions should serve as an easier platform on which to plan long-term reductions. There would also be time to develop our huge natural gas resources to generate electricity rather than rely on more coal fired stations. Consequently it should be easier to meet our targets not harder.

Of course the Greens and many of the conservation groups are horrified that the targets are so low. They point to the results presented at March 2009 Climate Conference in Copenhagen.

This was attended by over 2000 international climate change scientists – ~100 of them from Australia.

They concluded that:

> *'Recent observations confirm that, given high rates of observed emissions, the worst-case 2007 IPCC scenario trajectories (or even worse) are being realised. For many key parameters, the climate system is already moving beyond the patterns of natural variability within which our society and economy have developed and thrived. These parameters include global mean surface temperature, sea-level rise, ocean and ice sheet dynamics, ocean acidification and extreme climatic events. There is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts.'*

As Penny Sackett, the Chief Scientist for Australia, said in a recent speech to the 2009 Science meets Parliament gathering in Canberra:

> *'Sea level, which can now be measured even more accurately from space, shows that the effects of melting ice sheets are causing the sea level to rise about 50% faster than the IPCC prediction, which did not include the effects of this melting. The new estimates indicate that without intervention, sea levels could rise a metre or more during the lifetime of a baby born today.'*

So what will happen in the parliament? Given the state of the parties in the Senate I think it most unlikely that the present draft bill will be passed. The Fielding/Xenophon voting patterns do not bode well for Kevin Rudd and the complexities in the legislation do not make it an easy issue for people to understand, let alone do anything about. So I give it a thumbs-down to start in 2010.

Eristicus

Update on geophysical survey progress from the geological surveys of Queensland, Western Australia, Northern Territory and Tasmania and Geoscience Australia (information current at 10 March 2009)

Tables 1–3 show the continuing acquisition by the States, the Northern Territory and Geoscience Australia of new gravity, magnetic, airborne EM and radiometric data over the Australian continent. All surveys are being managed by Geoscience Australia. There are three new surveys listed in this issue. The Cape York airborne magnetic and radiometric survey (Figure 1), which comprises ~60 000 km over the Cape York Peninsular at 400 m line spacing, a gravity survey in the same region (Figure 2) but covering a larger area ~172 000 km^2 with a 4 km grid, and another gravity survey in Western Australia, near Cunderdin, east of Perth (Figure 3).

GSWA and GA commenced the Cunderdin Gravity Survey in the Cunderdin region of WA in late January 2009. The survey has a regional focus (2 km station spacing) and a detailed focus (50–250 m station spacing) with the aim to establish a site for testing airborne gravity gradiometer systems.

Airborne electromagnetic data for South Paterson (WA) released

Airborne Electromagnetic (AEM) data for the South Paterson survey, Western Australia were released on 4 March 2009. These were collected with line spacing of 1 and 2 km and cover the Rudall Complex and Coolbro Sandstone of the Paterson Province and Neoproterozoic to Mesozoic sediments of the Officer and Canning Basins. The survey results will provide information on the conductivities of a variety of surface and near surface

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
AWAGS2	GA	UTS	29 Mar 07	145 350	75 km, 80 m N/S	7 659 861	100% complete @ 14 Dec 07	Jun 08	124 – Oct 06 p15	Gridded data – Feb 09; line data – Mar 09
South Kimberley	GSWA	GPX	24 Jan 08	163 000	400 m, 60 m N/S	57 920	100% complete @ 3 Oct 08	Nov 08	128 – Jun 07 p26	Nov 08
Cooper Basin East	GSQ	UTS	8 Jan 08	214 352	400 m, 60 m N/S	76 980	100% complete @ 13 Sep 08	Dec 08	130 – Oct 07 p29	Feb 09
Cooper Basin West	GSQ	Fugro	8 Nov 07	N-S lines 161 088 E-W lines 47 993	400 m, 60 m N/S & E/W	N-S lines 57 700 E-W lines 16 710	91.6% complete @ 2 Nov 08	Dec 08	130 – Oct 07 p29	Feb 09
Normanton	GSQ	Thomson	25 Apr 08	114 487	400 m, 80 m E/W	74 410	100% complete @ 26 Sep 08	Nov 08	132 – Feb 08 p23	Dec 08
Cooper Basin North	GSQ	GPX	29 Sep 08	166 373	400 m, 80 m E/W	59 480	23.1% complete @ 2 Nov 08	TBA	134 – Jun 08 p22	TBA
Offshore NE Tas	GA	Fugro	8 Dec 08	29 262	800 m, 90 m E/W	18 750	100% complete @ 29 Jan 09	TBA	137 – Dec 08 p23	TBA
South-West Catchment Council – Dumbleyung	GSWA DAFWA and SWCC	Fugro	7 Mar 08	74 360 total (67 583 @ 100 m spacing and 6777 @ 400 m spacing	100 m, 30 m NS and 400 m, 60 m N/S	7783 total (100 m lines 5948 400 m lines 1835)	100% complete @ 17 Oct 08	Nov 08	132 – Feb 08 p24	Nov 08
Balladonia	GSWA	UTS	~2 Dec 08	43 449	400 m, 60 m E/W	14 960	100% complete @ 12 Jan 09	TBA	134 – Jun 08 p22	~May 09
Esperance	GSWA	Thomson Aviation	19 Sep 08	82 674	400 m, 60 m E/W	29 200	100% complete @ 18 Dec 08	TBA	134 – Jun 08 p22	~May 09
Cape York	GSQ	TBA	TBA	239 180	400 m, 60 m E/W	59 480	TBA	TBA	This issue Figure 1	TBA

TBA, to be advised.

Table 2. Airborne electromagnetic surveys

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Paterson	GA	Fugro	8 Sep 07	28 367	1000 & 2000 m for GA; 200 m–666 m company infill; 120 m; E/W & SW/NE North & South respectively of the Rudall River NP	33 950	100% complete @ 14 Sep 08	South Paterson Jan 09	130 – Oct 07 p30	South Paterson on DVD 4 Mar, from GA
South-West Catchment Council: Darkan – Wagin	GSWA DAFWA and SWCC	Geoforce	10 Jun 08	1127	300 m; N–S	288.6	21 Jun 08	TBA	133 – Apr 08 p20	TBA
Pine Creek (Kombolgie)	GA	Geotech Airborne	21 Aug 08	9350	1666 & 5000 m for GA; 200 m–1000 m compavny infill; E/W flight lines; Flying height 30 m	30 710	100% complete @ 16 Oct 08	TBA	133 – Apr 08 p21	TBA
Pine Creek (Woolner & Rum Jungle)	GA	Fugro	11 Oct 08	20 820	1666 & 5000 m for GA; 200 m–1000 m company infill; E/W flight lines; Flying height 120 m	44 689	50% complete @ 8 Dec 08	~Jun 09	133 – Apr 08 p21	TBA

TBA, to be advised.

Table 3. Gravity surveys

Survey name	Client	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Westmoreland – Normanton	GSQ	Integrated Mapping Technologies	Apr 08	5977	4 regular	95 620	100% complete @ 17 Aug 08	Nov 08	133 – Apr 08 p21	Dec 08
Central Arunta	NT	Atlas Geophysics	6 May 08	9958 in Area A & a possible 1128 in Area B	4 regular with selected areas for infill at 500 m to 2 km	97 600	100% complete @ 7 Aug 08	Nov 08	133 – Apr 08 p21	Jan 09
Windimurra	GSWA	Atlas Geophysics	30 Jul 08	6066	2.5 km regular	~30 000	100% complete @ 17 Sep 08	Nov 08	135 – Aug 08 p16	~Nov 08
Cunderdin	GSWA	Daishsat	28 Jan 09	10 744	50–250 m, 500 m, 2 km	22 500	80% complete @ 5 Mar 09	TBA	This issue	TBA
Cape York	GSQ	TBA	TBA	10 315	4 regular	171 900	TBA	TBA	This issue	TBA

TBA, to be advised.

materials which will aid exploration in the appropriate application of AEM in the region.

The data are available on DVD from the Geoscience Australia Sales Centre or telephone 1800 800 173.

For further information, email: alan.whitaker@ga.gov.au or phone +61 2 6249 9702.

Southern Gunnedah gravity survey data now open file

On 23 February 2009, the 2008 Southern Gunnedah gravity survey became open file and available for download from the Australian National Gravity Database.

This survey covering parts of the Gilgrandra, Tamworth, Dubbo and Singleton 1:250 000 sheet areas was commissioned by the Geological Survey of New South Wales and subsequently included in the Australian National Gravity Database.

Station spacing for the survey is 2 km and the total number of new gravity stations from the survey is 5406.

Open file data in the Australian National Gravity Database can be obtained free-of-charge via the Geophysical Archive Data Delivery System (GADDS).

For further information, email: mario.bacchin@ga.gov.au or phone +61 2 6249 9308.

Onshore energy security program seismic survey data releases

Gawler–Curnamona–Arrowie seismic survey

Geoscience Australia undertook acquisition of seismic reflection in South Australia as part of the Onshore Energy Security Program in June/July 2008. This survey consisted of three traverse lines, one across the Gawler province (08GA-G01, 253 km), one across the Curnamona province (08GA-C01, 262 km) and one in the Arrowie Basin (08GA-A01, 60.4 km). The unprocessed data for these lines is now available. Geoscience Australia's geophysicists are currently processing the data with the

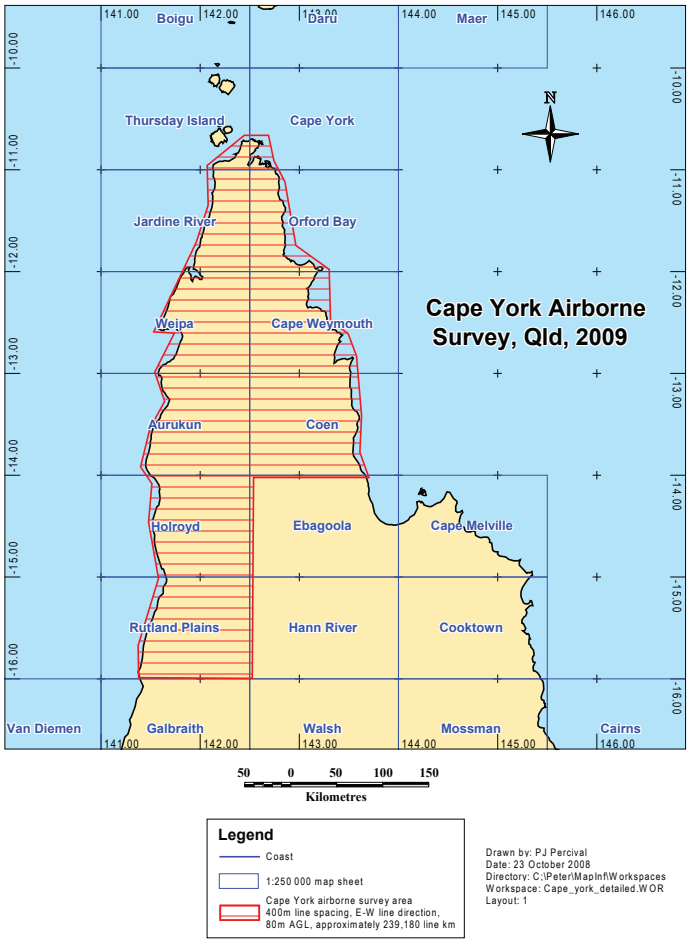


Fig. 1. *Location of the Cape York airborne geophysical survey (see Table 1 for details).*

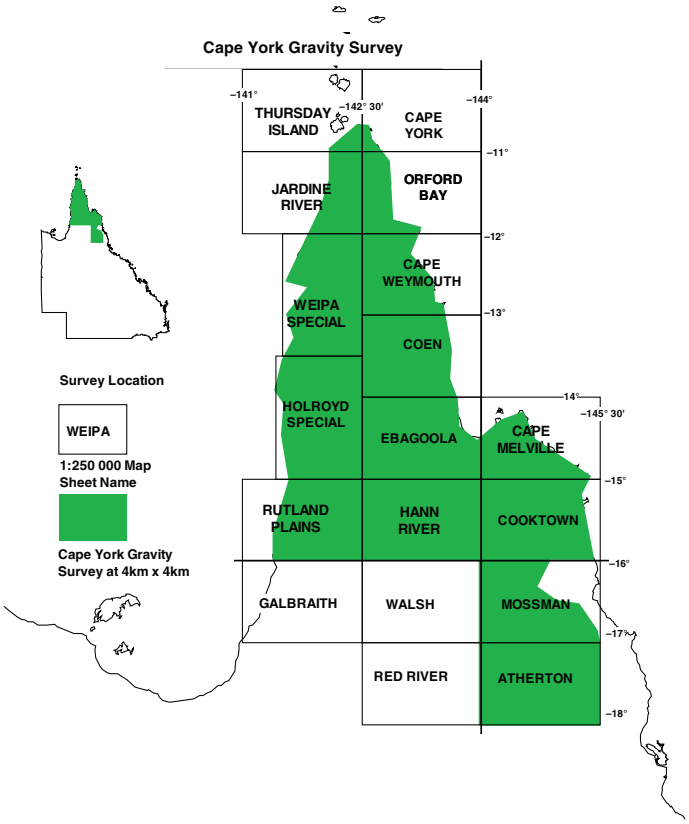


Fig. 2. *Location of the Cape York Gravity Survey (see Table 3 for details).*

aim of releasing the processed Arrowie traverse data in May 2009 at the APPEA conference and the processed Curnamona and Gawler traverse data later in the year.

Gawler–Officer–Musgrave–Amadeus survey (GOMA)

During November and December 2008, 634 km of seismic reflection and gravity data were acquired in one continuous north–south traverse beginning 25 km southeast of Erldunda in the Northern Territory and completing near Tarcoola in South Australia (08GA-OM1). This traverse followed the Alice Springs to Adelaide railway line utilising the railway access road and was jointly funded by Geoscience Australia through the Onshore Energy Security Program, AuScope and PIRSA. Processing of the seismic data will commence in mid 2009 with the aim of completing by the end of the year.

Curnamona–Gawler Link

In January 2009 seismic data were acquired along a traverse that crossed from the Gawler Craton to the Curnamona Province (09GA-CG1). This survey was jointly funded by PIRSA and Geoscience Australia through the Onshore Energy Security Program. 145 km of new seismic data were acquired and the traverse joins onto a previously acquired traverse of the Curnamona Province that was conducted in 2003–2004. Processing of these data will commence by mid 2009 with the aim of completing by the end of the year. Gravity data were collected along this traverse by PIRSA and are currently being checked and loaded into the Geophysical Archive Data Delivery System (GADDS). Figure 4 shows the locations of these traverses.

To obtain more information on these surveys or to request data contact Jenny Maher, Project Leader Seismic Acquisition and Processing, phone +61 2 62499896 or email: jenny.maher@ga.gov.au.

Northern Territory *Brings Forward Discovery*

The aim of all explorers is to make the next major discovery. *Bringing Forward Discovery (BFD)* is a new Northern Territory initiative directly targeted to assist explorers on the road to discovery.

It offers financial support for exploration geophysics and drilling in greenfields areas, new high-quality geoscience to lower exploration risk, and support for attracting investment in your exploration projects.

The Northern Territory Government has committed $14.4 million over 4 years to lower exploration risk and assist in making the Territory's next discovery. This unique program will assist to:

- identify exploration opportunities in greenfields terranes and undercover
- source collaborative funding for your exploration geophysical surveys and drilling
- attract investment partners for exploration projects

The BFD program is delivered by the Northern Territory Geological Survey (NTGS).

The Northern Territory Government has official cooperation agreements in China with the China Chamber of

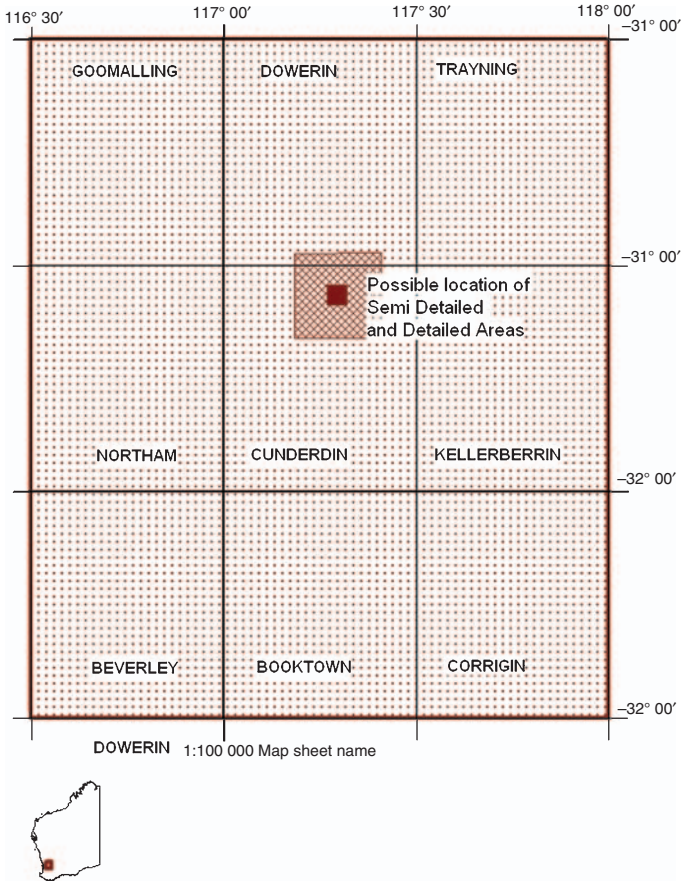


Fig. 3. *Location of the Cunderdin Gravity Survey (see Table 3 and the text above for details). The semi-detailed and detailed areas near the centre of the survey area are being proposed as an airborne gravity calibration site.*

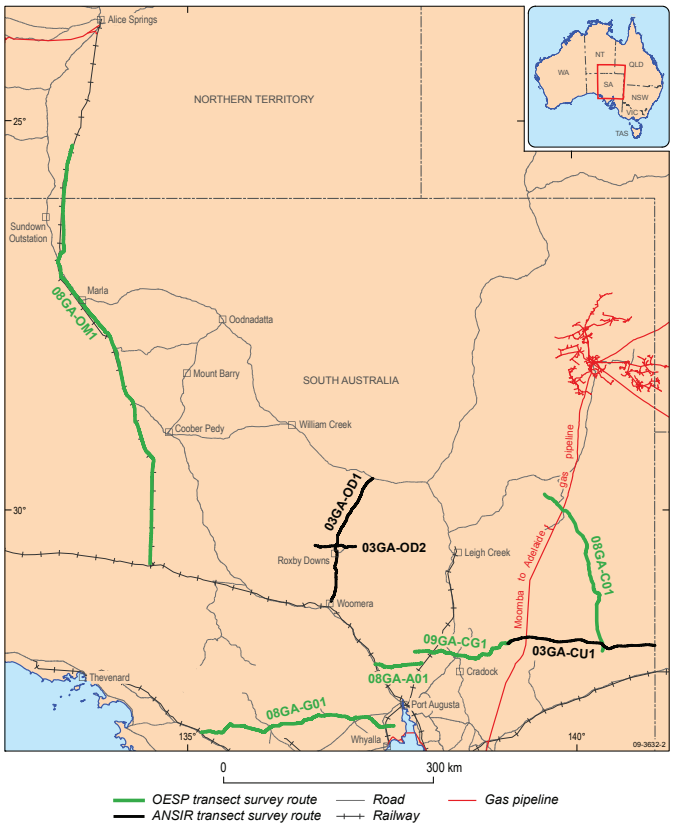


Fig. 4. *Location of the traverses referred to in the text above.*

Commerce Metals and Minerals and the China Mining Association and key links in Japan with the Japan Oil and Gas Minerals Corporation (JOGMEC).

These strategic partnerships assist to identify potential investors and open doors for Northern Territory explorers.

For more information contact: www.orestruck.nt.gov.au or http://www.nt.gov.au/d/orestruck/index.cfm?header=NT%20Investment%20Alert.

Mineral exploration declines

The global financial crisis has finally impacted on mineral exploration. Figures released by the Australian Bureau of Statistics in March 2009 show that the trend estimate for total mineral exploration expenditure fell by $20.4 million (3.1%) to $635.4 million in the December quarter 2008. However, this is still 6.3% higher than the December quarter 2007.

Figure 1 shows the expenditure estimates for the last 8 years and it clearly shows, what all those in the industry already know, that peak has passed.

However, the news was not all bad. The Western Australian figures only declined by about 4.4% from the September 2008 quarter, to a still substantial $343.3M in seasonally adjusted numbers. And both Tasmania ($7.5M to $8.2M) and the Northern Territory ($36.2M to 39.2M) recorded slight increases. Queensland recorded the largest fall both in percentage and dollar terms, dropping from $107.8M in the previous quarter to $94.9M.

In the context of commodities, gold, rather surprisingly because of the strong gold price, fell from $133M to $120M, whereas coal and iron ore rose from $68.5M to $82.9M and from $162M to $182.5M respectively.

Expenditure on existing deposits only fell from $417.1M in the previous quarter to $410.8M in the December quarter. However, expenditure on greenfield prospects fell from $270.6M to $237.7M as companies aimed to reduce their exploration risk.

In seasonally adjusted terms, total metres drilled fell 6.4% in the December quarter 2008 from 2424 km to 2270 km.

The number of actual metres drilled fell 17.3% from 2705 km in the September quarter to 2236 km in the December quarter. Drilling in areas of new deposits fell 25.9% from 1069 km to 792 km while drilling in areas of existing deposits only fell 11.7% from 1636 km to 1444 km. These numbers confirm that companies are exploring close to areas where they have already found ore deposits.

Figure 2 shows the longer term trends from March 1986. It indicates that in real terms the exploration levels are still very high. The big unknown is how far will exploration investment fall?

Global trends mirror Australian results

The Metals Economics Group, in a special report for the PDAC 2009 in Toronto (see http://www.metalseconomics.com/default.htm), indicated that in 2008 worldwide nonferrous exploration totalled $13.2 billion[1], up from $10.5 billion in 2007 – which was also a record year. The MEG surveyed 1912 companies with a budget of over $100 000 to compile these numbers. As can been seen in Figure 3, the increases since 2002 have been huge.

Figure 4 shows how each major region of the world fared in 2008. Australian numbers have increased from 2007 by 2% (from 12 to 14%) which is excellent when there is increasing global competition for the exploration dollar.

Petroleum exploration now greater than $1 billion

The Petroleum sector did well in the December quarter with expenditure on petroleum exploration rising by a massive $232.1 million (29.7%) to $1013.4 million. This is the first quarter when over one billion dollars have been invested in petroleum exploration in Australia (see Figure 5).

Expenditure on exploration on production leases rose $35.7M (17.9%), while exploration on all other areas rose $196.4M (33.7%) this quarter.

Offshore exploration rose $216.7M (32.8%) in the December quarter 2008, while onshore exploration expenditure rose $15.4M (12.8%).

Western Australia had the largest rise in exploration expenditure of $259.4M (48.1%) to a massive $798.9M, which is 79% of the Australian total. An excellent outcome for WA and the whole country.

Stock Market starts to recover

Meanwhile, although the financial market has taken a battering in the last year there are signs that it is starting to recover. The All Ordinaries Index has risen 16% in March and the market capital of the resource companies in the top 150 companies on the ASX has risen 31% since November 2008 through the end of March 2009.

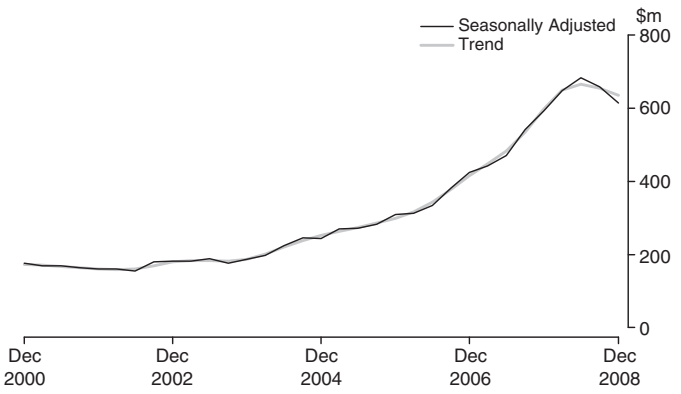


Fig. 1. *Trend and seasonally adjusted quarterly mineral exploration expenditure from December 2000 through December 2008 (provided courtesy of the Australian Bureau of Statistics).*

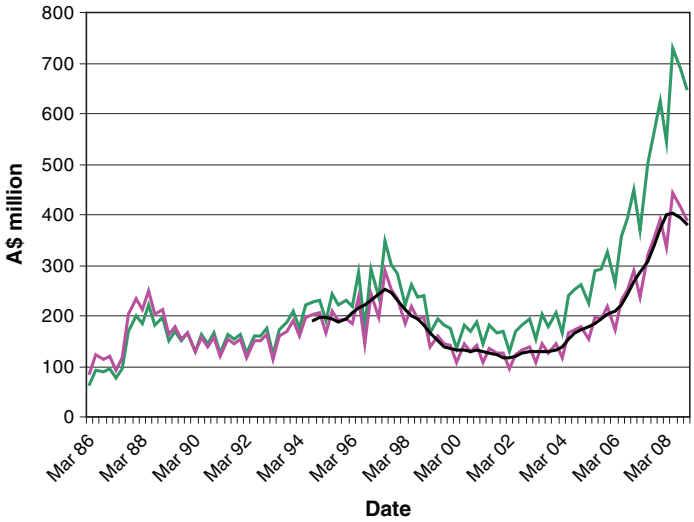


Fig. 2. *Quarterly 'actual' mineral exploration expenditure from March 1986 through December 2008 (from ABS data). The green curve represents actual dollars spent, the purple curve shows the CPI adjusted numbers to 1998/99 levels and the black line is the trend line (ABS data).*

[1]All the Mineral Economics Group numbers are in US$, not adjusted for inflation.

News

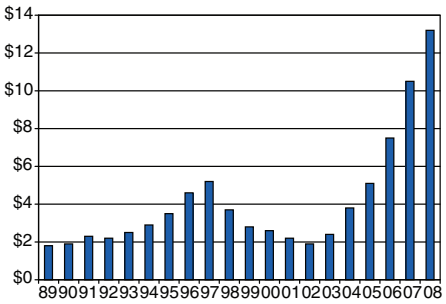


Fig. 3. *Estimated total worldwide non-ferrous mineral exploration budgets in US$ billions for 2008, not adjusted for inflation (courtesy Metals Economics Group).*

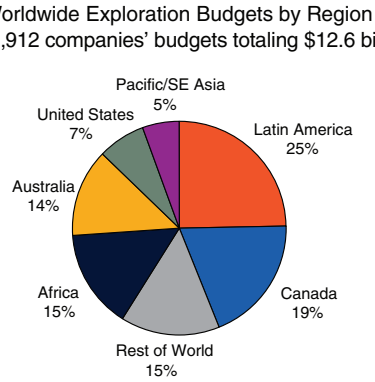


Fig. 4. *Worldwide Exploration Budgets by Region, 2008. The percentages are very similar to the 2007 numbers (courtesy Metals Economics Group).*

Figure 6 shows how the resource stocks and the All Ordinaries Index have fared.

Notice how the resource companies took longer to fall and appear to be recovering better than much of the rest of the market.

Is it time to buy if you can afford to?

OZ Minerals starts production at Prominent Hill but government knocks back Chinese takeover

The $1.15 billion Prominent Hill copper and gold mine, located 650 km north west of Adelaide and 130 km north west of BHP Billiton's Olympic Dam, started producing ore in February 2009. The first sales of concentrate are planned for the first quarter of 2009.

It is expected to produce up to 100 000 tonnes of copper and 2.2 tonnes of gold this year, and could operate until 2030, depending on the feasibility of underground mining at the site. Its production will add up to $627 million to South Australia's exports in 2009, depending on metals' prices.

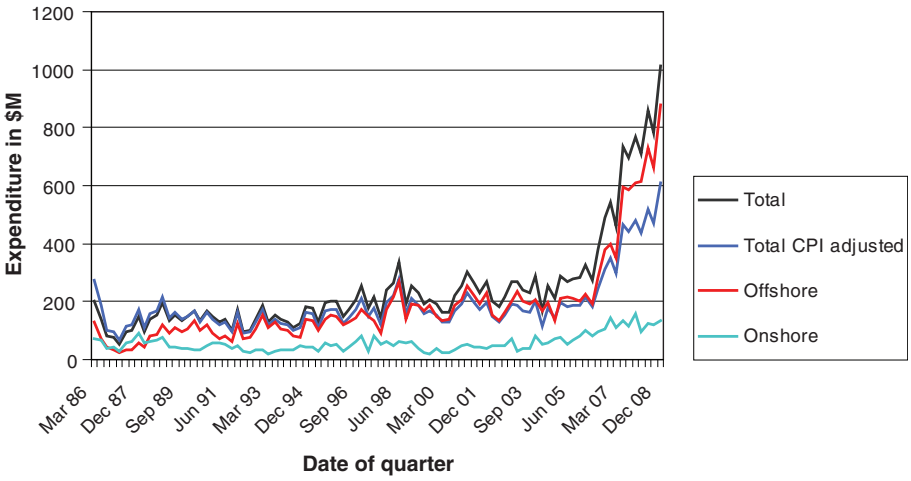


Fig. 5. *Quarterly petroleum expenditure from March 1986 through December 2008. The individual offshore and onshore numbers are actual numbers spent at the time, not CPI adjusted. The black graph shows the contemporary dollars spent and the blue curve shows the CPI adjusted number to 1989/90 dollars for the total of the petroleum exploration expenditure.*

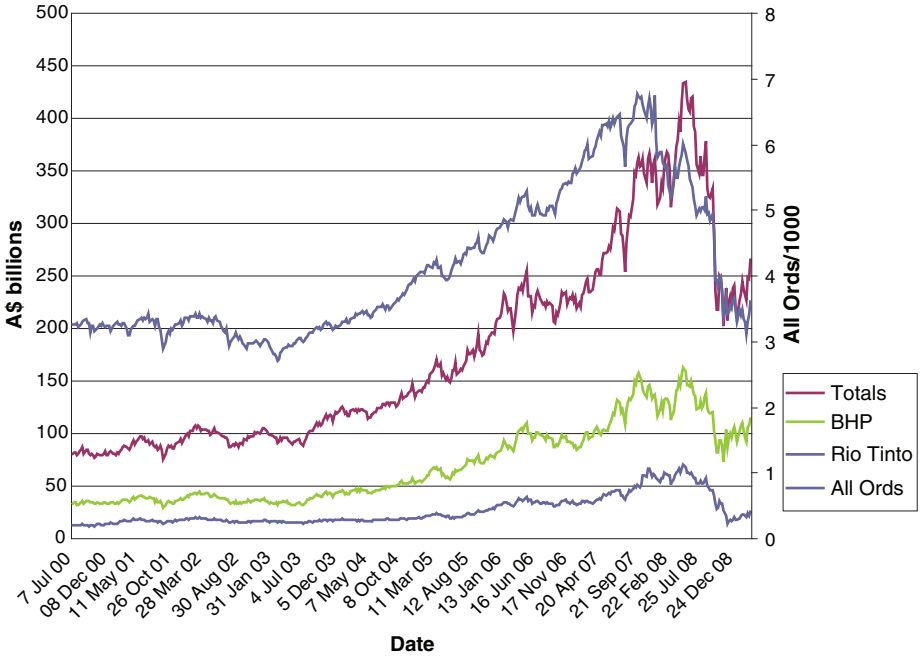


Fig. 6. *The brown line represents the total market capital of the resource companies listed in the top 150 of the ASX registered companies. The blue line represents the All Ordinaries Index and the other two curves shown the numbers for BHP Billiton and Rio Tinto. The data set goes up to 27 March 2009.*

However, OZ Minerals Limited, which owns 100% of the Prominent Hill copper-gold project, is having cash flow problems and the government has rejected the purchase by China Minmetals Non-Ferrous Metals Co. Ltd for 100% of the company.

The reason was rather unusual. It is because:

'OZ Minerals' Prominent Hill mining operations are situated in the Woomera Prohibited Area in South Australia. The Woomera Prohibited Area weapons testing range makes a unique and sensitive contribution to Australia's national defence.

The Government has determined that Minmetals' proposal for OZ Minerals cannot be approved if it includes Prominent Hill. I have informed Minmetals of this decision.'

So said the Treasurer, Wayne Swan.

Permit Area Number of Bids	Operating Companies	Exploration Program
Bonaparte Basin NT/P77 (released as NT07-4), one bid	Essar Exploration & Production Ltd	950 sq km of new 3D seismic, valued at ~$59 million and a secondary program of 600 km of new 2D seismic valued at ~$31 million.
Bonaparte Basin NT/P78 (released as NT07-5), one bid	Essar Exploration & Production Ltd	750 sq km of new 3D seismic valued at ~$35 million and a secondary program of 700 km of new 2D seismic valued at ~$27 million.
Gippsland Basin Vic/P66 (released as V07-3), one bid	Bass Strait Oil Company Ltd, Strategic Energy Resources Ltd & Oil Basins Ltd	400 km of new 2D seismic valued at ~$1.3 million and a secondary program of geotechnical studies and one well to a value of ~$15.6 million.
Browse Basin WA-413-P (released as W07-9), four bids	Hunt Oil Company	1033 km of reprocessed 2D seismic data and reprocessing 5450 km of 2D data, 1121 km of new 2D seismic valued at ~$2.45 million and a secondary program of 433 sq km of new 3D seismic and two wells to a value of ~$45.4 million.
Browse Basin WA-414-P (released as W07-10), one bid	Hunt Oil Company	785 km of 2D reprocessed seismic data, reprocessing 287 km of 2D seismic data and 374 km of new 2D seismic to an estimated value of ~$0.5 million. A secondary program of one well and 500 km of new 2D seismic to a value of ~$18.7 million.
Canning Basin WA-415-P (released as W07-13), one bid	Woodside Energy Ltd	1500 km of 2D seismic data, and 475 km of new 2D seismic to an estimated value of $3.2 million. A secondary program of 400 km of new 2D seismic surveying and one well to a value of ~$20.3 million.
Canning Basin WA-416-P (released as W07-14), one bid	Woodside Energy Ltd	700 km of 2D seismic data, and 55 km of new 2D seismic valued at ~$0.63 million. Secondary program of, 150 km of new 2D seismic and one well to a value of ~$18.85 million.
Canning Basin WA-417-P (released as W07-15), one bid	Woodside Energy Ltd	700 km of 2D seismic data and 175 km of new 2D seismic valued at ~$1.35 million. A secondary program of 200 km of new 2D seismic and one well valued at ~$19.1 million.
Carnarvon Basin WA-418-P (released as W07-18), one bid	Finder Exploration Pty Ltd	980 km of reprocessed 2D seismic data, reprocessing of 1000 km of 2D seismic data and 250 sq km of new 3D seismic valued at ~$4.6 million. A secondary program of one well to a value of ~$35.3 million.
Canning Basin WA-419-P (released as W07-12), one bid	Emerald Gas Pty Ltd	800 km of 2D seismic data, 450 km of new 2D seismic to a value of ~$1.21 million. A secondary program of, 100 sq km of new 3D seismic and two wells to a value of ~$41.5 million.
Bonaparte Basin WA-420-P (released as W07-2), one bid	Goldsborough Energy Pty Ltd	300 sq km of new 3D seismic to a value of ~$5.4 million. A secondary program of one well to a value of ~$15.6 million.
Bonaparte Basin WA-421-P (released as W07-3), one bid	Goldsborough Energy Pty Ltd	850 km of new 2D seismic and 3500 km reprocessing of 2D seismic data at ~$2.4 million. A secondary program of one well at a cost of ~$15.6 million.
Bonaparte Basin WA-422-P (released as W07-1), one bid	National Oil Corporation Pty Ltd	800 km of new 2D and 200 sq km of new 3D seismic to an estimated value of $4.2 million. A secondary program of one well to an estimated value of ~$15.6 million.
Browse Basin WA-423-P (released as W07-11), three bids	Murphy Australia Oil Pty Ltd	500 sq km of new 3D surveying and one well to a value of ~$25.5 million. A secondary program of 500 sq km of new 3D seismic and one well valued at ~$45.5 million.
Browse Basin WA-424-P (released as W07-8), seven bids	Nexus Energy Australia NL	Geotechnical studies and one well valued at ~$15.2 million. A secondary program of 500 sq km of new 3D seismic, one well and 200 sq km of new 3D seismic valued at ~$36.2 million.

We will have to wait and see how this issue develops because unless a majorcash injection is made OZ Minerals may have to go into receivership.

Award of 15 new offshore exploration permits

Fifteen new offshore petroleum exploration permits in the Western Australia, Northern Territory and Victoria offshore areas have been granted The work program commitments for the awarded permits are valued at $442 million over the next 6 years.

These new permits result from the second round of the 2007 Acreage Release that closed on 17 April 2008. All permits will be jointly administered by the Australian Government and the respective State and Northern Territory Governments.

The largest investment will be made by Essar Exploration and Production Ltd. It plans to spend a minimum of $95 million in the Bonaparte Basin. The table above provides details of the work being proposed.

More areas open for bids at APPEA 2009

The map shown in Figure 7 indicates the areas currently proposed for release in 2009 and now includes 2 additional special areas (marked in red). These areas contain known petroleum accumulations that cover the Barnett and Turtle discoveries. The formal release will be made by Minister Ferguson at the April APPEA conference in Darwin. Notice that there are several areas in deep water off South Australia and Western Australia.

Continued on p. 48

Uranium: why, where and how we look for it (part 2)[1]

How we look for uranium

Uranium occurs naturally in many rocks, and even in seawater. However, it is seldom sufficiently concentrated to be economically recoverable. As a rule of thumb we need concentrations of uranium greater than 750 ppm to develop an economical mine – unless you happen to have the Olympic Dam deposit, where concentrations in the range 300–400 ppm are economic because of the other valuables contained in the ore. One study argues that for concentrations below 100–200 ppm, the energy required to supply the fuel, extract and process the ore, operate reactors and dispose properly of the spent fuel, comes close to the energy gained by using the uranium in the reactor (http://en.wikipedia.org/wiki/Peak_uranium).

Table 1 (http://www.world-nuclear.org/info/inf75.html) indicates a range of concentrations using the Canadian definitions for the ore grades.

Because uranium is ubiquitous it is not surprising that it occurs in several mineralisation styles.

The International Atomic Energy Agency assigns the uranium deposits, according to their geological settings, to 15 main categories of deposit types, arranged according to their approximate economic significance (http://www.wise-uranium.org/uod.html). Table 2 shows the classifications and Figure 1 shows the locations of Australia's uranium mines.

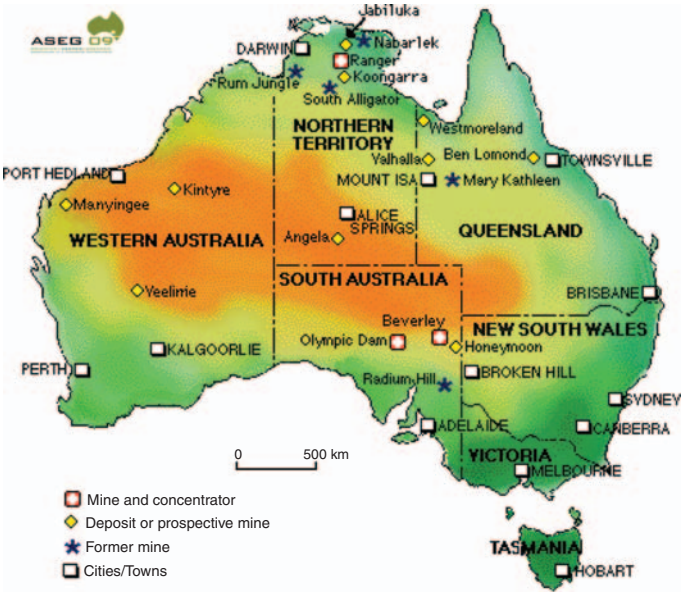
The main conclusion from this classification list is that there are almost as many categories as there are deposits. Therefore, we will identify the techniques generally used, rather than focus on the particular methods used to find individual deposits. Table 3 is a summary of those techniques as well as useful references that relate to uranium exploration. The Fairclough and McGeough paper is particularly good review of several of the techniques currently available.

Table 1. Uranium grades

Source	U concentration (ppm)
Very high-grade ore	200 000
High-grade ore	20 000
Low-grade ore	1000
Very low-grade ore	100
Granite	4–5
Sedimentary rock	2
Earth's continental crust (Av)	2.8
Seawater	0.003

Table 2. Uranium mineralised styles; typical deposits in Australia

1. Unconformity Redox-related deposits	Pine Creek (East & West), Ranger, Beverley (SA)
2. Sandstone deposits	Central Australian Basins
3. Quartz-pebble conglomerate deposits	
4. Vein deposits	Radium Hill
5. Breccia IOCG (Iron Oxide Copper Gold) complex deposits	Olympic Dam, Carrapateena
6. Intrusion-elated deposits	Olary, Rossing (Canada)
7. Phosphorite deposits	
8. Collapse breccia pipe deposits	
9. Volcanic deposits	East Kimberley WA, China, Russia
10. Surficial deposits	
Palaeochannels	Honeymoon, Beverley
Calcrete	Napperby
11. Metasomatite deposits	Mary Kathleen, Mt Gee (Arkaroola)
12. Metamorphic deposits	
13. Lignite	Mulga Rocks
14. Black shale deposits	
15. Other types of deposits	



Uranium Workshop

Fig. 1. *Australia's uranium mines (from Mark McGeough, General introduction to various uranium mineralisation styles focussed mainly on Australia, ASEG Uranium Workshop, Adelaide 2009).*

[1]Part 1 was published in the December 2008 issue of *Preview*.

Table 3. Summary of techniques used in uranium exploration

Technique	Application/comments
Gravity	Detailed airborne and land gravity is useful to model the geological structure in the target areas – depth to basement, shapes of intrusions and other structural features. Crucial in the discovery of Olympic Dam. Can be used to find paleochannels by using close (~20 m) station spacing. *(David McInnes, Integrated Case Histories, ASEG Uranium Workshop, Adelaide 2009; M Fairclough & M McGeough, How to find and mine uranium deposits in South Australia, Aus IMM International Uranium Conference, Adelaide, 2008.)*
Magnetics	Airborne magnetics are useful to model near surface geology, identify faults and other structural features, and to determine the thickness of sedimentary basins. Detailed airborne surveys (~80 m heights and line spacing) are useful to identify and delineate paleochannels that may host uranium. *(David McInnes, Integrated Case Histories, ASEG Uranium Workshop, Adelaide 2009; M Fairclough & M McGeough, How to find and mine uranium deposits in South Australia, Aus IMM International Uranium Conference, Adelaide, 2008.)*
Radiometrics	Airborne radiometric surveys measure γ rays and identify Potassium, Thorium and Uranium anomalies close (<1 m) to the surface. Useful in mapping surface and near surface geology and identifying possible source rocks for Uranium. (*Bruce Dickson, Airborne Gamma-Ray Spectrometry Surveys, ASEG Uranium Workshop, Adelaide 2009; Andrew Bisset, High Resolution Radiometric Surveying in the East Kimberley Region of Western Australia, Aus IMM International Uranium Conference, Adelaide, 2008; M Fairclough & M McGeough, How to find and mine uranium deposits in South Australia, Aus IMM International Uranium Conference, Adelaide, 2008.)*
Airborne EM	Airborne EM used to model the conductivity profile in the area of interest and identify possible fluid pathways. Although in some terranes it can penetrate, and provide data for modelling, down to ~500 m, it is most effective at depths <150 m. Techniques to acquire and interpret Airborne EM data have improved considerably in recent years and they are now increasingly cost effective. (*David McInnes, The Application of Airborne EM in Uranium Exploration & Richard S Smith, MegaTEM/geoTEM/HeliTEM Comparisons and Interpretation, ASEG Uranium Workshop, Adelaide 2009; M Fairclough & M McGeough, How to find and mine uranium deposits in South Australia, Aus IMM International Uranium Conference, Adelaide, 2008.)*
Ground-based EM	Useful for small areas where detailed surveys are needed. (*Graham Heinson, Ground Based EM Methods, ASEG Uranium Workshop, Adelaide 2009.*)
Ground Resistivity	Detailed ground resistivity surveys are useful to calibrate the airborne information and provide more detailed information over smaller areas.
Ground Penetrating Radar	High-frequency (10–1000 MHz) signals are directed into the Earth and EM reflections are recorded. Depths of penetration are limited to ≤50 m. It is most sensitive to water with high dielectric permittivity.
Radon Emanometry	The major limitation of airborne γ radiometrics is that 90% of the signal emanates from the top 15 cm. The detection platform has to be close to the ground because at 600 m, 98% of the signal is attenuated. A radon capture technique has recently been developed, which is based on the Radon-on-Activated Charcoal method developed by the SA Atomic Energy Board in the 1970s. A cartridge containing activated charcoal is inserted into the base of a plastic cup and the inverted cup is buried for ~10 days. The γ radiation from the daughter nuclides of the absorbed radon is then measured. Approximately 500 samples per day can be measured. It is very useful for detailed surveys. *(Reece Foster, Soil Radon detection, ASEG Uranium Workshop, Adelaide 2009.)*
Surficial Geochemistry	Samples soils, stream sediments and regolith carbonates. Shows strong surficial transported chemical characteristics. Some potential for groundwater-related carbonates, but not sure of deep penetrative chemical signature at the landsurface. (*David Rawlings, Napperby Uranium Project, Aus IMM International Uranium Conference, Adelaide, 2008.)*
Phyto-exploration	Provides surficial sampling of plants (eucalyptus) and animals (ants and their nests) to obtain expression of sub-surface chemistry. At Four Mile Project in SA, Eucalyptus Gillii, Camaldulensis and Intertexta were sampled together with the Inland Tea-tree and River Red Gum. Uranium concentrations ranged from 0.06 to 6.59 ppm. Meat ants or *Iridomyrmex* spp. were also sampled. The ants ranged up to 13 ppm and their nests up to 100 ppm U. This technique is still experimental. *(Steven Hill, Uranium in Animals, Vegetables & Minerals: The Biological Expression of U for Mineral Exploration Under Cover, Aus IMM International Uranium Conference, Adelaide, 2008.)*
Hyperspectral surveys	Uses airborne surveys transmitting and receiving EM radiation in the 0.5–15 μ band-width. Good for rapid mapping and mineral identification in areas of outcrop. Needs special aircraft dedicated to hyperspectral work. Good for identifying clays, iron oxides, silicates and carbonates. There needs to be a relationship between these minerals and uranium anomalies. *(Rob Hewson & Ivor Kahimise, Hyperspectral surveys for uranium deposits in Namibia using HS HyMap and geophysics, ASEG Uranium Workshop, Adelaide 2009.)*
Borehole logging	Measures a larger sample volume compared to standard cores and rock chips and enables estimates to be made of eU_3O_8 grade and deposit resources. There are three main logging measurement systems: Total Gamma, Spectral Gamma and Prompt Fission Neutron. The Prompt Fission Neutron system has several positive attributes: • Crucial for most Tertiary Uranium deposits as they are young and suffer extreme disequilibrium • Uses a safe neutron generator rather than a radioactive source • Produces an accurate direct measurement of *in situ* uranium over narrow intervals • Results are instantaneous • Measures a large sample volume (500 mm sphere) • Can be used during ISL mining to quantify recovery • Exploration tool – disequilibrium vector towards mineralisation (*Colin Skidmore, Borehole logging methods including Prompt Fission Neutron (PFN) techniques, ASEG Uranium Workshop, Adelaide 2009 and http://www.geoinstrumentsinc.com/PFN%20Oct05.pps.*)

New radiometric and geology maps of Australia

Minister Ferguson launches radiometric map in Adelaide

As Martin Ferguson, the Federal Minister for Resources and Energy, said at the Australian Society of Exploration Geophysics Conference in Adelaide when he launched Geoscience, Australia's new radiometric map of the Australian continent:

> 'This is another world first from Geoscience Australia. No other continent has been so extensively mapped or mapped in such detail. It will be a powerful addition to information used by companies exploring for energy and other minerals. This type of technology is particularly important for Australia because of this country's strong reliance on the mining and exploration industry for its economic future and the strength of its regional social fabric.'

Emphasising the importance to Australia of pre-competitive high-quality geoscience information, he continued:

> 'Mineral exploration is a long-term strategic investment – it is fundamental to the ongoing sustainability of the mining industry and maintaining Australia's standard of living. The new radiometric map provides a competitive edge for mining in Australia because it helps to reduce the cost and risk of exploring here. If the mining industry puts exploration on the backburner, we will miss the full benefits of the recovery from the Global Financial Crisis. That is why exploration undertaken today is so important – as are the tools, such as this new radiometric map, that will make it easier and cheaper.'

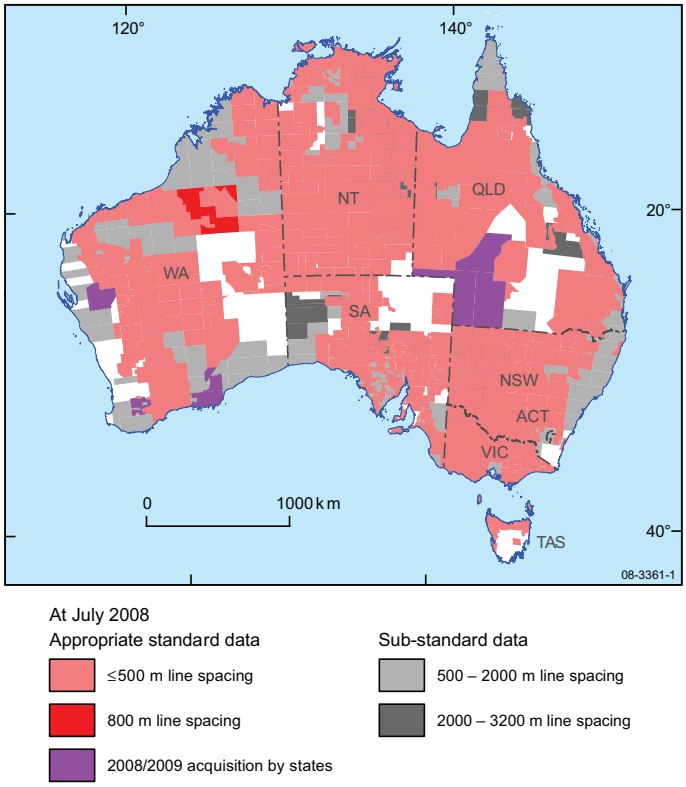


Fig. 1. *Radiometric data acquisition by Geoscience Australia and state and Northern Territory geological surveys (from Minty et al. 2008).*

The radiometric map

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The 1:5 million scale map complements the existing gravity and magnetic maps of Australia, and is part of a range of digital radiometric products that will directly assist exploration for uranium and thorium as well as heat flow studies and the assessment of geothermal resources. It will also benefit environmental studies and soil and geological mapping applications.

The map was developed by combining more than 450 individual surveys into a single seamless compilation that shows the distribution of the radioactive elements potassium (K), uranium (U) and thorium (Th) across the continent. It shows K in red, U in blue and Th in green, with the colours combined according to the relative concentrations of the radioelements. The radiometric responses and patterns in the ternary images largely reflect the surface geochemistry and mineralogy of bedrock and regolith materials. The map creates new opportunities for scientists and explorers to relate geochemical patterns in a specific area to similar patterns observed elsewhere in Australia.

Since airborne surveys commenced in 1951 under Geoscience Australia's predecessor, the Bureau of Mineral Resources, the Earth's magnetic field and gamma-radiation from the ground has been measured over more than 80% of the continent (Figure 1).

The airborne gamma-ray data had been collected as numerous separate surveys over many years and the equipment and procedures used evolved over time. Consequently, data from different surveys could not be easily compared because they were not registered to a common datum or baseline.

Geoscience Australia's Onshore Energy Security Program, which is providing pre-competitive geoscience information to boost investment in exploration for onshore energy resources, provided an opportunity to solve this problem. As part of this program, UTS Geophysics was commissioned to fly an Australia-Wide Airborne Geophysical Survey (AWAGS) at a cost of $2.6 million.

The survey covered the entire continent with north–south flight lines spaced 75 km apart, and east–west tie lines spaced 400 km apart (Figure 2).

Gamma-ray spectrometric data, acquired at a height of 80 m along the flight lines, was processed according to international specifications and the final estimates of the concentrations of the radioelements comprise the new Australian radioelement baseline.

In collaboration with the state and the Northern Territory geological surveys, Geoscience Australia used the processed AWAGS data to bring all of the surveys in the national database to the new baseline. The levelled surveys were then used to produce a range of new digital radiometric products. The fundamental datasets were the levelled and merged composite K, U and Th grids over Australia at 100 m resolution. These have been used to produce grids at the same resolution showing the terrestrial dose rate, dose due to natural sources of radiation (that is, terrestrial dose plus cosmic radiation), as well as

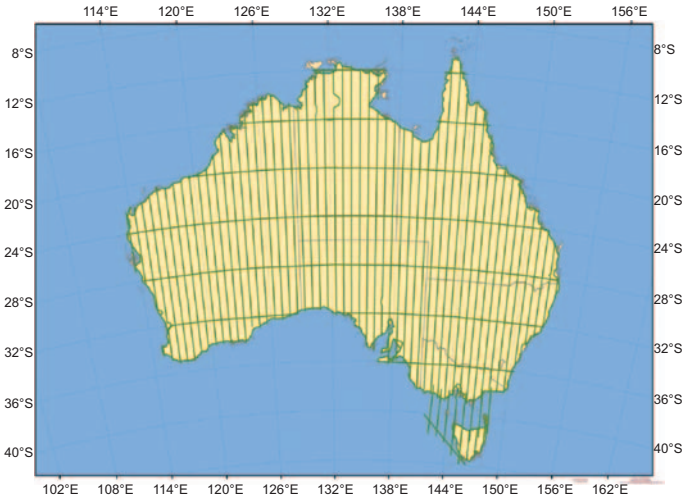

Fig. 2. *Locations of AWAGS flight lines flown to calibrate the magnetic field and the radiometric data over the Australian continent (from Minty et al. 2009).*

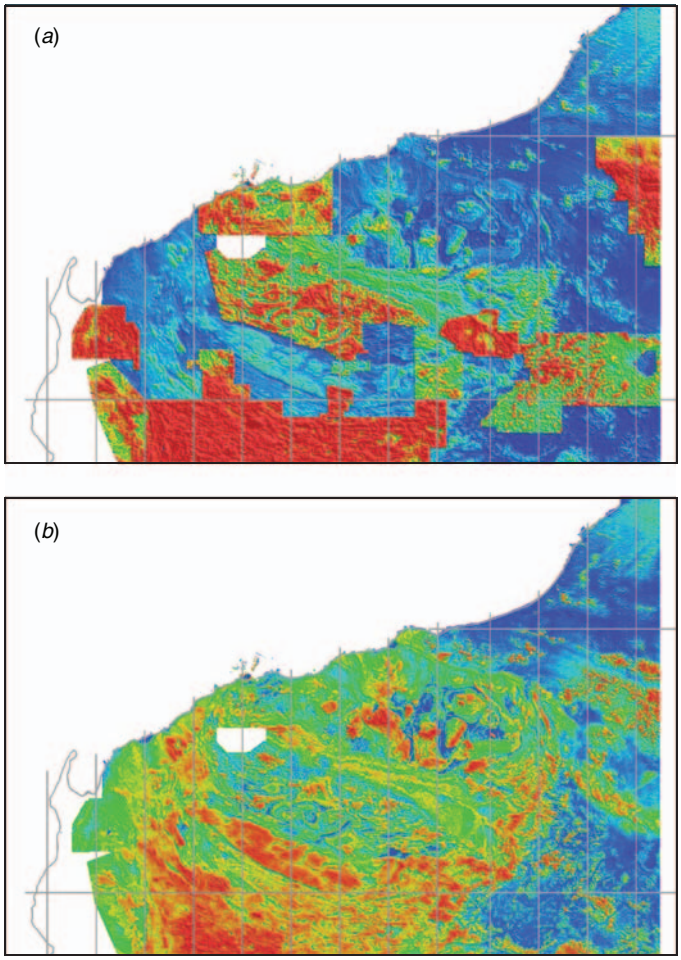

Fig. 3. *Dataset for the Pilbara region, Western Australia showing thorium data; (a) prior to grid levelling, and (b) after grid levelling (from Minty et al. 2009).*

K/U ratio, K/Th ratio and U/Th ratio grids. Figure 3 shows a before and after image of thorium data for the Pilbara region of Western Australia.

The radiometric responses and patterns shown in the ternary image (K shown in red, U in blue and Th in green) largely reflect the surface geochemistry and mineralogy of bedrock and regolith materials (Figure 4). In general, actively eroding felsic volcanic and igneous rocks are delineated by high concentrations of the radioelements and appear in white to reddish hues.

Low radioelement concentrations (black hues) correspond to ultramafic rocks and quartz-rich sandy materials (such as quartzites, sandstones and unconsolidated sands). Water bodies appear black in the ternary image.

Most of the gamma-ray responses relate to the distribution of regolith materials (for example, weathered bedrock, alluvium and colluvium) that reflect the overall antiquity and geomorphic stability of the Australian continent. Many of the relatively high Th and low K responses (green and green/blue hues) relate to ferruginous lags and weathered materials.

The composite levelled, merged and feathered K, U and Th grids of Australia allow explorers to compare the radiometric signatures observed over different parts of Australia, and to better appreciate the significance of broad-scale variations in radioelement concentrations. Consequently, Palaeozoic granites in eastern Australia can now be quantitatively compared and assessed for areas of potential mineralisation and geothermal prospectivity. A consistent radioelement datum also enables the use of quantitative modelling and processing techniques, which enhance and integrate the radiometric imagery with other datasets (such as magnetics, satellite imagery and gravity) to be applied over much larger areas. The new updated database will directly assist:

- U and Th exploration through the ability to make quantitative comparisons between the radiometric signatures in different survey areas;
- Heat flow studies and assessment of geothermal energy resources;
- Geological mapping, mineral and petroleum exploration;
- Geomorphological studies and environmental mapping; and
- Derivation of a radiation risk map of Australia.

The improved datasets will lead to an increased understanding of the geology, structure, geochemistry and geomorphology of the continent.

The gridded datasets are available free of charge in ERMapper format from the Australian government's Geophysical Archive Data Delivery System and can be downloaded via the Australian government's geoscience portal at http://www.geoscience.gov.au/gadds. Printed copies of the map will also be available from the Geoscience Australia Sales Centre.

Further information on the Radiometric Map of Australia can be found at http://www.ga.gov.au/map/index.jsp, from Murray Richardson on +61 2 6249 9229 or the Geoscience Australia Sales Centre on Freecall 1800 800 173 (in Australia) or +61 2 6249 9966. The email addresses are: murray.richardson@ga.gov.au or sales@ga.gov.au

A new geological map of Australia

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A new digital surface geology dataset covering Australia at 1 : 1 000 000 scale was released recently by Geoscience Australia.

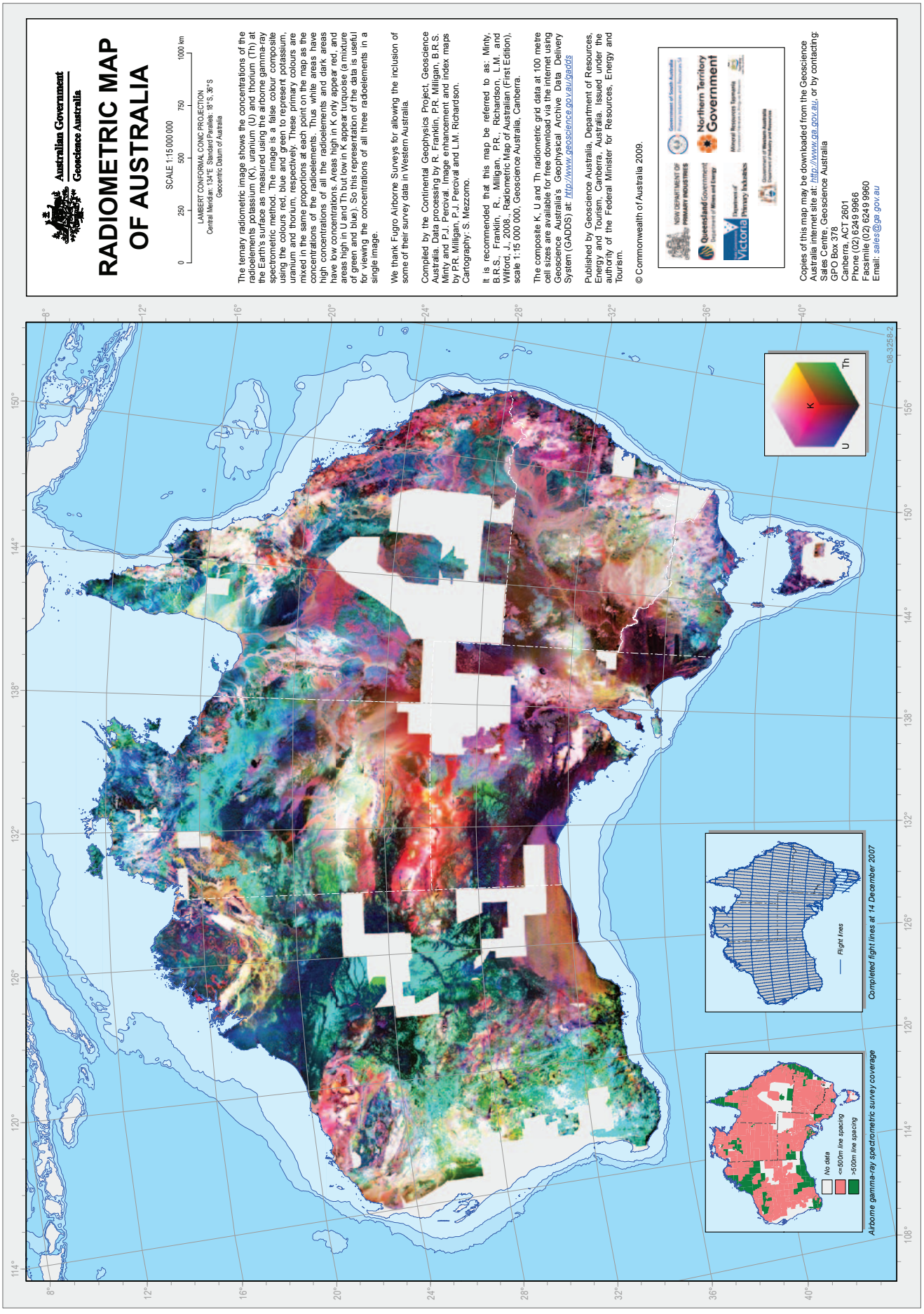

Fig. 4. *Ternary image (potassium in red, equivalent uranium in blue and equivalent thorium in green) of Australia derived from the new levelled National Radioelement Database (from Minty et al. 2009).*

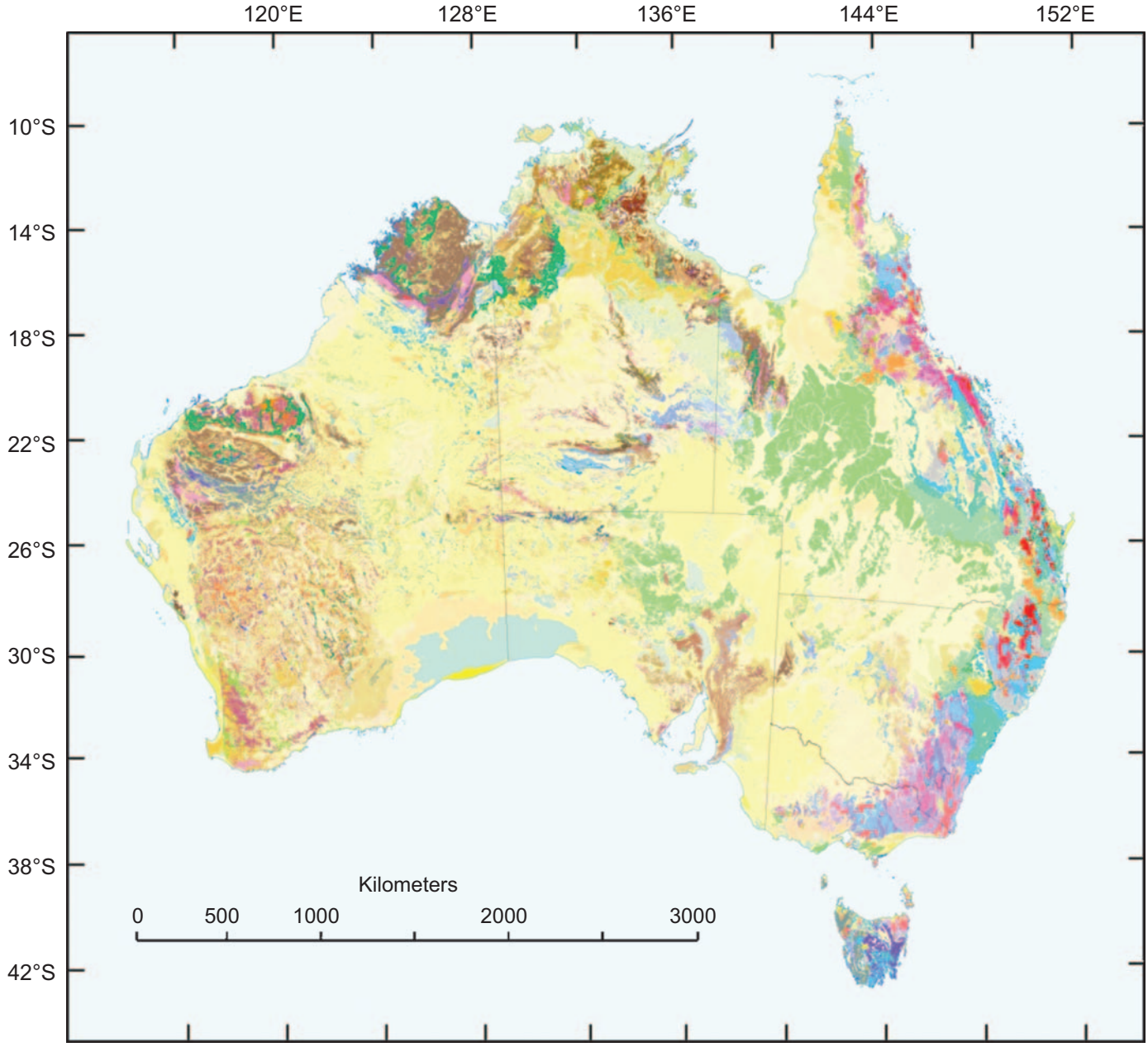

Fig. 5. *An overview of the new digital geology map of Australia. Paleozoic to Archean bedrock is shown in darker brown-red-blue-purple; Mesozoic sediments in pale green-blue; and Cenozoic surficial deposits in pale yellows.*

The digital map, which depicts geological units and structures seamlessly across state and territory borders, will provide an invaluable baseline dataset for national and regional evaluation of resources as well as environmental management and land use decision making. This national project was undertaken with the full co-operation of the geological surveys of each Australian state and the Northern Territory who provided their most recent map data for the national compilation as well as their advice in resolving stratigraphic issues.

The compilation of a seamless surface geology map of Australia at 1:1 000 000 scale started in 2001. Since then, more than twenty geologists, GIS technicians and stratigraphic indexers have combined their efforts to produce the most detailed, informative and consistent national geology coverage available (Figure 5).

The new data replaces the 1:2 500 000 scale digital map published by Geoscience Australia in 1998. The improved standard of information in the new dataset is exemplified by an increase from 8000 to 247 000 polygons, and the increase from 200 to around 5900 described geological units in the new data.

Most of the new Australian geology dataset has been compiled from the most recent 1:250 000 scale mapping or regional compilation maps. In some areas where the 1:250 000 maps were out of date, the compilers used 1:100 000 and even 1:50 000 scale source maps. Although compiled from these detailed geological maps, all the national data have been simplified for use at 1:1 000 000 scale.

In the past, geological information often failed to match up across jurisdictional boundaries because of differences in data acquisition methods and geological interpretations that may have

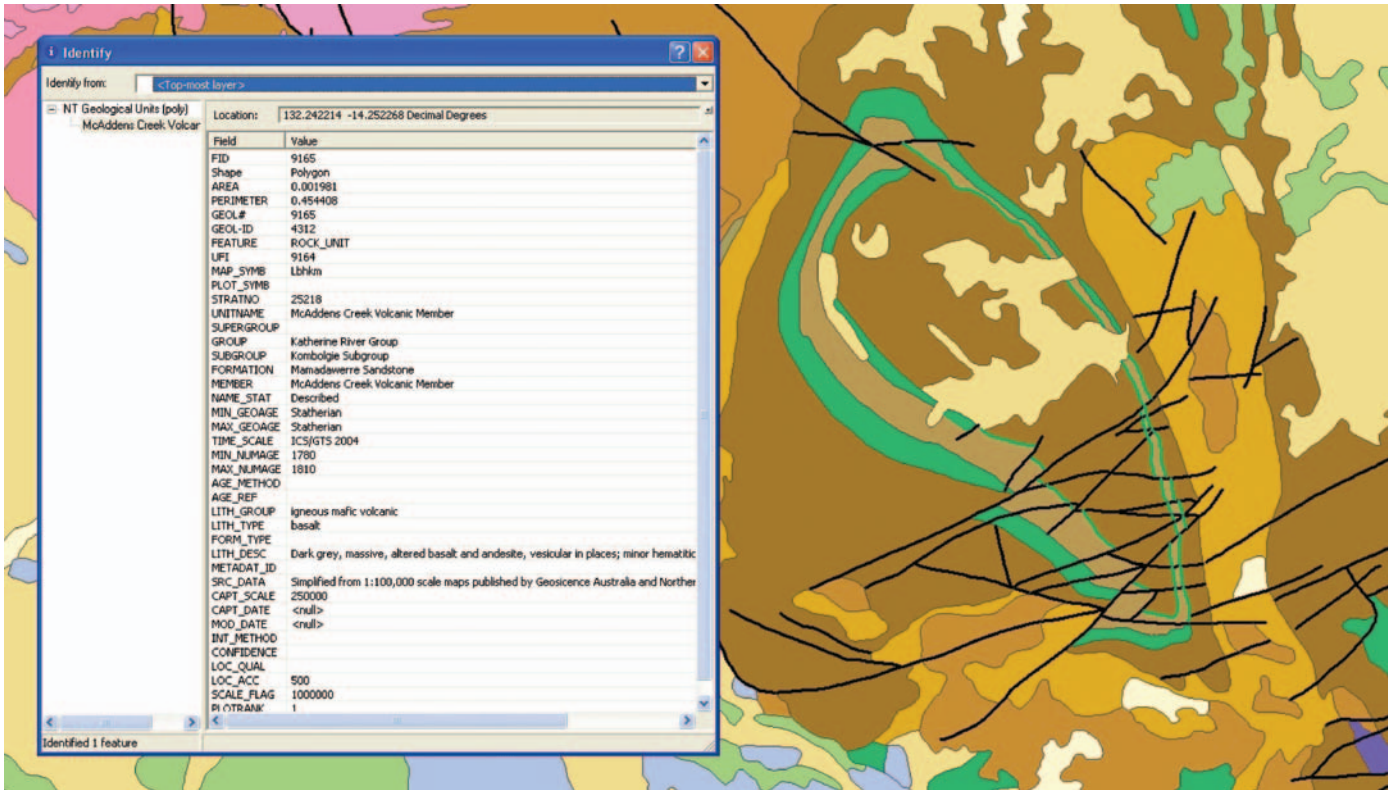

Fig. 6. *An example from the Pine Creek region of Northern Territory of the range of geological attribute data that can be displayed in a GIS mapping application.*

been published decades apart. An important and time-consuming task for the compilation team was matching the geological information between more than 400 source maps. Considerable time was invested in resolving stratigraphic mismatches across map tile and jurisdictional boundaries. Sometimes satellite imagery and geophysical data, such as gamma-ray spectrometry and magnetics, were also used to resolve edge-matching discrepancies and to reposition poorly located geological data on the oldest maps.

The standardisation of unit classification and descriptions was also important for the unconsolidated regolith materials, which cover a large proportion of the Australian continent. Regolith mapping has advanced considerably over the last few decades, particularly with the advent of remote sensing imagery. A simple standard scheme for regolith unit compilation, based largely on the classification of Grimes (Wilford 1983), was used for the mew national map. The new dataset contains comprehensive descriptions of around 5900 lithostratigraphic units (Figure 6). These unit descriptions include a unique stratigraphic name and number that provide a link to the Australian Stratigraphic Units Database, which is the authoritative repository of Australian geological unit descriptions.

Other geological attributes include a stratigraphic parent–child hierarchy, a text description of the unit, maximum and minimum ages and lithological classifications (Figure 6). Faults and stratigraphic boundaries are also coded in the database. The dataset also includes comprehensive metadata describing the origins of the source data.

The new data are designed primarily as a digital tool for GIS applications. It is not planned to issue a printed map – a paper map of Australia at 1 : 1 000 000 scale would be almost 4 m tall!

The Australian geology data are also available to view on the OneGeology portal website (http://www.onegeology.org). This international project aims to provide national scale geology data freely via the internet for users across the world using agreed international digital data standards. The data are currently displayed as a Web Map Service with the national geological coverage of many other nations. Geoscience Australia will be moving to provide the data as a Web Feature Service using the GeoSciML data standard (GeoScience Markup Language; Simons *et al*. 2008) in the near future.

The new digital map data is available for free download from the Geoscience Australia website in shapefile and ESRI export formats (http://www.ga.gov.au/minerals/research/national/nat_maps/nat_geol_maps.jsp).

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Results from the first field trial of a borehole gravity meter for mining applications[1]

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Abstract

Scintrex is in the final stages of the development of a borehole gravity meter, for mining and geotechnical applications, designed to log inside NQ drill rods to 2000 m depth, using standard 4 conductor cable, with a sensitivity of better than 5 µGal, and operable in boreholes inclined from 30° to vertical. École Polytechnique of Montreal has developed forward modelling software, as part of this project.

The first field test of the prototype probe was successfully conducted in December 2008 for Vale Inco in a deep borehole located in Norman township near Sudbury, Ontario. The results of this test show a large amplitude bipolar residual gravity anomaly, with the crossover at the location where the borehole intersected sulphides. Further analysis of the data is underway. A repeat log of the hole indicates that the Gravilog system has achieved operational specifications very close to its targets.

Field tests for the other sponsors are planned during the first half of 2009, with production surveys to follow during the second half of the year.

Gravity measurements inside boreholes provide evidence of density variations both in the immediate vicinity and at a distance from the hole. Scintrex's development of a new borehole gravimeter will, for the first time, allow the application of gravity logging in typical mining and geotechnical boreholes.

Primary applications of the Gravilog system in mining include the sensing and mass-estimates of massive sulphide bodies, either intersected by or remote from the hole; and accurate bulk density measurements of formations intersected by the hole.

Chris Nind

Introduction

The development of a Borehole Gravity Meter suitable for mining applications commenced at Scintrex in September 2005. Initial field testing of the prototype 'Gravilog' tool, in a borehole near Lindsay, Ontario, was completed in October 2008, followed by a successful field trial in December in a borehole chosen by Vale Inco in Norman township near Sudbury, Ontario. Field tests for the other industry sponsors of the project are planned during the first half of 2009.

[1]This paper is based on the presentation made by Chris Nind at the ASEG's 20th International Geophysical Conference, held at Adelaide in February 2009.

Borehole gravity has two main applications (Seigel *et al.* 2007). It is a valuable exploration tool, for mapping of density variations remote from the borehole, allowing useful gravity measurements to extend to smaller targets at greater depths. A second application, unique to borehole gravity, is bulk density determination of formations intersected by the borehole, which is significant in grade control and other mining applications.

The new Scintrex Gravilog BHG system can be deployed down to 2000 m depth inside small diameter boreholes (NQ drill rods) inclined from 30° to vertical. It is designed to provide the precision needed for detailed bulk density determinations of narrow formations and the high production rates required for efficient operations. A summary of the target design specifications is shown in Table 1. For a fuller description of the application of the Gravilog system in mining, see Seigel *et al.* 2007.

Background

Newton's Law of Gravity states that between two bodies of mass m_1 and m_2 whose centres of mass are separated by a distance r, there is a mutual attraction, F, given by:

$$F = Gm_1m_2/r^2 \quad (1)$$

On the earth's surface, for a unit mass and the earth itself, (1) simplifies to

$$g = GM/R^2 \quad (2)$$

where
$G = 6.67 \times 10^{-8}\,\mathrm{cm^3/gm\,s^2}$
$M = 5.97 \times 10^{27}\,\mathrm{gm}$
$R = 6.38 \times 10^{8}\,\mathrm{cm}$ (at the equator).

Hence, at the equator, $g = 978\,\mathrm{cm/s^2}$.

The common unit of acceleration to measure small changes in gravity is the 'microgal' (µGal). This is defined as:

$$1\,\mathrm{Gal} = 1\,\mathrm{cm/s^2}$$

$$1\,\mu\mathrm{Gal} = 10^{-6}\,\mathrm{Gal}$$

So, $g \approx 10^9\,\mu$Gal, or, alternatively, 1 µGal is one part per billion of the gravity at the surface of the earth.

Today's relative land gravity meters measure accelerations at the earth's surface with microgal sensitivity. Despite this ability to acquire field measurements in parts per billion at or above the earth's surface, the inverse square falloff of gravity with distance from the source is a serious limitation for deeper mining and petroleum exploration. LaCoste & Romberg developed a borehole gravity meter over 30 years ago, but the size and operational limitations of the probe made it impractical for mining applications. Scintrex, with partial financial support from a group of industry sponsors and the Canadian government, reduced the size of its quartz sensor and developed automatic leveling, temperature control and electronics systems to fit into a small diameter probe suitable for mining boreholes.

Table 1. Target specifications of Scintrex's Gravilog BHG system

	Target specification
Sensitivity	Better than 5 µGal with a 1 min reading time
Operating range	7000 mGal
Max. sonde diameter	48 mm
Max. sonde length	Approximately 3 m
Max. operating depth	2000 m (water filled hole)
Min. hole diameter	NQ drill rods (57.2 mm)
Max. hole deviation from the vertical	60°
Operating temperature range	0°C–+70°C (downhole section) –40°C–+50°C (uphole section excluding PC)
Vertical position determination in borehole	±5 cm between successive stations (depth will be determined with a combination of pressure sensor, winch encoder and inclinometer

Fig. 1. *Norman Township Test Site.*

Fig. 3. *Norman Township Test Site – data acquisition.*

Fig. 2. *Norman Township Test Site – drill collar.*

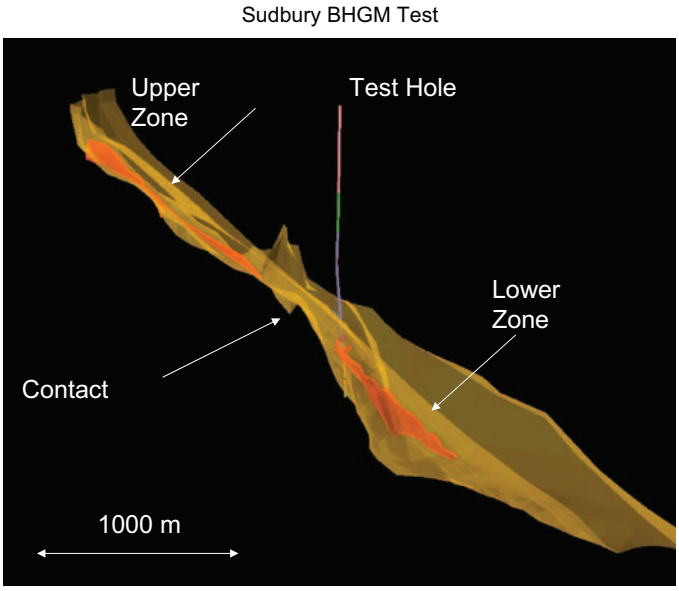


Fig. 4. *Norman Township Test Site – looking east.*

After completing a series of in-house tests, the Gravilog prototype was deemed to be ready for its first full-scale field test for an industry sponsor in December 2008. Vale Inco, one of the industry sponsors, supplied access and logistical support to Scintrex's Gravilog crew to log a suitable deep borehole near Sudbury, Ontario.

Test site

The location of the first field trial of the Gravilog tool was a near vertical borehole selected by Vale Inco in Norman Township, near Sudbury, Ontario. The drill site is shown in Figure 1.

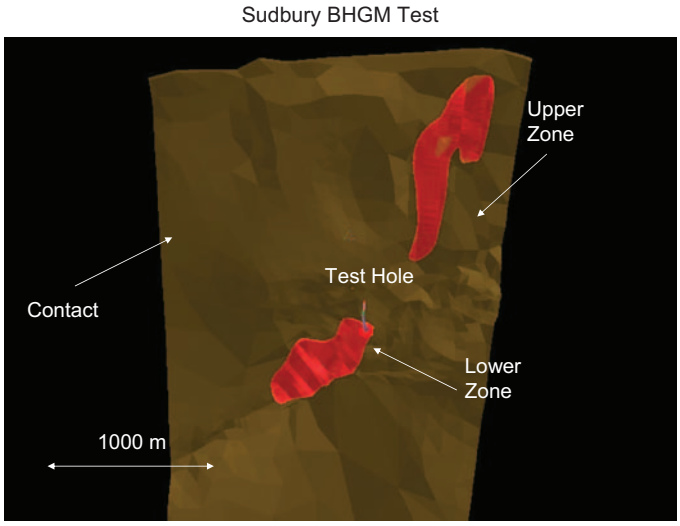


Fig. 5. *Norman Township Test Site – plan view.*

The Gravilog system was mobilized by strapping it onto the bed of a tractor supplied by Vale Inco and the Scintrex crew deployed the probe inside the NQ drill rods, lowered it to 1000 m and left it overnight to stabilize (Figure 2).

Logging commenced immediately the next morning. The borehole was logged in both directions over the next two days (Figure 3).

The near vertical test borehole intersects the 'Lower Zone' of a mineralized zone (Figures 4 and 5). From 1000 m to 1400 m, the geological log (courtesy of Vale Inco) records norite, pegmatite and gabbro. From 1400 m to 1800 m, the log records granite, granite breccia and diabase.

The hole 'intersects sulphides from 1400 m to 1480 m. The upper half of this interval is very weak, disseminated mineralization averaging 10–20% sulphide (SG = 2.8–3). The lower half of the intersection is much better consisting mostly of massive to semi-massive sulphides grading above 50% sulphide (SG = 3.5–4)' (courtesy of Vale Inco). This intersection represents the updip fringe of a massive sulphide 'Lower Zone', itself part of a large mineralized zone, dipping about 35°. A second massive 'Upper Zone' lies some hundreds of metres updip of the intersection, in this mineralized zone. Weak disseminated sulphides are also intersected in the borehole below 1750 m.

Expected response

The expected borehole gravity response of a Cu/Ni orebody in the Sudbury Basin has been modelled by Ecole Polytechnique using a 3D density model of Vale Inco's Kelly Lake orebody

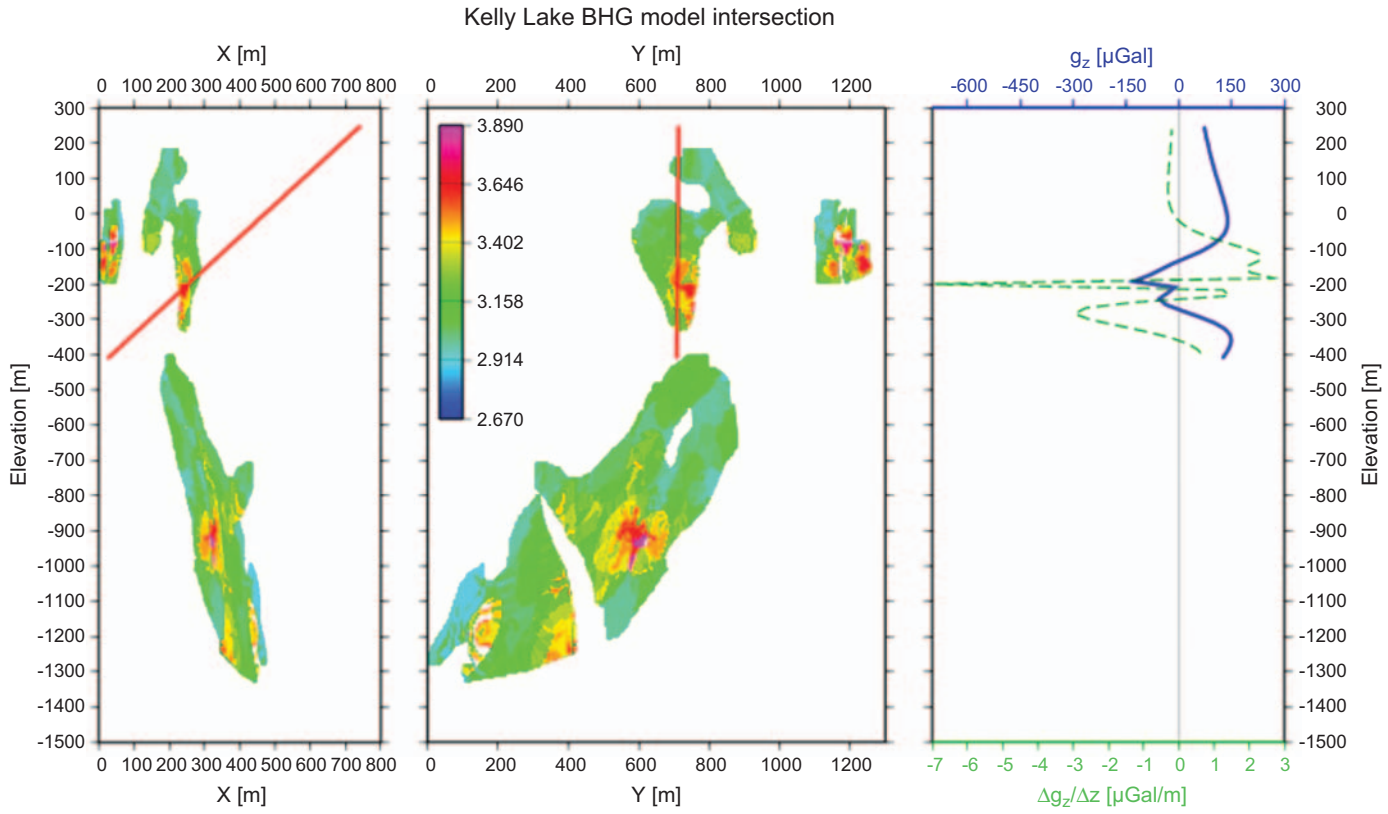


Fig. 6. *BHG response model of an intersection of the Kelly Lake orebody (from Seigel et al. 2007).*

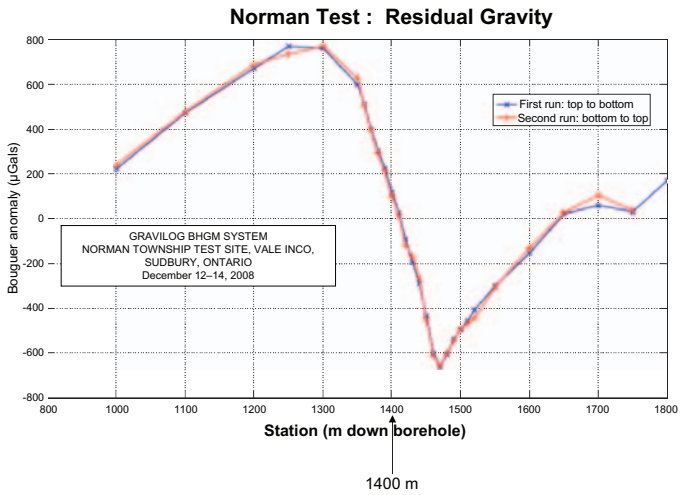


Fig. 7. *Norman Township Test Site – residual gravity from two logs.*

and a hypothetical borehole that intersects an upper portion of it (Figure 6). The main feature of the gravity response (blue trace on the right side of Figure 6) is the abrupt and complex crossover anomaly in the vicinity of the intersection (from Seigel *et al.* 2007).

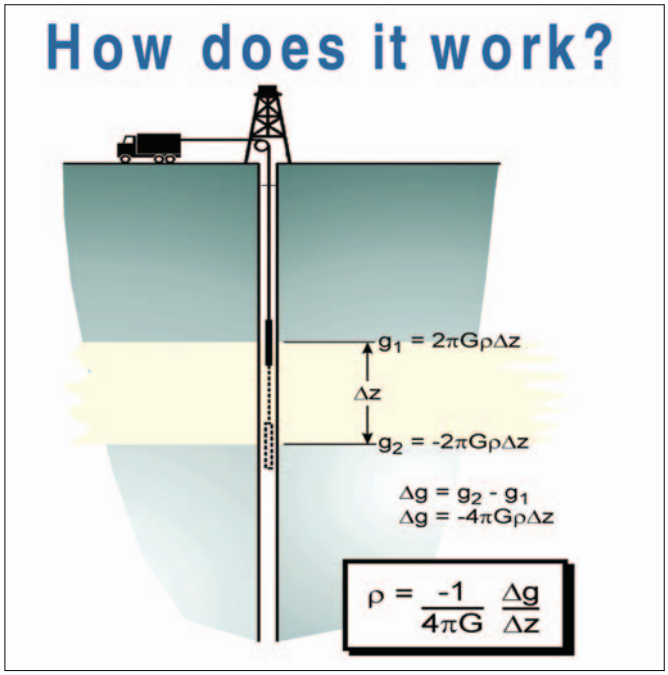
Norman borehole gravity data – preliminary results

The Gravilog prototype was deployed to collect gravity measurements in the Norman borehole inside NQ drill rods. The hole was logged from 1200 m to 1800 m depth, both upwards and downwards, from December 12–14, 2008. The reading intervals varied from 50 m in the host rock to 10 m through the mineralized zone. Depths were measured both using the winch counter at the surface and the pressure sensor in the probe. Water was added to the hole as necessary to keep the water level constant during logging, for purposes of the pressure sensor. At each station, the clamp was deployed to secure the probe, the pressure was recorded, the gravity sensor was leveled, two 60 second gravity measurements were taken, the clamp was then disengaged and the probe was moved to the next station location using the winch counter for a depth reference. This procedure required about 5 min at each station plus the time required for moving between stations.

The residual gravity from the two logs were processed separately and presented together (Figure 7). The mean repeatability of the gravity readings across the intersection is 6.0 µGal. A bipolar residual gravity anomaly was recorded, with the maximum gradient, or 'crossover' as the probe passed through the intersection. The peak-to-peak amplitude of the residual anomaly was of the order of 1.5 mGal, clearly indicating the presence of a large mass of high density sulphides, related to the intersection. Further processing and modelling are underway.

Bulk density measurements

The vertical gradient of gravity in a borehole is directly proportional to the bulk density of the horizontal formation between the measurement points (Smith 1951). This unique feature of borehole gravity is shown graphically in Figure 8 (Herring 1990).



Note: Density determination after normal terrestrial gradient (0.30861 mG/m) removal

Fig. 8. *Bulk Density Determination using borehole gravity measurements.*

After correcting the measured gravity values for the 'Free Air' effect (the vertical gradient of gravity in air), the bulk density is simply:

$$\rho = [-1/(4\pi G)]\ (\Delta g/\Delta z) = -1.193\ (\Delta g/\Delta z) \qquad (3)$$

where g is the measured gravity in µGal and z is the vertical distance below the surface in centimeters.

Note that z is the vertical depth below the surface, so that Δz is equal to the separation between stations in the borehole multiplied by the sine of the inclination of the borehole between the stations. Alternatively, Δz is obtained directly from the difference in the pressure sensor readings between the two stations.

These successive bulk densities are plotted in the normal drill log presentation format.

Bulk densities in the Norman borehole were calculated from the residual gravity data using the conventional algorithm that uses differences between neighbouring stations (Figure 9) and a proprietary algorithm developed by Jeff MacQueen at Micro-g LaCoste that makes use of the complete set of measured gravity differences (Figure 10). Error bars are included on both these figures.

The bulk densities calculated from the gravity data are representative of the host rock density above the intersection, increase through the intersection from 2.77 g/cm^3 at 1300 m to 2.95 g/cm^3 at 1460 m, then fall off rapidly beneath the intersection. These results are consistent with the comments provided by Vale Inco (see above).

Gravilog system test program – next steps

The processing of the Gravilog data acquired in the Norman Township Test Site will be finalized and Ecole Polytechnique will calculate forward models, incorporating additional

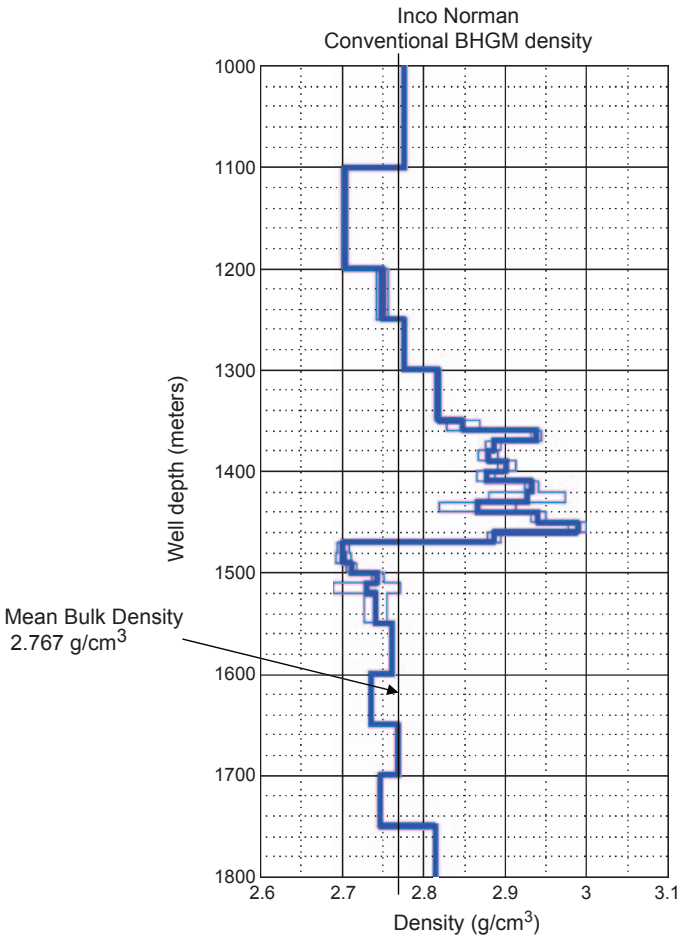


Fig. 9. *Camiro Project 05E01, Norman Township Test Site – bulk densities obtained from data collected on the first run, Nov 13, 2008, (top to bottom) using the conventional algorithm for calculating bulk densities.*

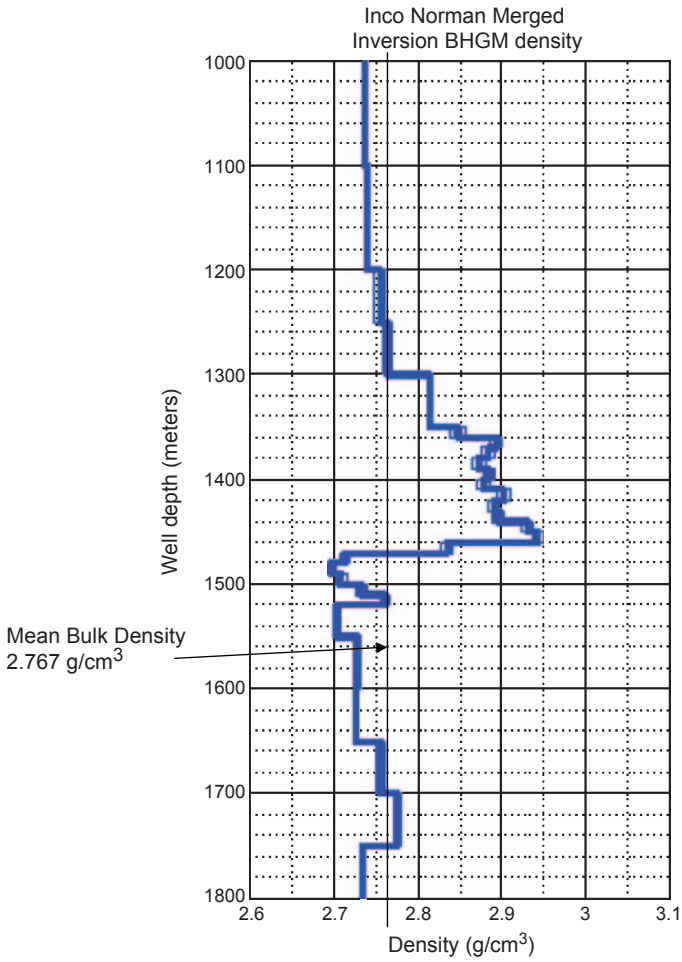


Fig. 10. *Camiro Project 05E01, Norman Township Test Site – bulk densities obtained from data collected on both runs (top to bottom and bottom to top) using a proprietary algorithm for calculating bulk densities, developed by Jeff MacQueen at Micro-g LaCoste.*

information provided by Vale Inco. A case history will be prepared, initially for the sponsors and then, with their permission, for general presentation.

Field tests for the other three industry sponsors are scheduled through the first half of 2009.

Scintrex is building additional Gravilog systems at the Concord location. The goal is for Gravilog services to be commercially available for mining and geotechnical applications during the second half of 2009.

Conclusions

Scintrex's Gravilog Borehole Gravity Meter for mining applications at Scintrex has successfully completed the first field trial for an industry sponsor, performing very close to its target specifications. Additional Gravilog probes are now being manufactured at Scintrex, and field trials for the other industry sponsors are planned for the first half of 2009.

Acknowledgements

Partial financial support was provided by the Ontario government (IRAP project #580123) and by four industry sponsors (BHP Billiton, Vale Inco, AREVA Resources Canada and Schlumberger) under CAMIRO Project # 05E01. The balance of the financial support was provided by Scintrex.

Scintrex thanks Vale Inco for the excellent support provided to the Scintrex Gravilog crew during the field test.

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The role of geophysics in mineral deposit discovery – a Rio Tinto perspective[1]

Stephen McIntosh

Exploration Director, Rio Tinto Exploration, Project Generation Group. Email: stephen.mcintosh@riotinto.com

What I'd like to do today is provide a quick overview of Rio Tinto and its operations. I will then talk more specifically about Rio Tinto Exploration and how it is organised – and finally provide some specific insights as to the role geophysics plays in mineral deposit discovery – from greenfield through to ore body evaluation and ultimately to its application in mining operations across Rio Tinto.

Rio Tinto – a world leader in mining

Rio Tinto is a world leader in mining and has a strategy for growth based around the major pre-requisites of developing world urbanisation – aluminium, copper and iron ore supplemented with a portfolio of world class energy, industrial mineral and diamond businesses.

The company is currently the world's largest bauxite miner and top-equal aluminium producer. We also have a path defined to become the largest producer of alumina. Rio Tinto is world number two in seaborne iron ore and world number five in copper.

In addition to these core commodities, the company is the world's largest supplier of industrial minerals. We were number one in uranium during 2008, number two in traded coal and the third largest diamond producer by carat weight.

The company has a broad geographic spread of operations (Figure 1) and following the acquisition of Alcan, Rio Tinto has about 80 individual operations in over 20 countries employing more than 100 000 people. These operations include mines, refineries, smelters and research facilities.

Stephen McIntosh

With over 90% of our assets in OECD countries, we are very strongly represented in Australia and North America with significant other businesses – or feasibility-level projects – in Europe, South America, Asia and Africa.

The role of exploration

The role of exploration is really very simple. We are here to grow the value of the company through discovering or acquiring superior quality resources that can increase our future cash flows.

Finding resources faster than they are being mined is a daunting prospect for a company the size of Rio Tinto. This has been particularly the case over the past few years of rapid production growth and intense competition for resources from other exploration companies.

Whilst the markets have obviously softened since late 2008, a return to anywhere near trend growth will see these same competitive pressures re-emerge.

Adding value to Rio Tinto effectively means that our exploration programs must regularly return what others might call 'company maker' discoveries, the largest and highest-quality mineral deposits that the natural world has to offer. A convenient label to describe such resources is a Tier 1 deposit (Figure 2).

Given the economic risk attached to exploration, a perennial debate in the mining industry is whether it is better for a company to discover its own resources or to acquire resources discovered by others. The position taken on this issue by Rio Tinto is that both discovery and acquisition can add value.

Exploration and acquisition are complementary avenues for growth and those companies that can do both successfully have more opportunities to participate in value creating growth.

Discoveries made by Rio Tinto Exploration

At the end of the day, you can only judge an exploration group by the value it is delivering.

Based on what we know from publicly available information, we believe that Rio Tinto has an exploration track record second to none among major mining companies.

Our sustained commitment to exploration since 1946 – funding programs through both good times and bad – means that it is a core competency of the company.

Since the year 2000, exploration has acquired for Rio Tinto two of the largest copper opportunities in the world – at Resolution in Arizona and at La Granja in Peru.

It has handed over the world's largest-known undeveloped high-grade iron ore province in the world – at Simandou in Guinea – as well as the Caliwingina channel iron deposits in the Pilbara.

It has handed over the Potasio Rio Colorado potash deposit in Argentina – the largest potash deposit known today in South America. The Sulawesi nickel deposit in Indonesia was handed

[1]*This article is based on the Keynote address of the same title presented by Stephen McIntosh at the 20th ASEG Conference in Adelaide, February 2009.*

Fig. 1. *Rio Tinto's global spread of operations.*


Mt Tom Price - Discovery 1962


Simandou - Discovery 2004

Fig. 2. *Two examples of Tier 1 discoveries. Mount Tom Price, discovered in 1962, and Simandaou in Guinea, discovered in 2004. Tier 1 deposits – the largest and highest quality in the world – are geologically rare and confer sustainable competitive advantage. They grow with exploration and commonly have other Tier 1 deposits nearby. Their capacity to support production expansions delivers optionality and value growth.*

across early last year and the Mutamba ilmenite deposit in Mozambique joins the list of Tier 1 handovers this month.

Many in this audience will be aware that Potasio Rio Colorado was recently sold to Vale together with the earlier stage Regina potash project for a total consideration of US$850 million. The price achieved tells the story as to the quality of both resources.

It is worth noting that over 60% of our Tier 1 discoveries have come from emerging countries (Figure 3). Yet our exploration spending until the mid-1990s was heavily weighted towards the OECD.

Mineral deposit discovery rates are diminishing in the OECD due to land access issues, the exploration maturity of outcrop areas and the ineffectiveness of covered area exploration.

Majority of Tier 2 discoveries are divested

The final part of the value story lies with minimising our discovery costs to the company and its shareholders.

As Figure 4 clearly shows, a significant proportion of our exploration spend is returned through the sale of our Tier 2 discoveries – deposits such as Sepon in Laos, Penasquito in Mexico, Corani in Peru and Kintyre in Western Australia.

So over the 8-year period 2000 to 2008, our net exploration spending of ~$226 million US returned eight Tier 1 discoveries. This equates to an average discovery cost of a little over $28 million US per deposit.

Rio Tinto's exploration group is now run along the lines of a profit centre and as such has built the in-house capability to undertake significant commercial transactions – netting in the region of US$ one billion in assets sales since 2000.

Our $28.25 million US discovery cost since 2000 is a fraction of the acquisition cost being enjoyed by our competitors. This looks like exceptional value if we look at the cost of some recent transactions. And while the cost of acquisitions should be considerably lower in the present market, exploration still stands out as a hugely cost-effective means of growing company value for Rio Tinto.

Exploration Strategy

So, what do we in Rio Tinto believe is required for exploration success?

Discovery

Date	Name	Commodity	Country
1947	Lac Allard	Ilmenite	Canada
1952	Weipa	Bauxite	Australia
1962	Tom Price	Iron Ore	Australia
1963	Kirka	Borates	Turkey
1965	Panguna	Copper	PNG
1967	Ok Tedi	Copper	PNG
1968	Rössing	Uranium	Namibia
1971	Paragominas	Bauxite	Brazil
1979	Argyle	Diamond	Australia
1982	Kaltim Prima	Coal	Indonesia
1983	Lihir	Gold	PNG
1985	QMM	Ilmenite	Madagascar
1990	Century	Zinc	Australia
1991	Corumbá	Iron Ore	Brazil
1994	Diavik	Diamond	Canada
1995	Orissa	Iron Ore	India

Hand over

Date	Name	Commodity	Country
2000	Potasio Rio Colorado	Potash	Argentina
2002	Resolution	Copper	USA
2004	Simandou	Iron Ore	Guinea
2005	La Granja	Copper	Peru
2005	Caliwingina	Iron Ore	Australia
2007	Caliwingina North	Iron Ore	Australia
2008	Sulawesi	Nickel	Indonesia
2009	Mutamba	Ilmenite	Mozambique

In operation
Divested/suspended
In construction (QMM just completed)
In evaluation

- **Sustained commitment over 60 years**
- **An unrivalled track record of discovery**
- **Sustainable into the future**
- **Discovery performance continues to improve**

Fig. 3. *Table showing Rio Tinto's Tier 1 discoveries and their current status.*

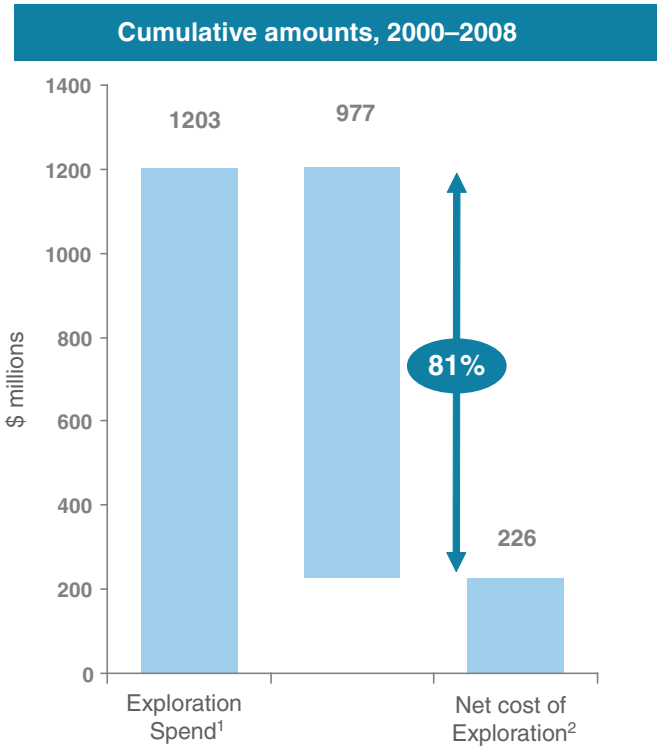

Fig. 4. *Majority of Tier 2 discoveries are divested and make an important contribution to self-financing exploration expenditure. Net cost per discovery $28.25m. Source: [1]Rio Tinto Exploration Greenfield spend (excluding evaluation) includes acquisition costs for La Granja and PRC; [2]Rio Tinto Annual Report 2008.*

First, there has to be complete alignment of the exploration programme with our corporate objectives with a focus on only the very best resource opportunities.

Second, Rio Tinto has never embraced the business model that involves the outsourcing of exploration to junior companies – for the very simple reason that there is no evidence that this model works. As such we largely explore to our own account so we can manage technical as well as health, safety, environment and community issues.

Third is our organisational structure. Any exploration group charged with finding the world's best mineral deposits – wherever they are located – obviously needs global reach.

Fourth is a well-tried and cost-effective boots-on-the-ground approach rather than a misplaced reliance on high-technology or silver bullets. While we do have a tradition of exploration innovation, technology is just another weapon in the exploration armoury – it cannot be the tail that wags the exploration dog.

Having said that, we do believe in highly focussed R&D. For the most part we do this work in-house as we find this delivers superior outcomes. As an example we have been developing an in-house gravity gradiometer system in conjunction with the University of Western Australia having returned development to Perth in 2005. Frank van Kann will say more about the progress with that system's development later this afternoon.

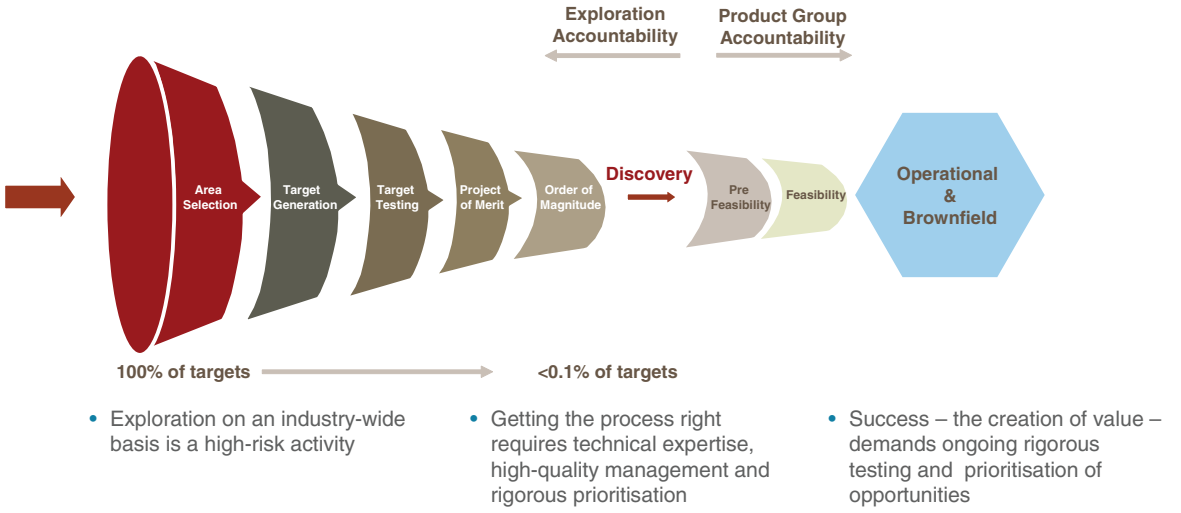

Fig. 5. *The path from area selection through discovery to an operational project.*

The key to value creation

Perhaps the most important factor for exploration success is managing the risk of failure.

Exploration involves the prioritisation and testing of opportunities – however they are generated (Figure 5). And as less than 0.1% of targets will actually deliver a discovery, a continuous flow of opportunities is required.

Success in exploration – the creation of value – demands early recognition and culling of opportunities that are unlikely to deliver. Ongoing prioritisation – the ranking of projects based on probability of discovery – is absolutely critical.

The most important event for Rio Tinto Exploration is the successful completion of an Order of Magnitude study. This involves a Product Group or Business Unit accepting the project on the basis of a defined resource underpinned by sound indicative financials. This acceptance marks the Discovery Event – for us today as it has since 2000.

During the next phase of my presentation to you today I will step through this process and indicate how we see geophysics playing a role at each stage.

Bump to discovery

History shows that Rio Tinto does not have a good track record of converting geophysical anomalies into world class ore bodies. But it does still happen – see Table 1 below.

Anecdotally it appears that the 1947 discovery of the world class Lac Tio hard rock ilmenite deposit in part owes its discovery to the early use of airborne magnetics.

The significance of the original Rössing mineral occurrence was finally revealed through the use of ground scintillometer surveys undertaken over 38 years after uranium mineralisation had been recorded in the area by Captain Louw.

Interestingly a hand held scintillometer was also employed during light aircraft reconnaissance for bauxite in Brazil in the early 1970s by the same person, Harry Evans, who discovered the giant Weipa deposit. This crude airborne surveying was credited with the identification of the world class Paragominas bauxite deposit.

Table 1. Bump discoveries

Discovery	Resource	Technique
1947 Lac Allard (Quebec)	Ilmenite	Aeromagnetics
1968 Rössing (Namibia)	Uranium	Ground scintillometer
1975 Paragominas (Brazil)	Bauxite	Airborne scintillometer
1994 Diavik (Canada)	Diamonds	AEM

The most recent Tier 1 geophysical discovery for Rio Tinto was at the Diavik diamond deposit, located in the Northwest Territory of Canada. Whilst the team might have reached the shores of Lac de Gras through till and esker kimberlite indicator results, it was the 1992 vintage helicopter EM survey that is credited with the identification of the key economic Diavik kimberlite pipes. This involved a switch from drilling the prevalent remanently magnetised pipes to a search for compact EM targets.

The point I want to make here is that it is possible to go from a 'bump to a deposit' – but for Rio Tinto it has happened only rarely.

Area selection through order of magnitude study phases

As we step from area selection through the various targeting stages through to order of magnitude, invariably the scale of observation is reduced and the level of detail required increases (see Figure 6). This holds for geophysical activities where the first steps of exploration activity might involve regional airborne surveys.

However, the later stages will be dealing with the reduction of geometric uncertainties and the collection of physical property information that will be informing resource calculations and the like. Some of the key steps are:

- Define commodity sought and generate target concepts – regional scale
- Field evaluation, follow-up surveys and early drill testing – prospect scale
- Build first pictures of potential ore body geometry – deposit scale
- Reduce uncertainties and study in ever increasing detail – order of magnitude study phase – geophysics typically used to reduce geometrical uncertainty and to gather physical property information e.g. density.

Area selection

One of the first activities in exploration is the selection of an area based on a view as to which commodity is sought and as to potential prospectivity. This selection process is also greatly informed by factors such as sovereign risk, general commercial, health, safety and cost considerations. The area selection process can actually be quite simple and in reality requires a continuous testing of assumptions around the quality and appropriateness of previous exploration efforts.

Given our relative lack of success in direct bump detection, it appears of limited value for the company to go and collect extensive and expensive regional datasets at this stage.

Some of the main issues/questions are:

- Understand which commodity is sought
- What defines a prime terrane?
- Where are the most productive prime terranes located?
- What regional data is available?
- Review commercial considerations, i.e. sovereign risk etc.
- Review health, safety, environment and community issues etc.

This is where the State, or in the case of developing countries, donor organisations step in. There is little doubt that access to good quality pre-competitive regional data – including key geophysical datasets – can stimulate considerable exploration activity. Arguably this is the best use of government funds as the multiplier effect is considerable.

Target generation – generic

The target generation phase is arguably one of the most difficult to get right. It requires a reasonably deep knowledge around the commodity sought. It also requires knowledge of past exploration efforts and key insights into the geology of the belt or terrain being explored. We need to consider:

- Company experience and local knowledge
- Access:
  - Public domain digital geology
  - Public domain satellite imagery
  - Public domain Digital Elevation Model
  - Public domain mineral occurrences
  - Public domain geochemical data
  - Public domain geophysical data
- Supplemented by in-house resources
- Collect minimum appropriate data
- Advance or exit?

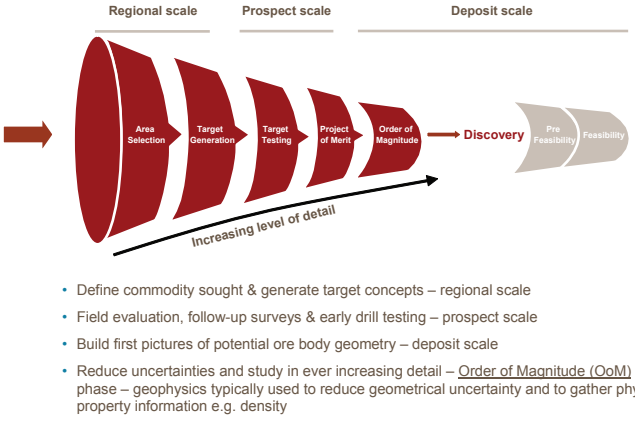

Fig. 6. *Stages of exploration from area selection through to discovery.*

For Rio Tinto the key to success here is the understanding of what a minimum size target might look like. This then drives where one might be able to 'fit' such a deposit. For Rio Tinto this is a very real issue given the scale of discovery required to deliver a project of economic interest to the company.

Target generation – Simandou magnetics I

The Simandou deposit was originally discovered in 1997 by Rio Tinto geologists following up on information gained relating to iron ore occurrences located within the interior of Guinea (Figure 7).

The initial field mapping of key exposures along a range extending for over 100 km north–south provided significant encouragement. This work was later supplemented by remote sensing and airphotograhy studies. Subsequently regional 1970s vintage airborne magnetics data were recovered and further targets we identified for field follow-up.

Target generation – Simandou magnetics II

Early drilling at Pic de Fon highlighted the potential quality of Simandou encountering significant thicknesses of +66% iron grades. A detailed helicopter magnetic survey was flown during 2003–04 confirming the presence of additional high grade haematite targets along the range.

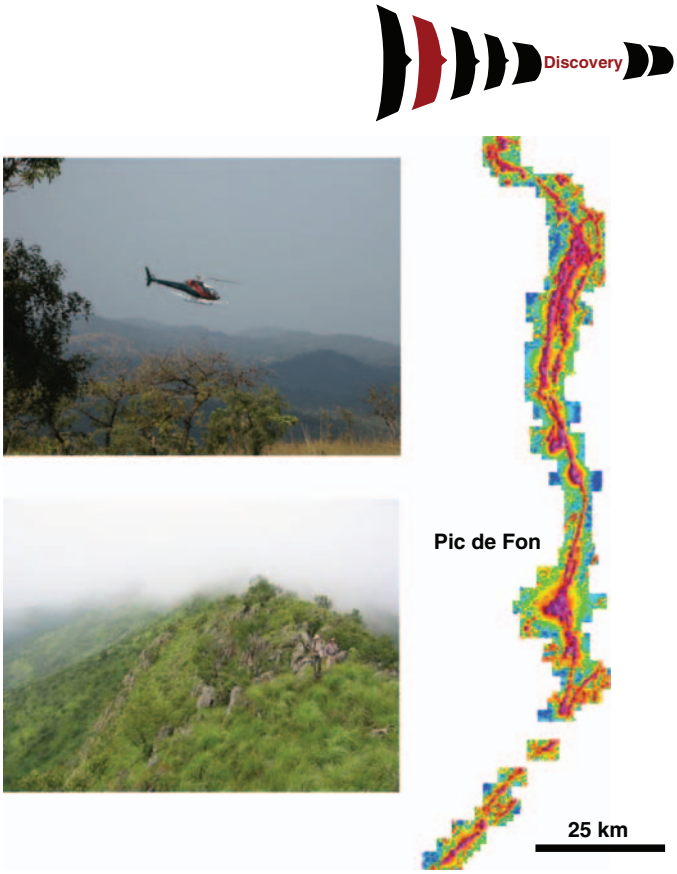

Fig. 7. *Showing the range from Simindou Nord to Simandou Sud, revealed in the initial mapping program. Detailed helimagnetic survey flown during 2003–04. Survey confirmed presence of additional high grade haematite targets along the range. Ongoing drilling. Significant field logistical issues to overcome. Limited borehole logging conducted to help build upon petrophysical knowledge.*

Simandou today represents the largest and highest grade undeveloped haematite iron ore deposit known in the world.

Target testing – Century IP

We now move from the target generation stage to target testing.

During the early 1990s CRA was exploring in Northern Queensland for base metals. Some excellent exploration work led to the discovery of the Century gossans. As part of the follow-up an IP survey was conducted in 1990 that identified interesting features lying at depth north of the discovery outcrop and the drilled confirmed southern block (Figure 8).

- Early 'quick & dirty' IP survey returned interesting results
- Produced an interesting 'picture' of geology and mineralisation.

Based on this work, holes to the north of the known mineralisation were drilled to a greater depth than the target horizon in the southern block, resulting in the discovery of the larger northern block. A more extensive higher quality IP survey was run a few years later and newly released University of British Columbia IP inversion code was used to invert these data. The unconstrained inversion results mapped out the location of the new north zone very well.

Project of merit – Regina potash

We continue to step along the evaluation pipeline moving from the target testing to the project of merit stage. The Regina potash project had been developed, targeting a solution mining opportunity. The best conditions for deployment of solution mining technology in North America were found located just outside the city of Regina located in Saskatchewan, Canada. Favourable geology, known mineralisation, and high formation temperatures at suitable depths came together to make this a high ranked opportunity.

Over 500 line-km of 1970s and 1980s vintage 2D petroleum seismics were recovered and reprocessed. This work mapped out a key marker horizon that indicated the potash-bearing Prairie Evaporite was present across the entire tenement and at low dips.

Subsequent drilling confirmed the interpretation of significant potash mineralisation with all three potash beds being present in the 5 wells drilled late last year.

This project was sold to Vale earlier this month (February 2009) along with the Potasio Rio Colorado potash deposit.

Order of magnitude – Jadar, Serbia

As I mentioned earlier the order of magnitude study phase constitutes Rio Tinto's explorations actual product and we now refer to this internally as the 'discovery event'.

The Jadar lithium-borate deposit in Serbia was first identified during 2004 as part of a global borate exploration effort. This deposit is comprised of three staked beds of a new mineral named Jadarite. Some may have seen the press related to the discovery of kryptonite. The chemical formula for Jadarite is apparently very close to that of Superman's Achilles heel.

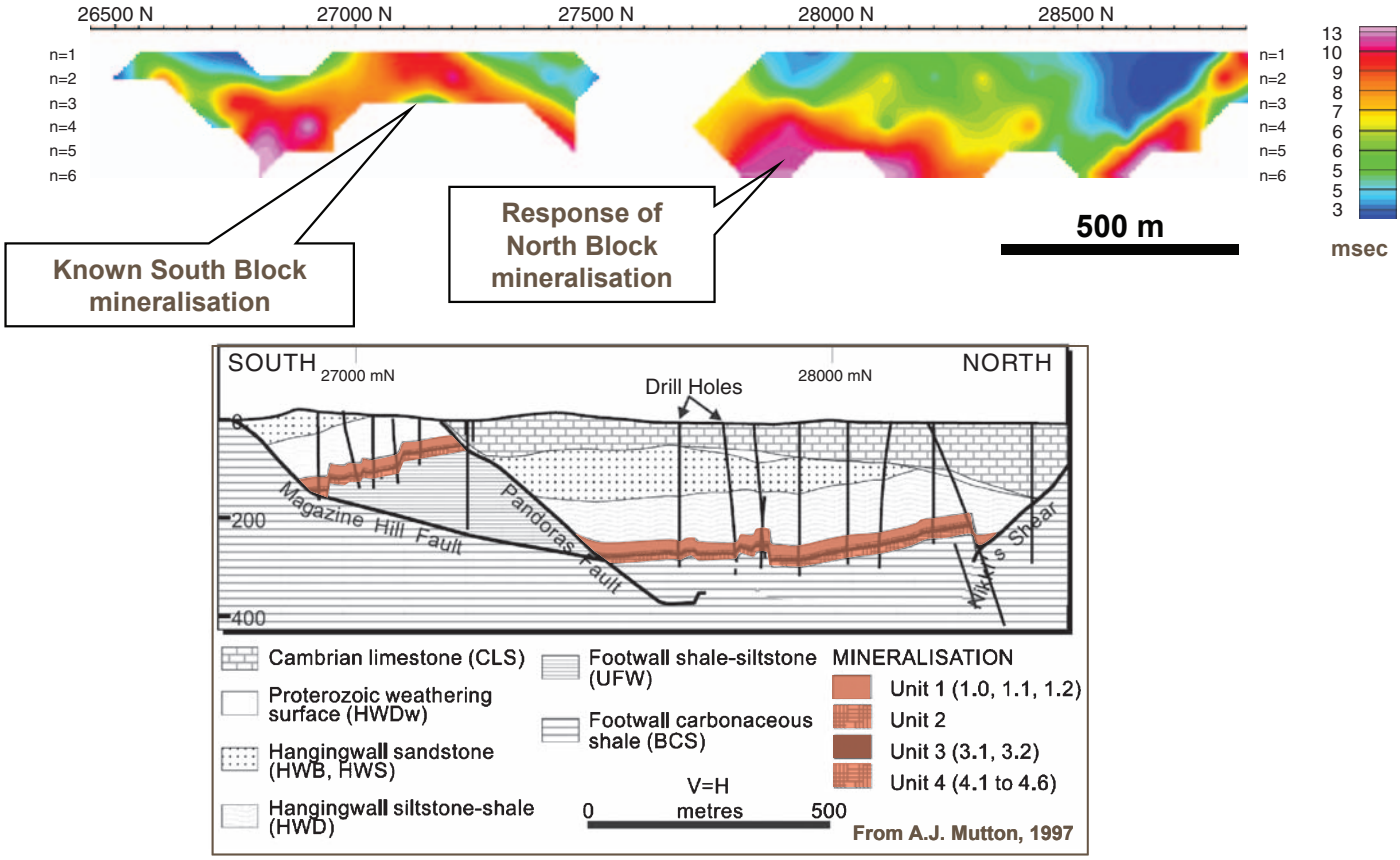

Fig. 8. *Target testing at Century using IP. Source: AJ Mutton, 1997, Proceedings of Exploration 97, 599–614. Available at: http://www.exploration07.com/pdfs/Expl97/07_03___.pdf.*

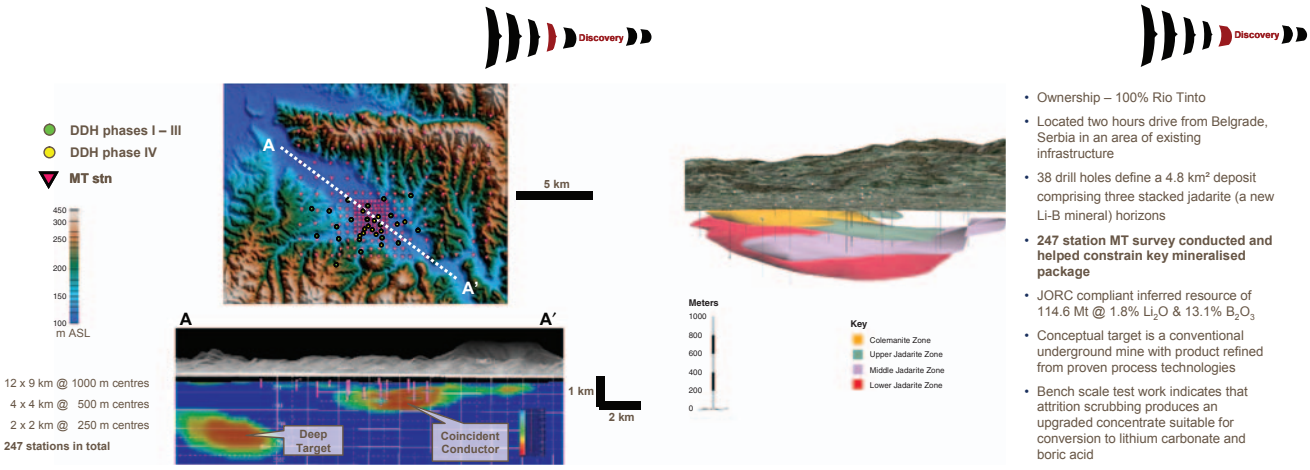

Fig. 9. *Jadar project in Serbia showing the MT results and the drill locations.*

Four campaigns of drilling were undertaken at Jadar. For the first 3 years the drilling stepped out in various directions seeking to define the boundaries of mineralisation. It is fair to say that this was a somewhat hit and miss approach – I describe this as the random walk (Figure 9).

In late 2006 an MT survey was conducted across the centre of the Jadar basin. This returned quite spectacular results with a highly conductive package of sediments essentially defining the extent of the high grade mineralisation.

Subsequent drilling was able to focus on the economically important centre of the deposit. Jadar represents the largest known mineral deposit resource of lithium known in the world today. This project has just entered pre-feasibility.

Prefeasibility and feasibility – role of geophysics

Once a project has successfully completed an order of magnitude study it is handed across to a pre-feasibility team for additional study. Over and above mining and metallurgical studies the key activities here are to improve ore body knowledge, to reduce geometrical uncertainties, to increase confidence in key physical properties such as density, and to start to build geotechnical knowledge.

Prefeasibility study – Kazan trona

The Kazan trona (soda ash [Na_2CO_3]) deposit was discovered in Turkey in the late 1990s. This was the first trona deposit to be discovered after targeted exploration. All previously known deposits were discovered whilst drilling for oil and gas. It is 100% owned by Rio Tinto, located 1 hours drive from Ankara in an area of existing infrastructure.

The deposit is set in a Tertiary aged lacustrine basin and both MT and 3D seismic correlates well with key trona mineralisation.

A 3D seismic survey was shot at Kazan to define the shape and structural status of the economically important bed 3. An MT survey was completed at a later stage and this survey added significantly to the overall understanding of the architecture of the Tertiary aged Kazan lacustrine basin.

The conceptual target is a solution mine with product refined from proven process technologies.

Feasibility study – Potasio Rio Colorado potash

In a similar vein, 3D seismics was shot at the Potasio Rio Colorado potash deposit located in Argentina.

This survey was designed to determine structure in the primary resource area. It was also used to provide positional assurance for the location of resource and pilot wells.

A key consideration for the design of this survey was to adequately image key structure and sub salt discontinuities that would impact the local dip of the potash beds, as low dip angles and lateral continuity are key requirements for productive solution caverns.

Operational effectiveness and brownfield exploration

Once a deposit is brought into operation there are many potential ongoing uses for geophysics ranging from improvement in geometrical uncertainties through the acquisition of key physical property information. The key issues are to:

- Optimise ore body knowledge
- Limit geometrical uncertainties
- Provide confidence in densities for resource modelling
- Provide adequate geotechnical knowledge
- Examine the situation away from immediate known resource.

In the brownfield setting one then starts to use again techniques that are more commonly deployed in the greenfield setting, albeit having to factor in cultural noise issues due to the operational footprint.

Operation – Diavik Down-hole Seismics, Canada

At the Diavik diamond mine drillhole seismics and Vertical Seismic Profiling has been used to good effect to help better define the shape of steeply dipping, narrow kimberlite pipes.

This work provided significant new insights into the actual shape of the pipes as generating a high density of pierce points through drilling was considered unviable, especially at depth considering the pipes are near vertical. This work was warranted given the very high grades and high value of Diavik goods. Figure 10 shows two of the models from this study.

Operational & Brownfield

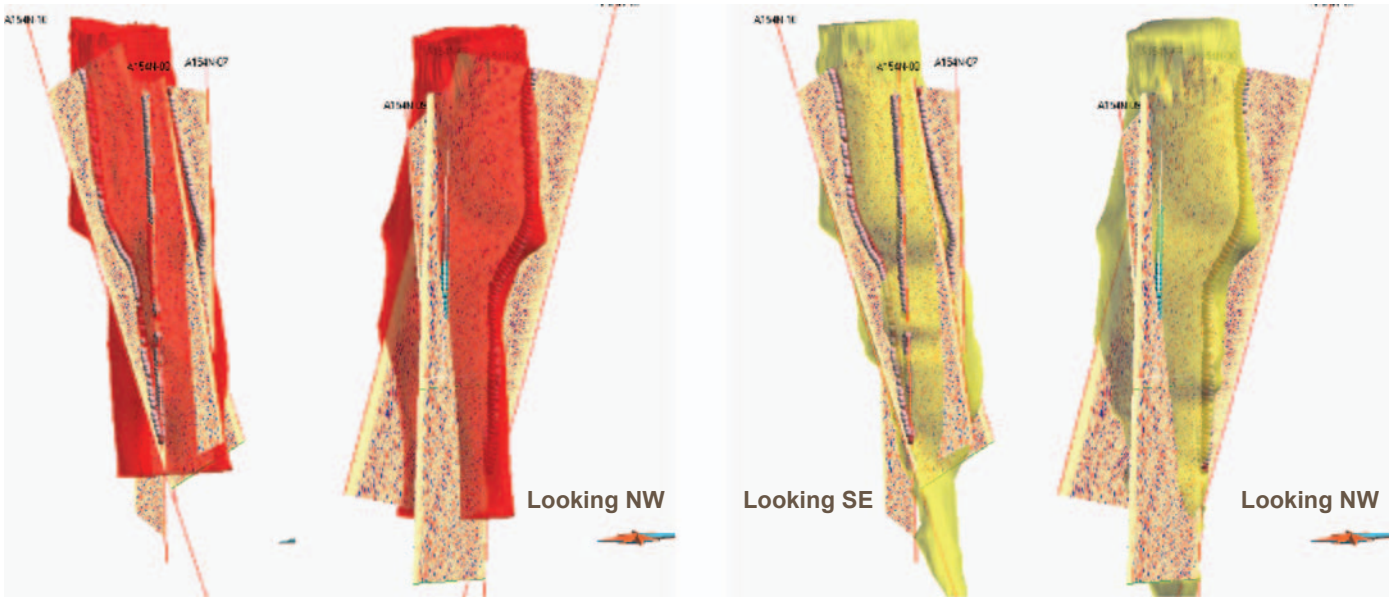

Fig. 10. *Two kimberlite models: (1) Best estimate (red) and (2) Diavik resource model Nov30_05 (yellow). Both models shown with best and worst case scenario interpretations from DH seismic.*

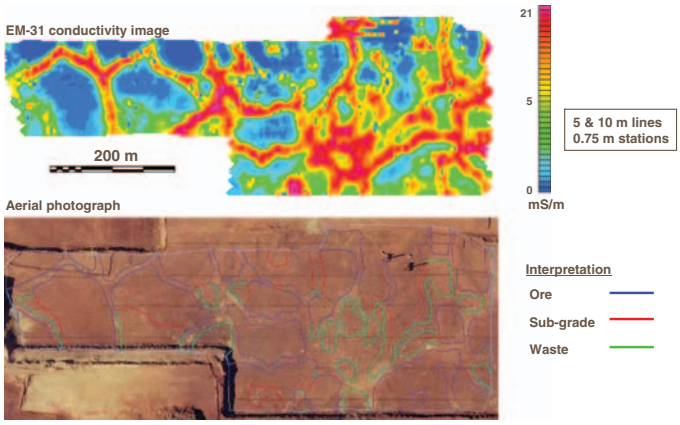

Fig. 11. *EM conductivity image and aerial photograph of Mount Tom Price (Pilbara, WA). The high conductive clays are shaded red.*

Operation – Mount Tom Price – EM

At Mount Tom Price ground EM has been used successfully to map out the clay content in iron ores. This method is quick and easy to use. The results can be quickly digitised and fed into the mine planning software (Figure 11).

The results help to improve grade control so that there are no surprise clay patches dominating the production feed. It helps with the design of better mining blocks, adjustment of blasts for ore and waste, maximises selective mining capability, and helps with the design of haul roads and ramps avoiding clay rich areas.

Summary

Once we are through this downturn and return to anything like trend growth, then commodity requirements of a growing global economy will again test the mineral exploration industry's ability to respond in a timely fashion to future consumption growth.

Geophysics has a number of important roles to play across our industry. There are a number of key take-aways to consider:

- Firstly the requirement to utilise the most appropriate tools and methods to meet objectives
- One then needs to clearly understand the scale of observation
- Applying geophysical techniques in isolation is rarely a recipe for success (i.e. no silver bullet)
- In conjunction with other tools, geophysics has played a significant role in the discovery and evaluation process across Rio Tinto
- It is the intelligent application of geophysics – occasionally innovative – that deliver greatest value
- The role of geophysics to the minerals industry *must* grow as we strive to improve our effectiveness at finding and evaluating orebodies under cover
- And finally, the integration of multiple datasets and use of petrophysically constrained but geologically realistic models are keys to future success in convergent modelling.

I believe strongly that geophysics has an increasingly important role to play in mineral exploration and in the critical areas of ore body knowledge.

iTunes U, a free online window to intellectual self-education

In this edition I will focus on the vast collection of free lectures, language lessons, audio-books, video presentations and more, available from Apple's 'iTunes' web site. In total, one can explore over 100 000 educational audio and video files from top universities, museums and public media organizations from around the world. To access the material you will need to install iTunes, also available for free at http://www.apple.com/itunes/download/. You do not need an iPod or MP3 player to play the podcasts. iTunes will run on any PC or Mac too.

As introduced at http://www.apple.com/education/guidedtours/itunesu.html, 'iTunes U' includes the broad categories of Business, Engineering, Fine Arts, Health & Medicine, History, Humanities, Language, Literature, Mathematics, Science, Social Science, Society, and Teaching & Education. Well over 100 (mostly US) universities are represented, complemented by more than 100 'beyond campus' institutions, and 11 schools for K–12 children's level. Australian representations are made by ANU and UWA.

Overall, I find that iTunes U is excellent for general self-education and awareness. Priority appears to have been given to keynote lectures and presentations by international authorities, business leaders, government figures, and academia. My own introduction to iTunes U was the 'Stanford Technology Ventures Program' accessed via the following path: Stanford → Business → Business Leaders and Entrepreneurs. Notable CEOs and business leaders speak for about an hour on their path to success, and more appealingly, on their many failures and pitfalls along the way. It is both entertaining and insightful to hear of the ubiquitous last-chance, last-gasp scenario they all faced, perched on the edge of the financial abyss, before success finally rewarded their monumental struggles.

There is, however, quite considerable material available for specific topics. As an example, when searching under 'Mathematics', one can perform a wildcard search in the 'Search iTunes Store' box at the top right-hand corner of the screen. A search on 'linear algebra' returned 118 hits, including several articles by the well-known academic Gilbert Strang, a comprehensive full course by MIT, and audio and video material from many other universities and academics (see below). In total several days of listening and viewing are available for this single topic. Roughly two-thirds of hits were video podcasts.

A search on 'geophysics' returned a more moderate 21 hits, almost all of a general earth sciences/climate context. A pitfall when using the 'Search iTunes Store' options is that everything is searched, including music, videos, etc. Fortunately, the 'Quick Links' box contains a 'Power Search' option that allows filtering of the iTunes store. Thus, one can only search within the iTunes U database. It is better to insert your keywords into the 'Description' box, unless you are confident of the exact title of a podcast.

Ultimately, there is no substitute for simply browsing through the vast collection available. Inevitably, most discoveries are accidental rather than purposeful, and one is again reminded of the fundamental challenge we all face with the monstrous information space on the web: How do you intelligently search, filter and screen it all without getting bogged down? The consolation in this case is that most of the material is well produced and presented.

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News

Continued from p. 25

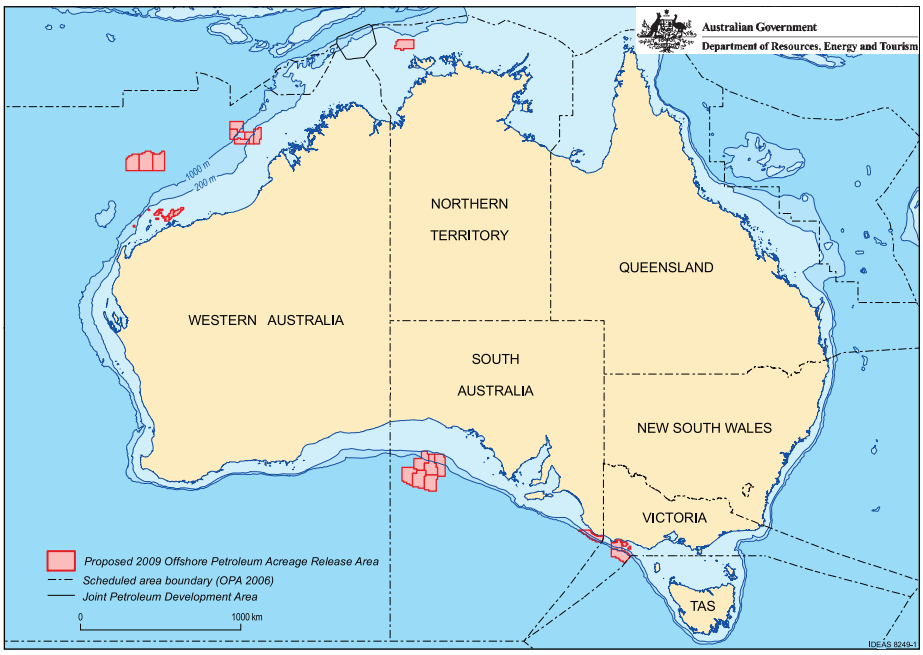

Fig. 7. *Proposed 2009 Offshore Petroleum Exploration Release Areas.*

Preview is published for the Australian Society of Exploration Geophysicists. It contains news of advances in geophysical techniques, news and comments on the exploration industry, easy-to-read reviews and case histories, opinions of members, book reviews, and matters of general interest.

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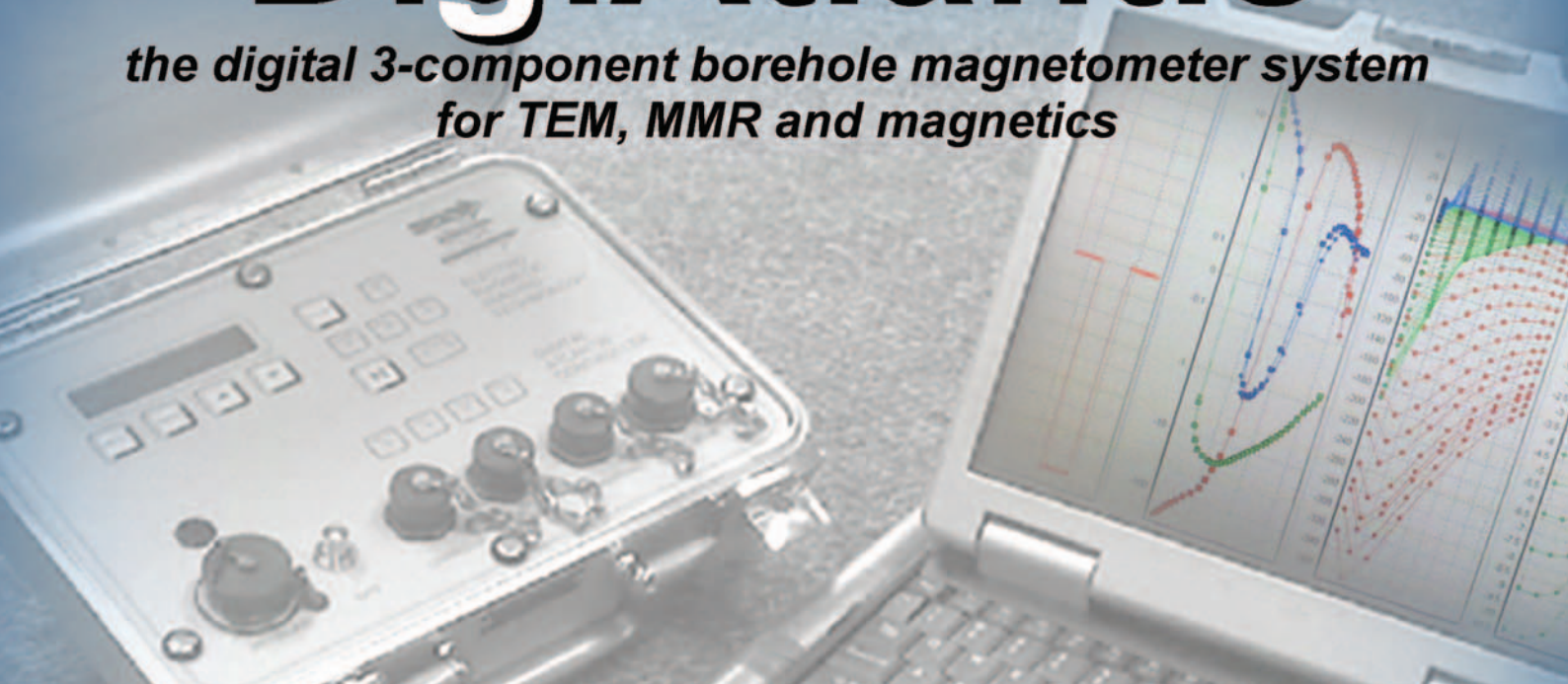

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