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PREVIEW

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

CELEBRATING 25 YEARS AND 150 ISSUES

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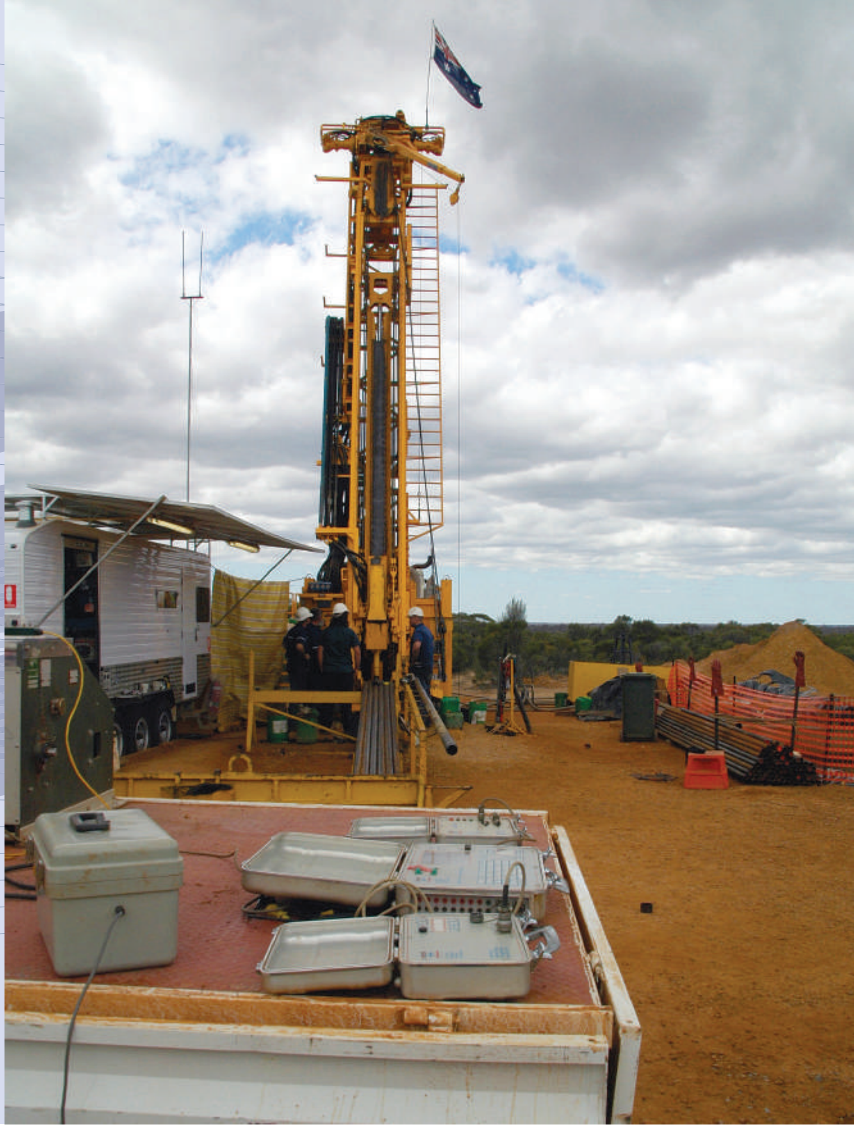

PREVIEW

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FRONT COVER

A collage of *Preview* covers from the last 25 years.

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Ann-Marie Anderson-Mayes

Email – friend or foe?

On p. 9 of this issue you will find an article about the history of *Preview* celebrating this 150th issue which also marks the 25th year of publication. In the course of researching that article, I stumbled across an interesting piece entitled 'Well Connected – Hooking up to the global network of electronic mail and news' by David Hayward (p. 22, Issue 42, February 1993). In an era where email and Internet access are ubiquitous (and almost mandatory) in our industry, it was fun to read an article which walked readers through the absolute basics – defining the Internet, how email works, electronic news, the technology required to make it happen, etc.

Less than 20 years ago, this technology was new and noteworthy and the article describing it took up four pages in our magazine. Now, the whole production of *Preview* is enabled by the Internet. Emails flow out from me sourcing material, flow back (hopefully!) with articles and contributions, then transfer to CSIRO Publishing for layout, then back to me for checking, etc. And finally, the magazine is published online for all to read well before the printed copy is distributed. At my end of the magazine's production at least, the process is almost entirely paperless.

Coincidentally, I have also been reading a book called *Shrinking the World* by John Freeman. This book looks at 'the 4000-year story of how email came to rule our lives'. The book starts with a fascinating exploration of the history of communication through early mail services, telegram services, typewriters, newspapers, etc. This history sets the scene for a population that gradually experienced faster and faster modes of communication, right up to the modern day where we live in an era of 'instant' communication around much of the globe.

However, the real theme of the book is to question whether email has been a positive development. Freeman's point is that email consumes so much of our lives that for many it is almost an addiction. And the quoted statistics are alarming – 65% of North Americans spend more time with their computers than with their spouse! Handheld devices have enabled the checking of email just about anywhere and anytime. Apparently, more than 60% of Americans check their email when they are on holidays and respond to work queries, and a similar number check their emails in bed before they go to sleep and when they wake up.

The book ends with a list of 10 things you can do to control your email usage. I read the list and found that I do most of them already. But then, I am not an email junkie. I love the fact that this technology keeps me in ready and easy contact with everyone involved in producing *Preview*. It makes the job of producing the magazine very straightforward. However, it is just a tool and when I am not actually working I figure the messages will keep. I don't check my email on my iPhone and I typically check it only once a day on my computer, except when we are right in the middle of the production cycle. So, my apologies in advance if it takes me a few days to respond to your email – I'm not ignoring you personally, I am just choosing not to be connected all the time!

In this issue

In keeping with the theme of this issue marking 25 years and 150 issues of *Preview* publication, there is a wide variety of material to peruse. John Denham's article is based on his ASEG2010 presentation, 'The History of Seismic Resolution', and looks back but in doing so makes us think about the way we work today as well. Marina Costelloe's article reports the latest exciting results from the Kombolgie AEM data. And Kim Frankcombe takes a look at the claims made for Real Section IP with a modelling study. Whilst it is the 25th birthday of *Preview*, it is also sadly the 25th anniversary of the aircraft accident that killed Grahame Sands. Bob Timmins remembers Grahame and his contribution to geophysics in Australia. And our regular columns include Industry News, Research News, Geophysics in the Surveys, and two Book Reviews.

As I was preparing this issue, the flood crisis was developing in Queensland and then further south in New South Wales and Victoria. This followed hard on the heels of the WA floods in December. My thoughts have been much occupied by the tragic loss of life and devastating impact on property and businesses. I heard that at least one geophysical contractor was relieved that the Brisbane River did not reach the predicted peak and thus their office escaped flooding. Also, some crews were either left stranded or separated from their equipment as large areas were affected. Our best wishes go to all the people affected and especially to members of the ASEG and their families.

The challenge of 'under' cover

In August 2010, the Australian Academy of Science convened a Theo Murphy High Flyers Think Tank to address the issue of 'Searching the Deep Earth: the Future of Australian Resource Discovery and Utilisation'. The workshop assembled a group of scientists that heavily represented Geoscience Australia, CSIRO, Government Surveys and various universities with very minimal industry representation. In fact, the ASEG only found out about it through their press release. The recommendations that came out of the workshop were released on 11 January (visit www.science.org.au/events/thinktank/thinktank2010/index.html) and read like a scientific business plan for Geoscience Australia rather than a future vision for the industry.

I won't repeat them here, but they cover topics that have been widely discussed among Australian academics and geologists for decades. For such a well qualified group, the outcomes were at best of predictable 'bi-plane' standard and at worst unexciting. Worse still, if the meeting was about the future of the industry, it read like a geologist's grab bag rather than an industry one. Maybe it wasn't the fault of the participants but more the terms of reference developed by those who set up the Think Tank. The issues contained in the Roadmap and the Outcomes have been articulated before and are not new.

The issue of cover has been around for decades. Regardless of the perceived challenges, we have actually been very successful at it over the past 40 years. This has been without any special government intervention other than the normal 'stuff' Geological Surveys and Geoscience Australia (or was it the BMR) are good at, the most important being the completion of the continental aeromagnetic coverage. Olympic Dam 300 m, Acropolis 300 m, Cannington 40 m, Prominent Hill 100 m, Admirals Bay 1500 m, Carapateena 470 m, Ridgway 500 m, to name a few. All were discovered by drilling through cover, the targets however were generated from the data sets available or acquired at the time and with the geological nous and commitment of the exploration teams who made the discoveries. More importantly, these teams were backed by mining company managements that had a commitment to the future of their companies and the industry.

I agree that the issues identified by the Think Tank are important and that the future of discovery for certain deposit types is under cover, however there are two questions that come to my mind. Firstly, 'what' deposits are we looking for under cover and secondly 'who' is going to discover them?

The contribution of gold and base metal deposits, while locally important to the Australian economy, is insignificant compared to that of coal, iron ore and bauxite (aluminium). Strategically, these are our most important mining industries. The largest single sector expenditure on minerals exploration is on gold exploration, a notoriously difficult commodity to target under cover. I doubt that a strategy to look under cover will add one ore deposit to these industries, so the question of 'what' deposits is just as important as 'how'.

On the question of 'who' will find them? It will be those that can afford to. There is a certain mythology that says it will be junior companies but in general, they neither have the capital necessary nor the time to face the high cost and risk of looking for 'blind' deposits. There is no real incentive for shareholders to invest in such risky ventures.

Previously it was predominantly the major companies, however over the past couple of decades there has been a fundamental shift in the structure of our industry. Current mega company managers are mining the great discoveries of the past 50 years. Responding to the 'short-termism' of fickle capital markets, they see greater potential for short term rewards in mergers and acquisitions rather than in the risk of long term exploration.

Since the 1990s, exploration teams have been systematically disassembled while others have disappeared as part of efficiency gains in mergers. Even if they did want to embark on grassroots exploration again, a lot of the skill and knowledge built up over thirty years has been lost or forgotten. All of us who have been involved in exploration know that it takes enthusiasm, science, money, time and luck to make major discoveries. Funny though, as a particular golf professional once commented on luck, 'the more you practise the luckier you get'. Many of the majors are seriously out of practice.

So, back to the Think Tank. All of the proposals are worthwhile but I have heard of all of them in different guises before, some in the current Deep Exploration Technologies CRC with which I am involved and others at various meetings I have attended. The issue of cover has been on the research agenda for many years. The fact is that there is more than enough data in Australia to make discoveries under cover…we have a track record of doing it!

The real issue is to encourage risk money into exploring under cover in the face of appalling odds. In the recent debate about the mining super profits tax this point has been entirely overlooked, in fact sacrificed. The industry consultative committee was chaired by a banker and an ex trade union official (the Minister). Invited participants hardly represented the exploration industry and while I have a high regard for those I know personally, the exploration issue was entirely sidelined, in fact sacrificed, to the interest of current profits.

I hope that the Minister doesn't think that the assembled 'fendis' at the Academy of Sciences Think Tank represented the industry because in fact the industry was barely visible.

On another note, as I write this I am totally distracted by the serious flooding in Queensland and elsewhere in Australia. My heart goes out to all of those people who have lost loved ones and property as a result. On behalf of the Federal Executive, I pass on our best wishes thoughts to any member of the ASEG family that has been affected in any way whatsoever.

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Notice of 2011 AGM

The ASEG's AGM will be held on Tuesday 12 April 2011 at 5.30 pm in the City West Function Centre, 45 Plaistowe Mews, West Perth.

An important part of the meeting will be to elect a President, President-Elect, Treasurer and Secretary for the period 2011–2012, in accordance with the Articles of Association.

We are calling for nominations for all these positions. They should be lodged with the Secretariat no later than COB Monday 14 March 2011 and must be supported by a proposer and a seconder.

The contact details for the ASEG Secretariat are:

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Fax: +61 8 9427 0839
Email: secretary@aseg.org.au

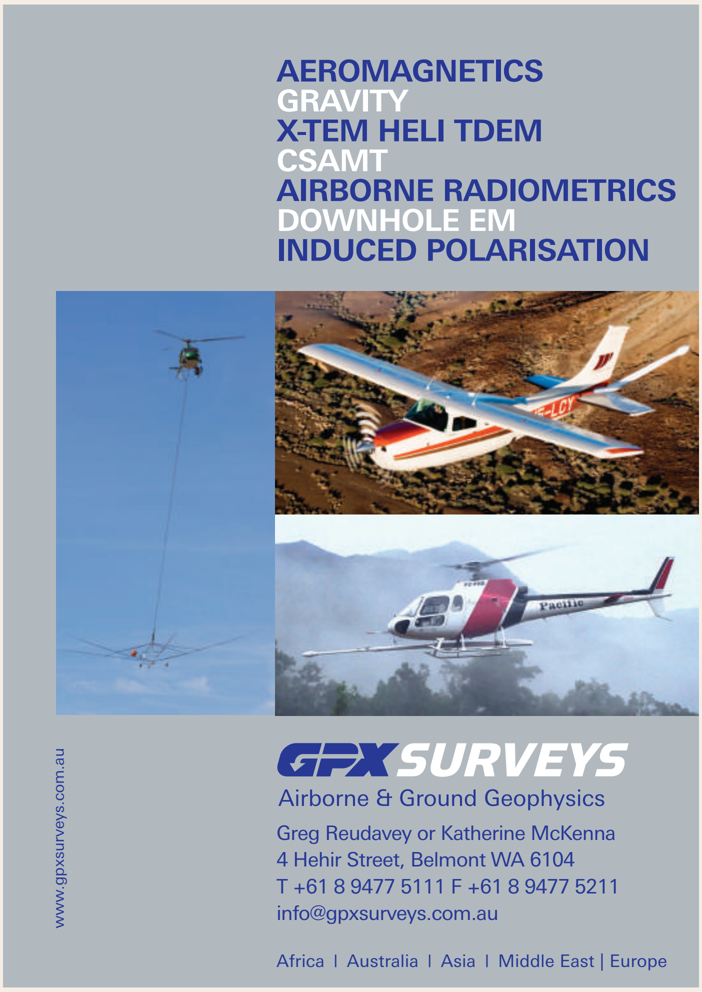
Please contact me or the Secretariat for any further information.

David Denham
Secretary

New members

The ASEG extends a warm welcome to 8 new members to the Society (see table below). These memberships were approved at the Federal Executive meeting held on 25 November 2010.

Name	Organisation	State	Member grade
Richard John Carter	Self Employed	WA	Active
Christopher Moore	Moore Geophysics	VIC	Active
Robert Lewis Richardson	Geotangent Pty Ltd	NSW	Active
M. Andy Kass	Broken Spoke Development	USA	Active
Alex Lukomskyj	Australian National University	ACT	Student
Charles Gianfriddo	University of Melbourne	VIC	Student
Thy Kim Thi Nguyen	University of Melbourne	VIC	Student
Terence Paul Kratzer	RMIT University	VIC	Student



Remembering Grahame Sands

Grahame Sands

It has been 25 years since the demise of (Duncan) Grahame Sands in an aircraft accident on 27th February 1986. Grahame was 40. The accident also took the life of pilot, Brian Mickelberg. Physicist, Bob Groves was the sole survivor.

It is in Grahame's memory and honour that the award known as the Grahame Sands Award for 'Innovation in Applied Geophysics' is awarded to nominated recipients who significantly contribute to the advancement of geophysical exploration. The award was inaugurated in 1986 and has been presented by the ASEG, on 11 occasions.

Grahame's introduction to exploration was as a vacation field assistant (1968) in Cloncurry, Queensland, with Australian Selection (Seltrust). After a brief flirtation with Vet Science at Sydney University terminated in colourful circumstance (a larrikin born), Grahame entered the Army Survey Corps as part of his National Service.

Serving a stint in New Guinea, Sapper Sands began a lifelong interest in surveying. The career of this free thinking scientist with a disdain for questionable regimentation had begun.

The next larrikin/scientist conflict occurred with a termination a year before graduation from the Bendigo School of Mines. His indiscretions are legend and have been subject to many interpretations and exaggerations by his peers over the years.

From Bendigo, Grahame and family were sent to Kalgoorlie (1971) by Seltrust. After a brief time in field work, he was assigned to estimating the ore reserves for the Perseverance nickel deposit. Grahame completed a degree in Mining Geology from the Kalgoorlie School of Mines based on this work. At this time, Grahame learnt the 1970s limitations of computer power (Seltrust had purchased a HP9100), and the imprecise borehole measurement of dip and azimuth in magnetic ore bodies.

Grahame experimented with his home brand of computer to enable computation and graphics to be integrated. He met with some success and with his enthusiasm, plus the fact that he was being distracted from his assigned task, Grahame convinced Seltrust management to purchase a then state-of-the-art HP8945, a work station that preceded PCs.

His experimental directional borehole logger based on angular accelerometers was an object of curiosity in Seltrust's Kalgoorlie office. The instrument was later (1980) patented by Aerodata/Grahame Sands when Aerodata expanded its business into downhole logging.

His enthusiasm for computer evolution and applications was to be the catalyst for his joining fledgling airborne geophysical company, Aerodata.

In 1979, Seltrust, with Grahame as technical advisor, engaged Aerodata to conduct an airborne magnetic survey in the search for the potentially diamond bearing lamproite intrusives. Aerodata utilised a HP9825 computer as the controller for the aircraft acquisition system. With his previous Hewlett Packard experience, Grahame wrote algorithms and converted them to FORTRAN programs for the band width filters to extract the signature of the lamproites. Several lamproitic intrusions were thus identified.

Subsequently, with technical and social compatibility having been tested at Fitzroy Crossing, Grahame invested in and joined Aerodata as a director and technical driver.

With Aerodata's commitment to research and development, Grahame's innovations flourished. Some of his innovations were:

- The digitising of flight paths and the production of standard projection maps. This led to image processing of magnetic and radiometric data. Grahame launched an imaging project with Dr Frank Honey, resulting in Aerodata being an early leader in geophysical image processing.
- Demagnetisation of an aircraft's magnetic signature was poorly understood in the 1980s. Grahame established the determination of induced and permanent component of an aircraft's magnetic field, allowing each component to be nulled individually and quantitatively.

Grahame died while testing a hybrid navigation system aimed at eliminating the use of aerial photography and radio triangulation as the primary sources of aircraft navigation. The system he pioneered utilised the Navstar Global Positioning System (begun in 1984 by the US Air Force) and the Omega Global Nav. System (GNS). The Omega system was instituted by the US Navy as a navigation aid. It comprised VLF signals from fixed transmitters and gave absolute accuracy of approximately 6 km. With limited GPS satellite coverage at the time, Grahame developed an interface to take velocity and heading data from the Omega GNS system to provide '*x*' and '*y*' coordinates between GPS fixes. The '*z*' component was obtained from a radar altimeter, fitted with a standard rubidium clock.

The first commercial survey utilising the GPS system occurred in 1988 when a survey was conducted in the Arafura Sea as part of the exploration of the Timor Gap. Full GPS satellite coverage for routine use was not completed until 1993 and is now routinely used as the primary navigation tool.

Grahame was posthumously awarded a Masters degree in Geophysics from Curtin University for his technical work on a horizontal airborne magnetic gradiometer system which he designed and built. After Grahame's death, the system as the first of its kind, continued to operate commercially. This system was the precursor of many systems in operation today. His written notes and ideas were compiled into thesis form by Aerodata's Gary Spencer with theory input from Bob Groves. His many and disparate unwritten ideas will never be known.

Widely revered by his peers this family man, friend, scientist, innovator and larrikin, Grahame created a legacy of innovation and technical excellence deservedly recognised by the award which bears his name.

> *'Do great talent and misfortune make a pair?' Nguyan Da, Vietnamese Poet*

Bob Timmins
Email: hayou@iinet.net.au

Craig Hoffman – 13 January 1961, Strathalbyn, SA – 3 December 2010, Aldinga, SA

Craig Hoffman

Craig Hoffman was a well known personality in the Australian geophysical community. He was one of the first employees of the Australian branch of Zonge Engineering, commencing in 1984 and continuing through until 2006.

Craig began as a field assistant then crew chief for many years, finishing his career in equipment maintenance and as the Zonge Safety Officer. During his last years at Zonge he worked diligently toward certification in both electronic engineering and Occupational Health and Safety. He then worked freelance for a number of companies both as a field geophysicist and in equipment maintenance.

In 2010 he started a new job in Melbourne as a Health and Safety Officer/Trainer attending the 2010 ASEG Sydney conference with renewed energy.

Many of us were aware of his significant health issues, culminating in three years of dialysis and a kidney transplant in 2005. Shortly after the Sydney ASEG conference he was diagnosed with a brain tumor and died of associated complications in early December. He was characteristically optimistic until the end, complaining indignantly about his physiotherapy treatment and that he was better than most people at balancing on one leg with his eyes closed.

Craig is survived by his wife Mela, son Yatha, mother Marlene and brother Peter.

He will be missed.

Michael Hatch and Kelly Keates

ASEG News

Australian Capital Territory

The technical aspects of 2010 drew to a close for the ACT Branch with two talks on 24 November by Yusen Lay and Aaron Davis. Both gave slightly updated versions of their 2010 conference talks, which allowed those members who weren't at the conference to hear some of the latest developments in Airborne EM. Both Aaron and Yusen were kept honest by interstate ASEG visitor and AEM expert Jim Macnae.

Yusen's presentation mainly dealt with the importance of calibrating borehole conductivity instruments, a process that evidently involved visits to Batemans Bay, Canberra's Lake Burley Griffin and even the swimming pool at the Australian Institute of Sport. Yusen also impressed on the audience that AEM is more than just mineral and groundwater explanation and proved this point by showing some examples of using AEM for mapping rock slide areas on the flanks of Norway's spectacular fjords.

Aaron's talk stressed the importance of calibrating different AEM systems against each other. This process ensures compatibility before different datasets measured with different AEM systems are combined and modelled. He demonstrated the benefits of this process by showing seamless conductivity maps of the Broken Hill region and also highlighted the strong links between Australia and Denmark in AEM circles.

On 7 December, the ACT Branch combined with the local branches of the GSA and AusIMM to gather for a pre-Christmas BBQ using the new facilities recently set-up at Geoscience Australia. Despite a wetter than normal spring in Canberra (like just about everywhere else), the weather cooperated and many lingered in the twilight chatting and even enjoying beer on tap from the local Zierholz Premium Brewery.

The program of events for 2011 is beginning to take shape. At this stage Canberra will be hosting SEG Pacific South Honorary Lecturer Richard Lane on 20 April at the ANU. Andrey Bakulin, SEG 2011 Distinguished Lecturer is also expected in Canberra on 17 June. Mark these dates in your diary now and keep an eye on the branch web page for details.

We wish all members a very geophysical 2011 and also a Happy 150th to *Preview*!

Ron Hackney

Queensland

Student night 2010 was held in December at the University of Queensland. Three excellent presentations were made and Steve Hearn also spoke. Steve described how students had volunteered to do honors over 2 years so that they could take all the classes that were currently on offer at UQ. Terry Ritchie and Peter Fullager are contributing their considerable talents to this cause. I'm sure many of us were concerned about the low numbers of graduates but the calibre of the student presentations gave great comfort. The meeting was held at the same time as a Geomodellers workshop and almost 40 people attended the evening. Well done Steve!

Henk van Paridon

Preview – 25 years and 150 issues

This issue marks a significant milestone for *Preview* – the 150th issue. *Preview* Issue 1 was published in January, 1986 and *Preview* Issue 150 will be published in February, 2011 – so the 150th issue also marks the 25th birthday for our magazine. From humble beginnings as a simple photocopied newsletter, *Preview* has evolved into a professionally produced, glossy colour magazine. It is freely available online and is being read by a global audience in its digital format (see article on p. 11 for more).

The first meeting of the ASEG was held in January 1970. Before the first issue of *Preview* in 1986, an A4 newsletter was distributed under the guidance of the ASEG Executive, then based in Sydney. In April 1985, the ASEG Executive moved to Adelaide. Peter Elliott was Honorary Secretary and preparation and distribution of the ASEG Newsletter was included in his responsibilities. In an effort to reduce costs, Peter discovered that publications attracted a lower postage charge than ordinary mail. And thus, the Newsletter became a publication with the name *Preview*. It started as an A5 booklet (which also reduced production and distribution costs) printed on coloured paper.

Over the next 14 or 15 years the editorship of *Preview* moved with the ASEG Secretariat and Federal Executive.

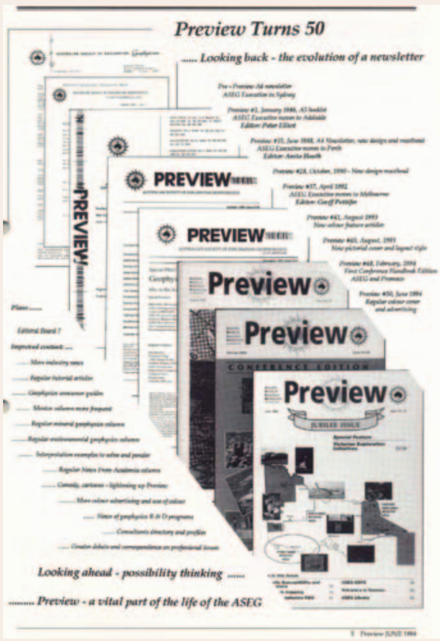


Fig. 1. *A pictorial history of the first 50 issues – p. 5,* Preview *Issue 50, June 1994.*

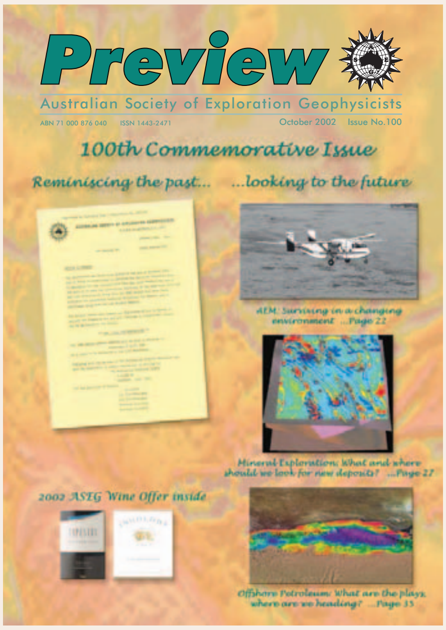


Fig. 2. *Cover of* Preview *Issue 100, October 2002.*

In Adelaide, Issues 1–4 were produced by Peter Elliott and then Issues 5–14 by Reg Nelson. In 1988 the Federal Executive moved to Perth and Anita Heath edited Issues 15–36. Geoff Pettifer edited issues 37–60 following the Federal Executive move to Melbourne in 1992. With the move to Brisbane in 1996, Mike Shalley edited Issues 61–67 and then Henk van Paridon steered the magazine through Issues 68–81. For more on the early story of *Preview* see p. 5 of Issue 50 (Figure 1) and p. 6 of *Preview* Issue 100 (October 2002 – see Figure 2).

During this period the magazine gradually evolved, with each editorial team contributing new developments. Issues 1–14 were A5 booklets. Issue 15 saw a change to A4 format with a new design and masthead, and a further masthead change in Issue 28. The first colour feature article 'Geophysics in AGSO' by David Denham, Jim Colwell, Doug Finlayson and Colin Reeves appeared in Issue 41. At this time contributors could purchase 4 colour pages (with extra monochrome pages as required) for an article and advertising for $2100 or only 1 colour page of advertising for the same cost – sounds like a good incentive to write articles with lots of colour figures! Issue 45 saw the introduction of a pictorial cover and Issue 50 saw the start of a regular colour cover and colour advertising. The Advertiser's Index was introduced in Issue 67 and this also

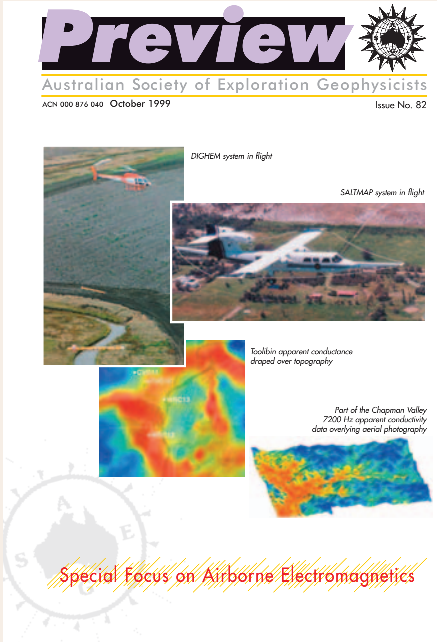


Fig. 3. *Cover of* Preview *Issue 82, October 1999.*

heralded a new era where advertising and routine contributions became the responsibility of the then printer, Jenkin Buxton Printers Pty Ltd. The magazine had now evolved to the stage where a printer/publisher took responsibility for advertising, layout and production and the Editor sourced and checked the content.

Issue 82 (October 1999 – see Figure 3) was the beginning of David Denham's era as Editor. David steered the magazine through 58 issues and still contributes items to nearly every issue of the magazine. He has made a truly wonderful contribution to *Preview* in the second half of its life thus far. Issue 82 was also the first issue produced by a new publisher, RESolutions Resource Energy Services, based in Perth. RESolutions published *Preview* for the next seven years, and then at the beginning of 2007 *Preview* and *Exploration Geophysics* transferred to CSIRO Publishing. CSIRO Publishing has produced *Preview* from Issue 126 to the present and has also contributed significantly to the development of *Preview*'s online presence.

The most rewarding aspect of the exploration of the *Preview* archives was simply to reflect on the diversity of information stored in the pages of our magazine. The magazine provides a wonderful historical record of the activities of our Society at Branch level, through conferences, and through records of various Executive Committee activities. For example, news from the ASEG Research Foundation has been a regular feature from almost the earliest *Preview* issues. *Preview* was first used as the Conference Handbook when it was published as the Conference Edition for the 10th ASEG Conference in Perth in February 1994 (Issue 48 – Figure 4).

Over the years, a wide variety of topics have been explored. Special issues on topics such as borehole geophysics, airborne electromagnetics, radiometrics, and seismic have been produced. The magazine has looked at wider issues associated with our industry such as safety, professional accreditation, shortage of geoscience graduates (a recurring theme!), and women in geophysics. Numerous technical papers have been published to showcase new technology, interesting case studies, and the excellent databases of geophysical and geospatial data that cover our continent. The article describing BHP's development of the world's first airborne gravity gradiometry published in *Preview* Issue 86 was a scoop for the magazine, in what is now becoming a standard exploration tool. Applications of geophysics to minerals, petroleum, groundwater and environment, engineering, bathymetry, geohazards, archaeology, astronomy and others have been reported. The work of individuals, companies, research organisations, government bodies, educators and professional associations has also been represented.

Fig. 4. *Cover of* Preview *Issue 48, February 1994 – the first Conference Edition of Preview.*

So, the evolution of *Preview* to a modern, professional magazine has clearly involved the dedication and hard work of many people. The Editors have been supported by a host of excellent Associate Editors and many regular contributors. The chairmen of the Publications Committee, Andrew Mutton (1998 to 2004) and Phil Schmidt (2005 to present), have both provided excellent leadership and support liaising between Editors, Federal Executive and the publishers. This publication is one of which our Society should be justly proud. Long may it continue!

Ann-Marie Anderson-Mayes
Editor

ASEG publications doing well

Access to *Preview* and *Exploration Geophysics* is one measure of how well the ASEG's publications are being used. And at the moment the news is all good!

First, citations for *Exploration Geophysics* are increasing rapidly as shown in Figure 1. An approximate three-fold increase can be seen for 2008 to 2009 and then again for 2009 to 2010. This is excellent news for *Exploration Geophysics* because journals that begin to attract citations generally attract more readers, more citations, and thus potentially increased subscriptions.

Second, audited numbers of PDF and XML downloads for the two publications are also good. For *Preview*, the 2008 total was 34 000, 2009 was also 34 000 and 2010 was 30 400. These numbers are holding steady indicating sustained interest in the publication. For *Exploration Geophysics*, the 2008 total was 19 800, 2009 was also 54 000 and 2010 was 46 900. The big jump made in 2009 has been reasonably maintained in 2010. Also, online access to the Extended Abstracts has been steadily increasing with download totals of 1400 in 2008, 10 000 in 2009 and 14 700 in 2010. It should be noted that until recently, *Preview* was a single PDF download, whereas for *Exploration Geophysics* each article is a separate download in either PDF or XML format. Thus the two publications cannot be compared to each other directly – it is the trends that are important.

Data from Google Analytics enables us to understand more about the visitors to the *Exploration Geophysics* and *Preview* websites. In 2009 there were 113 008 views of *Exploration Geophysics* web pages and in 2010 this number was 106 700. Figure 2 shows the distribution by region for web visitors accessing the *Exploration Geophysics* website in 2009 and 2010. The top ten countries for both years are Australia, USA, Canada, UK, India, Germany, China, Indonesia, Iran and France. As you would expect for a home-grown journal, Australia is the largest viewer of *Exploration Geophysics* pages (note that visitors coming via the ASEG website redirection are interpreted as Australian), but in 2010 70% of visitors were coming from websites outside Australia. Once again, in terms of the citation data above this is excellent news.

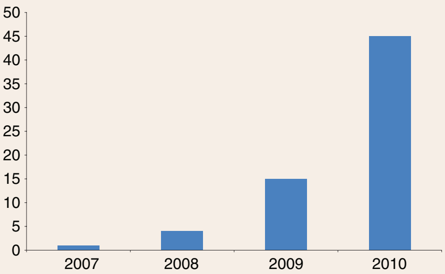


Fig. 1. *Annual citations attributed to Exploration Geophysics in each calendar year from 2007 to 2010.*

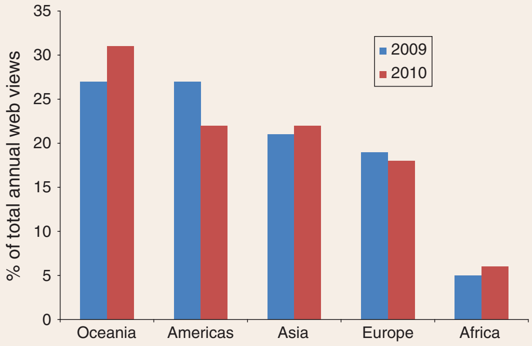


Fig. 2. *Distribution by region for visitors to the Exploration Geophysics website in 2009 and 2010 sourced from Google Analytics data.*

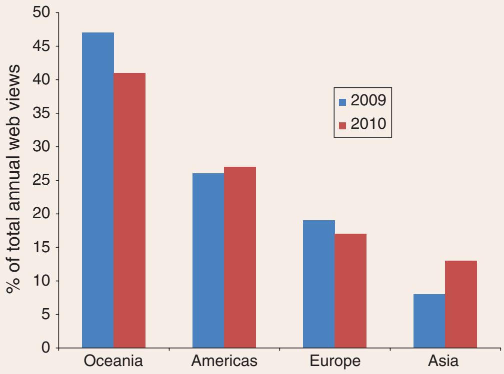


Fig. 3. *Distribution by region for visitors to the Preview website in 2009 and 2010 sourced from Google Analytics data.*

The results are similar for *Preview*. Figure 3 shows the distribution by region for web visitors accessing the *Preview* website in 2009 and 2010. In 2009 *Preview* attracted 6400 views and in 2010 there were 7300 views. The top four countries in both years are Australia, USA, Canada and the UK. The remaining six top ten places over the two years include Norway, New Zealand, Saudi Arabia, Germany, Belgium, India, China, Denmark, Taiwan, France and Argentina. And again, whilst 40% of the *Preview* readership is interpreted as Australian, 60% of the readership is outside of Australia. Given that only 18% of the ASEG membership is outside of Australia, it is fair to deduce that the readership of *Preview* is extending internationally beyond ASEG members only. This would seem to suggest that a large number of readers are taking advantage of the fact that *Preview* is freely available online. If we take the view that one role for *Preview* is to promote the ASEG and Australian geophysics, then this wider readership should be viewed as a positive. Let me know what you think – I would welcome your feedback.

Sincere thanks go to Richard Hecker at CSIRO Publishing for providing all the data for this article.

Ann-Marie Anderson-Mayes
Editor

News

Report from SEG 2010 – Denver, Colorado (16–21 October)

The 80th Annual Meeting of the Society of Exploration Geophysicists (SEG) was held in Denver, Colorado from 16 to 21 October, 2010. I attended this conference on behalf of ASEG President Phil Harman who was away at that time (see President's Piece in *Preview* 149, December 2010). The venue, Colorado Convention Center, is a large building. It was large enough to accommodate 7265 official delegates with nearly 400 exhibitors. In fact the SEG Conference only used less than half of this large conference facility. It is located two blocks from the main shopping mall of Denver, and the hotels are within a couple of blocks from the mall. The mall is only for pedestrians and bicycles except for a free shuttle bus running frequently. It was very convenient to the Convention Center.

There were 78 oral technical sessions; 13 of them running concurrently at any one time, from morning to late afternoon with about two hours for a lunch break. There is no break for morning tea or afternoon tea. As each session includes about eight presentations, over 600 papers were presented in four days. In addition, about 150 poster presentations were exhibited in the large corridor areas. When this many papers are presented, it is hard to decide which sessions to attend.

Unlike our ASEG conferences, SEG does not have an opening ceremony and plenary session for everyone to attend. Perhaps a football stadium would be needed to accommodate all these delegates! Instead, the 'SEG Honour and Award Program and Presidential Session' takes the place of the opening ceremony, where organisers welcome the delegates and past and current presidents present honours. You can find the recipients on the SEG website, but I want to mention one special award given to Mr Jerome Freel for his 75 years of membership (of SEG's 80 years history)! Unfortunately, he could not come to Denver, but a video of his recollection of early geophysics was presented at the ceremony. The 98-year old geophysicist looked well and he is still an active geophysicist. It gave some encouragement to everyone there.

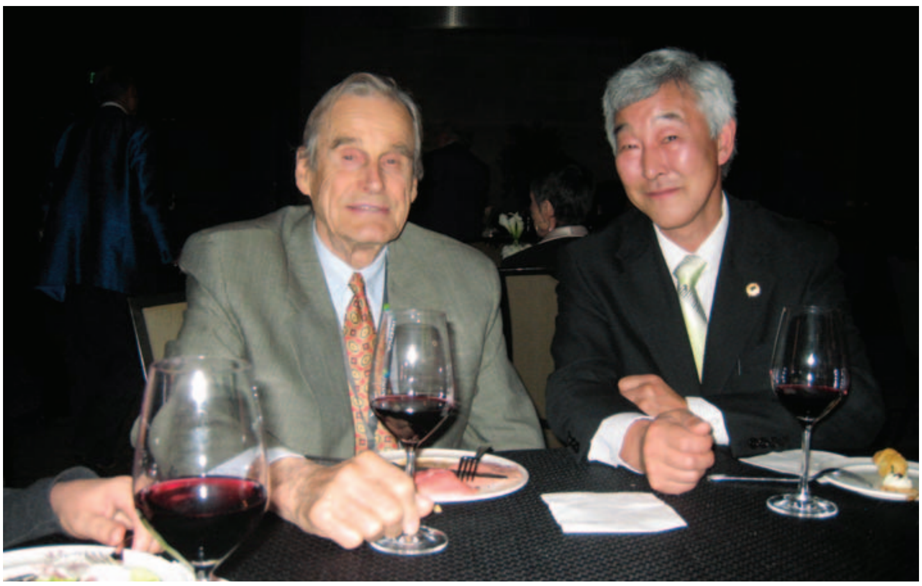
The three exhibition halls were filled with about 400 exhibitors, both large and small, dominated by large seismic and petroleum service providers and contractors. The ASEG booth was in the well away from the 'main street' of the exhibition, but a fair number of visitors came to enquire about our conference and membership. Petrosys and Down Under Geosolutions were among the exhibitors from Australia. I also met quite a few ASEG members from Australia at the booths of the multi-national companies.

An important aspect of the SEG conventions is committee meetings in which many of the SEG activities and planning for the coming year are discussed. Among the meetings, the SEG Council meeting was the most controversial. The Executive Committee had been working on the new constitution and by-laws. It meant to rectify some inconsistencies among the constitution and by-laws in the relationship between the Executive Committee and the Council. The proposed amendment also included a reform of the Council. Currently there are over one hundred Council members, they meet only once a year and many of the attendees are not well prepared. This is hard for the Executive Committee to work with, and they wanted to reduce the number and to meet more frequently. This meant reduction of representation of the large sections like Texas and Oklahoma. By their strong opposition, the proposal was narrowly defeated. Those interested may refer to the President's Page in the December 2010 issue of *The Leading Edge* and SEG website. Other committees I attended were Global Affairs, Youth Education and Near Surface Geophysics committees.

A special meeting between the ASEG and SEG was organised and Dennis Cooke, our President-Elect, and I explained issues particularly important to Australia: we are so far away from the centre of activities and SEG's DISC and Distinguished Lecturer tours are some of the few good opportunities to learn the forefront technology. We asked SEG to send the lecturers to many locations in Australia. We also emphasised Australia's strength in minerals geophysics and asked the SEG to consider minerals DISC; we may export lecturers to other countries where minerals exploration is a key interest like west Africa.

A conference is an opportunity to meet senior members of other societies. We had a meeting with SEGJ and KSEG presidents and their editors to discuss the details of the editorial structure of the new joint *Exploration Geophysics*, which will start in 2012.

No conference is complete without social activities. The most important social event is the 'Presidential Dinner' for the changeover of the SEG President. Invited guests queue up at the podium to greet the outgoing and incoming Presidents and First Ladies and to take a photo together. The new SEG President is Klaas Koster, the ASEG President of 2003. We collected a smorgasbord dinner and looked for a vacant seat.



Koya Suto (R) with Dr Lawrence Morley Snr at the SEG Conference 'Presidential Dinner', Denver, Colorado.

I sat at a table near the middle of the room and greeted the people sitting at the same table, introducing myself. The person next to me was Dr Lawrence Morley, who introduced his 90-year old father, also Dr Lawrence Morley, a still active geophysicist, sitting next to him. As conversation went, I found that Dr Morley Snr was one of the persons who first reported the magnetic stripe in the Atlantic Ocean. I learnt about this stripe in my student days as one of the pieces of evidence for plate tectonics, discovered when searching for submarine by airborne magnetic survey. As it was well established and learnt from the textbook, I thought it an historical fact like Galileo and Newton's, but the living history appeared in front of my eyes! This was a big surprise of the conference.

The Conference Reception, 'An Evening of Discovery', was held at the Denver Art Museum. The whole museum was open in the evening for us. Coincidentally, there was an exhibition of Tutankhamen and ancient Egypt, and the delegates were invited to view this splendid exhibition too. The place was so large that thousands of delegates did not feel crowded.

The conference concluded successfully, and some fruitful discussions were held between ASEG and SEG to strengthen our ties.

Koya Suto

Richard Lane – SEG's 2011 Honorary Lecturer, Pacific South

Richard Lane, well known to many of us as a regular presenter at ASEG conferences, is the SEG's Honorary Lecturer, Pacific South. Richard is a senior geophysicist in the Onshore Energy & Minerals Division at Geoscience Australia. His lecture is titled 'Building on 3D Geological Knowledge through Gravity and Magnetic Modeling Workflows at Regional to Local Scales'. Richard's itinerary is shown in the table below. For more information, visit www.seg.org and follow the links under the 'Education' tab.

Date	Location	Host
Thursday, 24 February	Melbourne	ASEG Victoria
Thursday, 3 March	Brisbane	ASEG Queensland
Tuesday, 8 March	Adelaide	ASEG South Australia/Uni of Adelaide Student Chapter
Wednesday, 30 March	Sydney	ASEG New South Wales
Wednesday, 30 March	Sydney	University of Sydney
Tuesday, 5 April	Crawley	University of Western Australia SEG Student Chapter
Wednesday, 6 April	Perth	ASEG Western Australia
Wednesday, 20 April	Canberra	ASEG Australian Capital Territory
Tuesday, 10 May	Wellington, NZ	Wellington Geoscientists
Wednesday, 11 May	Dunedin, NZ	University of Otago Geophysics Society
Friday, 20 May	Melbourne	Monash University
Tuesday, 14 June	Kuala Lumpur, Malaysia	SEG Malaysia
Friday, 17 June	Manila, Phillipines	SEAPEX

ASEG 2012 22nd ASEG Conference and Exhibition News Update (03)

After a short break the COC will meet (at time of writing) in late January. We are hoping the weather in 2012 will be a kinder, gentler version of 2011. Koya Suto has been busy gathering candidates for his workshops sub-committee and has approached presenters. Potential keynote speakers have also been approached.

Please visit our website at www.aseg2012.com.au to lodge an expression of interest.

Co-Chairs: Wayne Mogg & Andrea Rutley
Technical: Binzhong Zhou
Sponsorship: Ron Palmer & Howard Bassingthwaighte
Exhibition: Gary Butler & Dave Burt/John Donohue
Finance: Noll Moriarty
Workshops: Koya Suto
Publicity: Henk van Paridon
Students: Shaun Strong
Social: Janelle Kuter

Anyone able to help (urgent request for people to help with papers) should contact Binzhong, Wayne or Andrea.

The conference theme, 'Unearthing New Layers' was chosen to highlight how resources can exist in places that we have already explored and how geophysical data can be re-examined to help see them. The logo is a stylised map of Queensland with a standard colour look-up showing the sea in blue and the earth in red.

Henk van Paridon

$376 M for new ARC research projects – $18 M less than last year

The Minister for Innovation, Industry, Science and Research, Senator Kim Carr, on 25 October 2010, announced total funding of over $376 million for 1128 new research projects to be funded through the Australian Research Council's National Competitive Grants Program. This is a decrease of $18 million or 4.5% compared with the 2009 allocations.

All these projects are funded through the Council's *Discovery Indigenous Researchers Development*, *Discovery Projects* and *Linkage Projects* schemes (see http://www.arc.gov.au/applicants/fundingoutcomes.htm).

For a government that prides itself on supporting research and innovation, the continual reduction in funds, in real terms, for basic research is unacceptable. The tables later in this article tell a very disappointing story.

Of the three schemes, *Discovery Projects* captured the bulk of the money with $318.2 million committed to 931 projects; followed by $56.2 million for 186 *Linkage Projects* and $2.0 million for 11 *Discovery Indigenous Researchers Development*.

Discovery Projects still hard to get with 22% success rate

Discovery Projects are the main vehicles for funding basic research in tertiary institutions. Table 1 summarises the funds provided since 2005. There are several worrying trends.

First, in real terms (CPI adjusted) the total funding provided for Discovery Projects has declined by 7% since 2005. Although the total funds have increased by 8% since 2005, the CPI index has increased by about 15% in the same period. Second, the success rate of 22% remains low and it has declined since 2005 when it was nearly 31%. It is hard to imagine that something like 80% of the proposals were not worth funding. Finally, the average size of each grant has only increased by approximately 2% in dollar terms since 2007 (~$334 k up to ~$342 k), whereas the CPI will increase by at least 10% in the same period. So the average 'real value' has declined.

One can only conclude that the government's funding for basic research through the ARC is slowly declining, irrespective of which government is in power.

Thirty-five tertiary institutions were successful in obtaining grants. Ten universities received funding of more than $10 million for Discovery Projects starting in 2011; compared to eight for projects starting in 2010. The top ten universities are shown in Table 2, together with last year's results. Apart from The University of Newcastle replacing the University of Wollongong the same universities occupy the top ten places in the league. However, the order in the table has changed significantly. Melbourne still takes the number one spot, but Sydney has slipped from being second to fifth and Monash has jumped from sixth to second.

As expected the Group of Eight Universities occupy the top positions in the table with Adelaide hanging on to eighth place.

Table 1. Discovery Project funding 2006–2011*

	2005	2006	2007	2008	2009	2010	2011
Applications considered	3413	3742	4033	4112	4152	4068	4230
Applications funded	1053	917	822	878	845	925	931
Success rate (%)	30.9	24.5	20.4	21.4	20.4	22.7	22.0
Average total grant size	$280 627	$298 350	$334 267	$342 593	$341 344	$351 973	$341 743
Total funds requested ($M)	$443.7	$496.1	$502.1	$532.0	$2106.3	$2097.8	$2203.6
Total funds approved ($M)	$295.5	$273.6	$274.8	$300.8	$288.4	$325.6	$318.2
Average first year funding	$94 340	$103 768	$105 019	$106 469	$116 055	$109 179	$108 467

**None of the dollar numbers have been adjusted for inflation.*

Table 2. Top Ten Universities for Discovery Projects starting in 2011

Administering organisation	Proposals approved	Total ARC funding	2010 comparison
The University of Melbourne	107	$37 566 056	$38 821 177
Monash University	93	$35 273 201	$29 015 749
The Australian National University	92	$33 794 578	$35 697 944
The University of Queensland	94	$33 319 278	$36 685 217
The University of Sydney	102	$33 003 498	$38 164 052
The University of New South Wales	85	$25 647 887	$36 381 799
The University of Western Australia	37	$12 891 105	$16 144 610
The University of Adelaide	36	$12 435 897	$10 587 493
The University of Newcastle	31	$11 497 063	$8 201 000
Macquarie University	35	$11 345 589	$9 177 180

Linkage Grants deliver better success rates but funding reduced

The Linkage Projects scheme funds collaborative projects between university researchers and Partner Organisations. These projects encourage and develop long-term strategic research alliances between higher education organisations and other organisations, including within industry, in order to apply advanced knowledge to problems and/or to provide opportunities to obtain national economic, social or cultural benefits.

Of the 398 Linkage Projects proposals considered for 2011 Round 1, 186 were approved with a total approved funding, over the life of these projects, of $56.2 million. There are 407 Partner Organisations involved with these

Table 3. Comparison of funding allocations over the project life for approved Linkage Projects from Round One 2006 to Round One 2011

Funding round	Applications considered	Number approved	Success rate (%)	Requested funds over project life (approved proposals) ($)	Funds granted over project life ($)
Rd 1 2006	529	194	36.7	70 511 313	58 524 390
Rd 2 2006	577	206	35.7	68 502 938	53 980 315
Rd 1 2007	485	208	42.9	80 426 175	59 434 944
Rd 2 2007	472	217	46.0	79 990 761	60 313 034
Rd 1 2008	424	202	47.6	78 546 893	62 267 846
Rd 2 2008	487	208	42.7	93 414 877	63 717 139
Rd 1 2009	441	218	49.4	106 032 303	71 704 687
Rd 2 2009	522	239	45.8	105 186 071	71 856 782
Rd 1 2010	470	211	44.9	94 619 567	66 827 891
Rd 2 2010	512	218	42.6	98 419 105	66 753 570
Rd 1 2011	398	186	46.7	82 443 432	56 235 992

projects and they have pledged a total (cash and in-kind) of $117.2 million. This represents $2.08 from Partner Organisations for every dollar funded by the Australian Government. A very good investment of taxpayers' money.

Geophysics fared better with Linkage Projects. Although, out of the 186 projects approved only six were placed under the Earth Science heading, four of these have strong links to geophysics. Congratulations to ASEG members Nicholas Direen, Nicholas Rawlinson and Malcolm Sambridge for their efforts in obtaining substantial research funding. Summaries of these projects are listed later in this article.

Table 3 summarises the results for the period 2006–2011. The current success rate of 46.7% for Linkage Projects is approximately twice the success rate for Discovery Projects – so Linkage Projects are the ones to go for. However, they are usually harder to develop because there has to be negotiations and legal agreements with several partners in the team – and these can be time consuming.

Table 3 also shows how the average dollars per project grant has remained approximately the same over the last six years. This means that, as with the Discovery Projects, their real value has declined because of inflation. Furthermore the 12 Australian Postdoctoral Fellowships (Industry) are also funded from Linkage Project funds.

Thirty-six tertiary institutions applied for Linkage Grants and 31 were successful. The Top Ten Universities for Linkage Project funding are shown in Table 4. The Group of Eight Universities fill the first six places with The University of New South Wales at the top of the list. The University of South Australia did very well, obtaining more funding than either the Universities of Sydney or Adelaide. It is worthwhile noting that if the ARC funding is added to the partner funding, then The University of Melbourne takes first place with $27.1 million, just edging out The University of New South Wales on $26.1 million.

Earth science-related Discovery Projects

The exploration-related Earth Science Discovery Projects are listed below. Out of the 931 projects approved only 41 were listed under the Earth Science umbrella and of these only nine could be classified as exploration-related. These are listed below.

The effective strength of oceanic plate bounding faults

Researchers: Craig J O'Neill and Juan C Afonso

Funding: 2011, $65 000; 2012, $65 000; 2013, $65 000.

Administering Organisation: Macquarie University

Project Summary: This project will address the anomalously weak behaviour of the seismically active faults on the boundary of the Australian plate, in three key geodynamic areas. This will constrain the mechanisms which weaken such faults, and produce a model for their effective strength and evolution over geological timescales their effective strength and evolution over geological timescales.

Table 4. Top Ten Universities Linkage Projects 2011 Round One – Funding outcomes

Administering organisation	Proposals considered	Proposals approved	Success rate (%)	ARC funding over project life (approved proposals) ($)	Partners' contributions (cash & in-kind) over project life ($)
The University of New South Wales	50	30	60.0	8 343 201	17 805 772
The University of Western Australia	17	13	76.5	5 969 571	10 424 997
The University of Melbourne	31	14	45.2	5 272 125	21 834 850
The Australian National University	18	12	66.7	4 611 926	9 594 889
Monash University	18	12	66.7	4 330 273	8 024 433
The University of Queensland	29	16	55.2	3 583 424	6 329 303
University of South Australia	17	7	41.2	2 318 222	3 945 160
The University of Sydney	23	9	39.1	2 292 474	4 986 490
The University of Adelaide	12	7	58.3	2 136 406	3 783 464
The University of Newcastle	13	5	38.5	1 998 949	2 939 417

News

Three dimensional geospatial model of the Australian continent from geologically constrained inverse modelling of the Earth's gravity and magnetic fields

Researchers: Peter G Betts, Laurent Ailleres, Mark W Jessell and Eric A de Kemp

Funding: 2011, \$100 000; 2012, \$70 000; 2113, \$90 000.

Administering Organisation: Monash University

Project Summary: This project enhances Australia's reputation in integration of geology and geophysics and will create a three dimensional model of the Australian crust that will image and define the geometry of the fundamental building blocks of the continent. The outcomes will create new concepts for resource exploration and hazard recognition.

The link between the deep Earth and its dynamic surface

Researchers: Fabio A Capitanio, Louis N Moresi and Philip Allen

Funding: 2011, \$80 000; 2012, \$60 000; 2013, \$60 000.

Administering Organisation: Monash University

Project Summary: Modelling the two-way interaction of plate tectonics with the actions of erosion and sedimentation gives a fundamentally new view of the dynamics of our planet and the importance of the surface on the deep interior. It will improve our understanding of the formation of sedimentary basins, their evolution and their preservation over geological time.

Three-dimensional subduction models of overriding plate deformation and mantle flow using laboratory and numerical methods

Researchers: Wouter P Schellart, Alexander R Cruden and David R Stegman

Funding: 2011, \$100 000; 2012, \$90 000; 2013, \$80 000.

Administering Organisation: Monash University

Project Summary: This project investigates the interaction of the Earth's tectonic plates at subduction zones, places where one plate sinks below another plate into the Earth. This is important for understanding the evolution of the Australian plate that has active subduction zones to the north and east, and how its geological evolution is controlled by subduction.

New observational constraints on 2004–2007 rupture of the Sumatra megathrust

Researcher: Phil R Cummins

Funding: 2011, \$110 000; 2012, \$110 000; 2013: \$100 000.

Administering Organisation: The Australian National University

Project Summary: This project will develop innovative methods and generate new data for studying the rupture of giant subduction zone earthquakes and the generation of destructive tsunamis. This will lead to a better understanding of these phenomena that will enhance our ability to forecast, warn and map the hazards associated with them.

Frequency-dependent seismic properties of cracked and fluid-saturated crustal rocks: a systematic laboratory study

Researchers: Ian Jackson and Douglas R Schmitt

Funding: 2011, \$50 000; 2012, \$50 000; 2013, \$40 000.

Administering Organisation: The Australian National University

Project Summary: Novel experimental techniques will be used to build a better laboratory-based understanding of the seismic properties of fluid-saturated crustal rocks. The outcome will be an improved capacity to monitor the presence of fluids in diverse situations ranging from geothermal power generation and waste disposal to earthquake fault zones.

Taming the nonlinearity of geophysical inversions

Researchers: Malcolm Sambridge and Brian L Kennett

Funding: 2011, \$115 000; 2012, \$120 000; 2013, \$130 000; 2014, \$33 000.

Administering Organisation: The Australian National University

Project Summary: This project will develop new ways to extract information from complex geophysical data sets used to construct images of the Earth's interior. Applications will be important to indirect imaging problems in the physical and engineering sciences and particularly to the discovery of resources within the Earth upon which Australian society is dependent.

Southern Ocean storms and noise sources from Australian seismic array recordings

Researchers: Anya M Reading and Keith D Khoper

Funding: 2011, \$70 000; 2012, \$70 000.

Administering Organisation: University of Tasmania

Project Summary: Storm severity in the Southern Ocean – is it increasing? This project will investigate storminess using decades of seismic records from Australian stations, adding unique data for remote ocean areas with no direct weather observations, with profound implications for the global climate system.

Precision inertial sensing with cold atoms

Researchers: John D Close, Nicholas P Robins, Wolfgang Ether and Ernst M Resell

Funding: 2011, \$120 000; 2012, \$110 000; 2013, \$110 000.

Administering Organisation: Macquarie University

Project Summary: Many advances in our technology-driven society rely on precision measurement. The project will provide the Australian industrial and government sectors with new and better inertial sensors to measure acceleration, rotation and gravity. The technology will find application in navigation, defence, mineral exploration, earth science and fundamental physics.

Earth science-related Linkage Projects

The exploration-related Earth Science Linkage Projects are listed below. Out of the 186 projects approved only six were placed under the Earth Science heading but four of these have strong links to geophysics. These are listed below.

Chemical optimisation of geothermal heat extraction

Researchers: Katy A Evans and Hue Tong Chua

Collaborating Organisations: Geothermal Power Pty Ltd and Greenock Energy

Administering Organisation: Curtin University of Technology

Funding: 2011, $50 000; 2012, $50 000; 2013, $40 000.

Project summary: Geothermal energy can contribute to our energy needs, but we must understand chemical interactions between geothermal fluids, the host aquifers and the engineered environment to use the energy safely and efficiently. This project will assess those interactions, provide guidelines for geothermal energy use and train future geothermal scientists.

Four dimensional lithosphere evolution and controls on mineral system distribution in Neoarchean to Paleoproterozoic terranes

Researchers: Thompson C McCuaig, Mark E Barley, Marco Fiorentini, Anthony I Kemp, John M Miller, Elena Belousova, Mark W Jessell, Kim A Hein, Graham C Begg, Janet Tunjic, Thomas Angerer, Nuru Said and Leon Bagas

Collaborating Organisations: AMIRA International Ltd, AngloGold Ashanti, Gold Fields and the Northern Territory Geological Survey

Administering Organisation: The University of Western Australia

Funding: 2011, $540 000; 2012, $520 000; 2013, $560 000.

Project Summary: This project will resolve important questions about the links between the evolution and preservation of continents and important mineral deposits in Australia and West Africa between 2.7 and 1.8 billion years ago. The results will improve the understanding of a key period of Earth history and make a major contribution to mineral exploration.

Earthquake hazard in Indonesia

Researchers: Phil R Cummins, Paul Tregoning, Malcolm Sambridge, Sri Widiyantoro and Fauzi

Collaborating Organisation: Australian Agency for International Development

Administering Organisation: The Australian National University

Funding: 2011, $300 000; 2012, $250 000; 2013, $250 000.

Project Summary: This project will deliver breakthrough science that will strengthen Indonesia's ability to reduce its vulnerability to earthquake disasters. This will be achieved through a collaboration of Australian and Indonesian scientists who will fundamentally improve understanding of the destructive potential of Indonesian earthquakes.

Beneath Bass Strait: linking Tasmania and mainland Australia using a novel seismic experiment

Researchers: Nicholas Rawlinson, Anya M Reading and Nicholas G Direen

Collaborating Organisations: FrOG Tech, GeoScience Victoria and Mineral Resources Tasmania

Administering Organisation: The Australian National University

Funding: 2011, $70 000; 2012, $90 000; 2013, $54 000.

Project Summary: A new low-cost approach based on background seismic energy and earthquake recordings will be used to construct three-dimensional maps of the deep structure beneath Bass Strait. Understanding the broad scale geology of southeast Australia is of national importance because the area is host to an abundance of petroleum, geothermal and mineral resources.

David Denham

News

Update on Geophysical Survey Progress from the Geological Surveys of New South Wales, Tasmania, Western Australia, and Geoscience Australia (information current at 17 January 2011)

Tables 1–3 show the continuing acquisition by the States, the Northern Territory and Geoscience Australia of new gravity, airborne magnetic and radiometrics, and airborne EM over the Australia continent. All surveys are being managed by Geoscience Australia.

There are thirteen new airborne magnetic and radiometric surveys reported in this issue. Twelve of these new surveys are funded under the WA Exploration Incentive Scheme – Phase 3. Figures 1–12 show detailed survey boundaries. In total, more than 1.5 million line kilometres of data will be collected over an area of approximately 342 000 km^2 with line spacings of 200 m, 400 m, or 800 m. Figure 13 shows a new survey off the east coast of Tasmania which will cover an area of 19 570 km^2 with 800 m line spacing data.

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
South Officer 1 (Jubilee)	GSWA	Thomson	1 June 10	180 000	200 m 50 m N–S	32 380	28.1% complete @ 16 Jan 11	TBA	148 – Oct 10 p23	TBA
South Officer 2 (Waigen – Mason)	GSWA	Thomson	28 June 10	113 000	400 m 60 m N–S	39 890	100% complete @ 5 Jan 11	TBA	148 – Oct 10 p24	TBA
East Canning 3 (Stansmore)	GSWA	Thomson	14 July 10	114 000	200 m (east) 400 m (west) 50 m N–S	25 934	100% complete @ 2 Nov 10	TBA	148 – Oct 10 p24	TBA
Eucla Basin 2 (Loongana)	GSWA	Fugro	20 June 10	113 000	200 m 50 m N–S	20 320	100% complete @ 3 Dec 10	TBA	148 – Oct 10 p24	TBA
Eucla Basin 4 (Madura)	GSWA	Fugro	1 July 10	102 000	200 m 50 m N–S	18 220	100% complete @ 22 Nov 10	TBA	148 – Oct 10 p24	TBA
Eucla Basin 5N (Forrest)	GSWA	Fugro	16 June 10	75 000	200 m 50 m N–S	13 040	100% complete @ 12 Sep 10	TBA	148 – Oct 10 p25	TBA
Eucla Basin 5S (Eucla)	GSWA	Fugro	6 July 10	87 500	200 m (onshore) 400 m (offshore) 50 m (onshore) 100 m (offshore) N–S	16 100	100% complete @ 5 Nov 10	TBA	148 – Oct 10 p25	TBA
South Canning 1 (Madley – Herbert)	GSWA	UTS	19 July 10	95 000	400 m 60 m N–S	33 520	100% complete @ 12 Nov 10	TBA	148 – Oct 10 p25	TBA
South Canning 2 (Morris – Herbert)	GSWA	UTS	1 July 10	125 000	400 m 60 m N–S	45 850	100% complete @ 11 Jan 11	TBA	148 – Oct 10 p25	TBA
North Canning 4 (Lagrange – Munro)	GSWA	UTS	20 September 10	103 000	400 m 60 m N–S	36 680	68% complete @ 9 Jan 11	TBA	148 – Oct 10 p26	TBA
Southeast Lachlan	GSNSW	Fugro	1 March 10	107 533	250 m (NSW) 500 m (ACT) E–W	24 660	100% on 9 Sep 10	TBA	144 – Feb 10 p15	TBA
West Kimberley	GSWA	TBA	TBA	134 000	800 m 60 m N–S Charnley: 200 m 50 m N–S	42 000	TBA	TBA	This issue (Figure 1)	TBA

Table 1. *Continued*

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (Preview)	GADDS release
Perth Basin North (Perth Basin 1)	GSWA	TBA	TBA	96 000	400 m 60 m E–W	30 000	TBA	TBA	This issue (Figure 2)	TBA
Perth Basin South (Perth Basin 2)	GSWA	TBA	TBA	88 000	400 m 60 m E–W	27 500	TBA	TBA	This issue (Figure 3)	TBA
Murgoo (Murchison 1)	GSWA	TBA	TBA	128 000	200 m 50 m E–W	21 250	TBA	TBA	This issue (Figure 4)	TBA
Perenjori (Murchison 2)	GSWA	TBA	TBA	120 000	200 m 50 m E–W	20 000	TBA	TBA	This issue (Figure 5)	TBA
South Pilbara	GSWA	TBA	TBA	136 000	400 m 60 m N–S	42 500	TBA	TBA	This issue (Figure 6)	TBA
Carnarvon Basin North (Carnarvon Basin 1)	GSWA	TBA	TBA	104 000	400 m 60 m E–W	32 500	TBA	TBA	This issue (Figure 7)	TBA
Carnarvon Basin South (Carnarvon Basin 2)	GSWA	TBA	TBA	128 000	400 m 60 m E–W	40 000	TBA	TBA	This issue (Figure 8)	TBA
Moora (South West 1)	GSWA	TBA	TBA	128 000	200 m 50 m E–W	21 250	TBA	TBA	This issue (Figure 9)	TBA
Corrigin (South West 2)	GSWA	TBA	TBA	120 000	200 m 50 m E–W	20 000	TBA	TBA	This issue (Figure 10)	TBA
Cape Leeuwin – Collie (South West 3)	GSWA	TBA	TBA	105 000	200/400 m 50/60 m E–W	25 000	TBA	TBA	This issue (Figure 11)	TBA
Mt Barker (South West 4)	GSWA	TBA	TBA	120 000	200 m 50 m N–S	20 000	TBA	TBA	This issue (Figure 12)	TBA
Offshore East Coast Tasmania	MRT	TBA	TBA	30 895	800 m 90 m E–W	19 570	TBA	TBA	This issue (Figure 13)	TBA

TBA, To be advised.

Table 2. 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
Albany – Fraser North	GSWA	Atlas	21 Oct 2010	9200	2.5 km regular	50 980	87% on 24 Dec 2010	TBA	146 – Jun 10 p17	TBA
Sandstone	GSWA	IMT	Early Oct 2010	6300	2.5 km regular	35 640	100% on 17 Dec 2010	TBA	146 – Jun 10 p17	TBA
South Gascoyne	GSWA	IMT	9 Aug 2010	9700	2.5 km regular	55 760	100% on 27 Oct 2010	TBA	146 – Jun 10 p17	TBA

TBA, To be advised.

Table 3. Airborne electromagnetic surveys

Survey name	Client	Contractor	Start survey	Line (km)	Spacing AGL Dir	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Frome	GA	Fugro	22 May 10	34 986	5000 and 2500 100 m E–W	95 450	100% on 31 Oct 2010	TBA	146 – Jun 10 p18	TBA

TBA, To be advised.

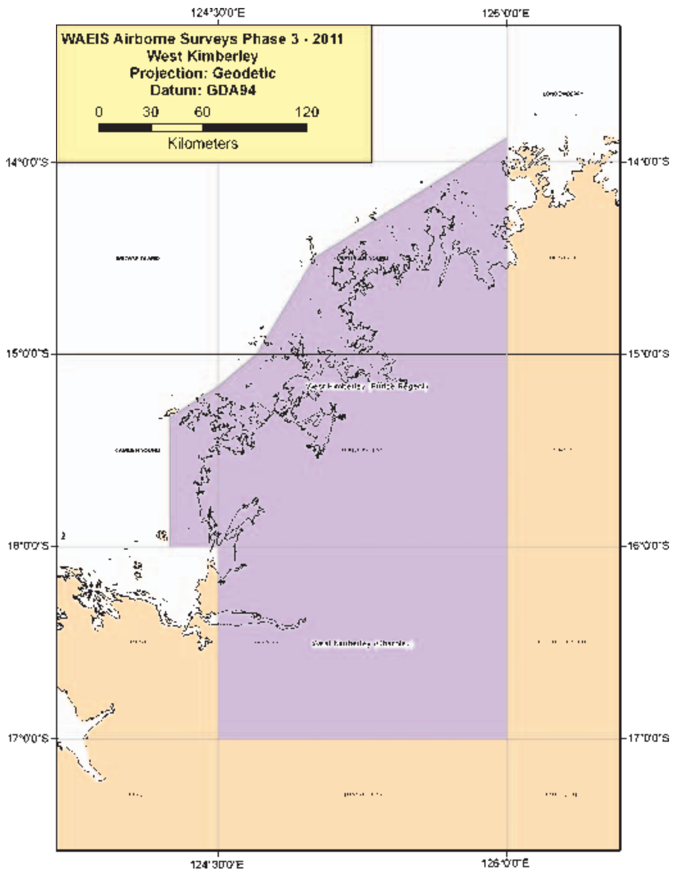


Fig. 1. *Location diagram for the West Kimberley airborne mag/rad survey.*

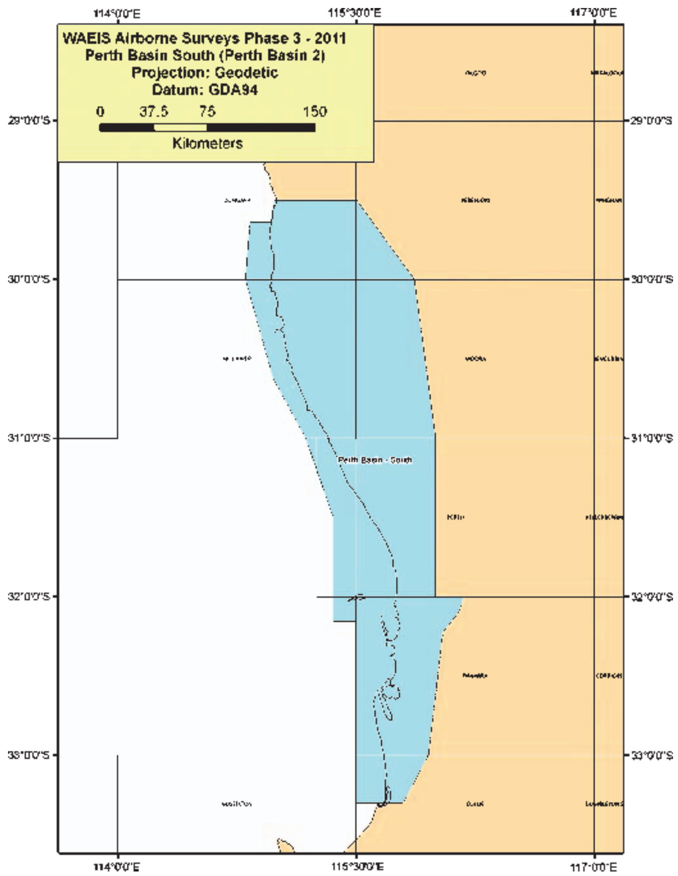


Fig. 3. *Location diagram for the Perth Basin South airborne mag/rad survey.*

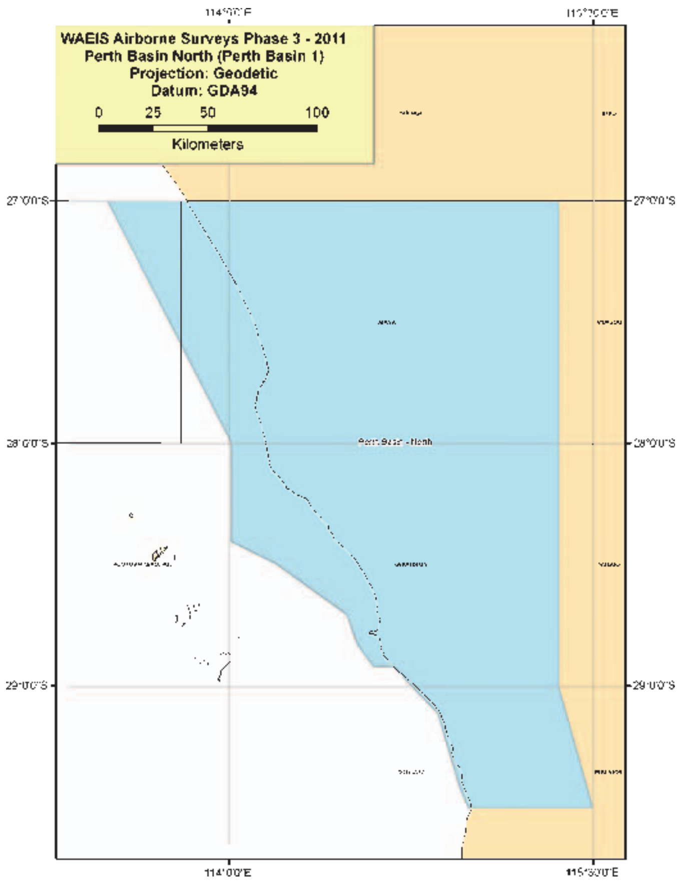


Fig. 2. *Location diagram for the Perth Basin North airborne mag/rad survey.*

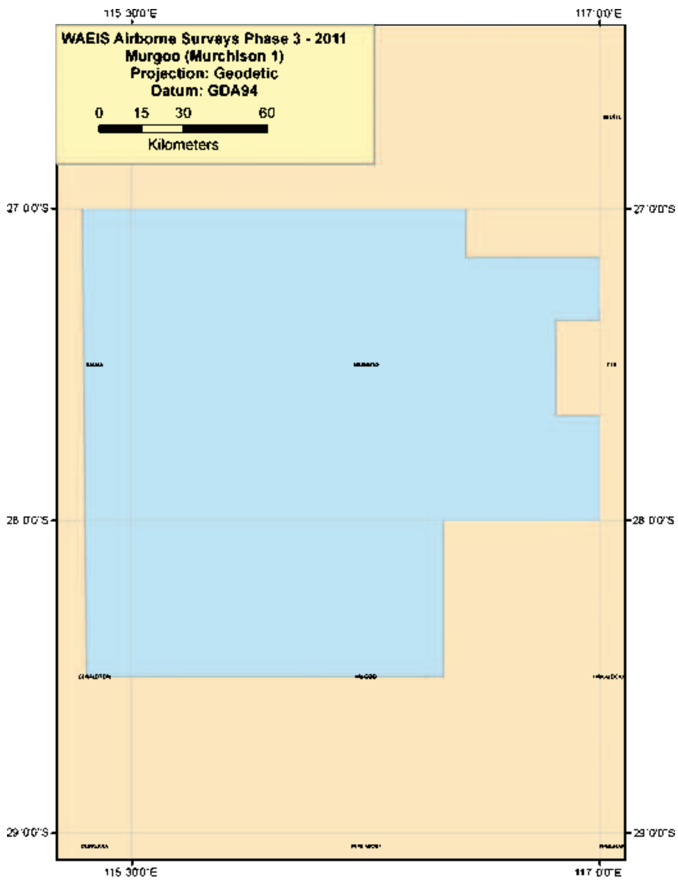


Fig. 4. *Location diagram for the Murgoo airborne mag/rad survey.*

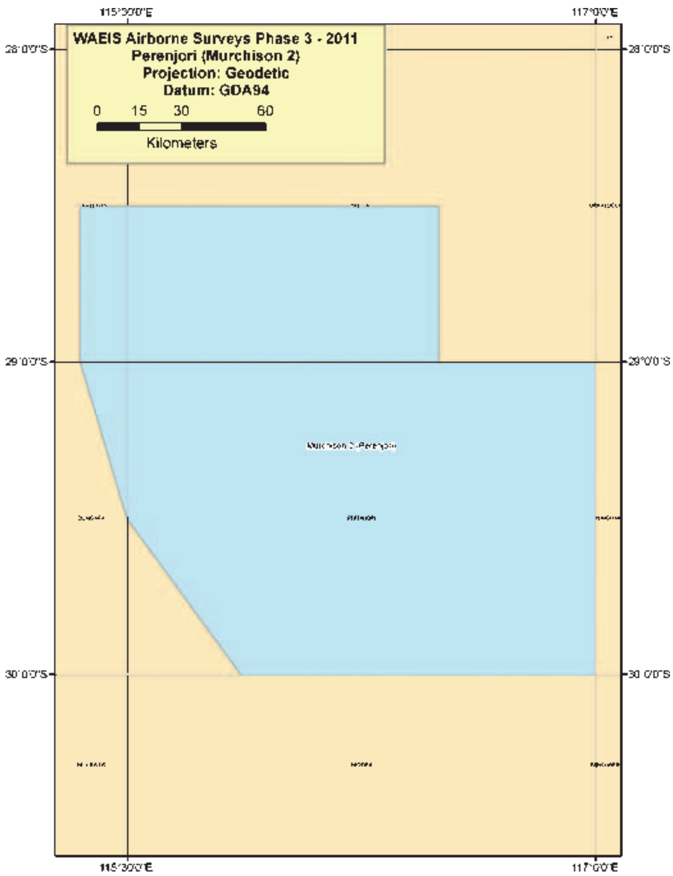


Fig. 5. *Location diagram for the Perenjori airborne mag/rad survey.*

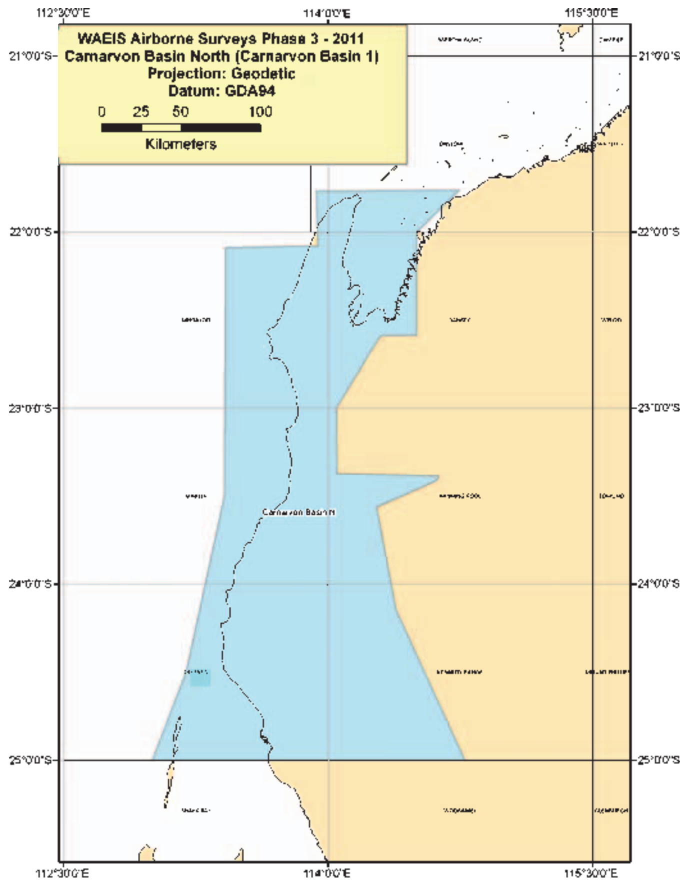


Fig. 7. *Location diagram for the Carnarvon Basin North airborne mag/rad survey.*

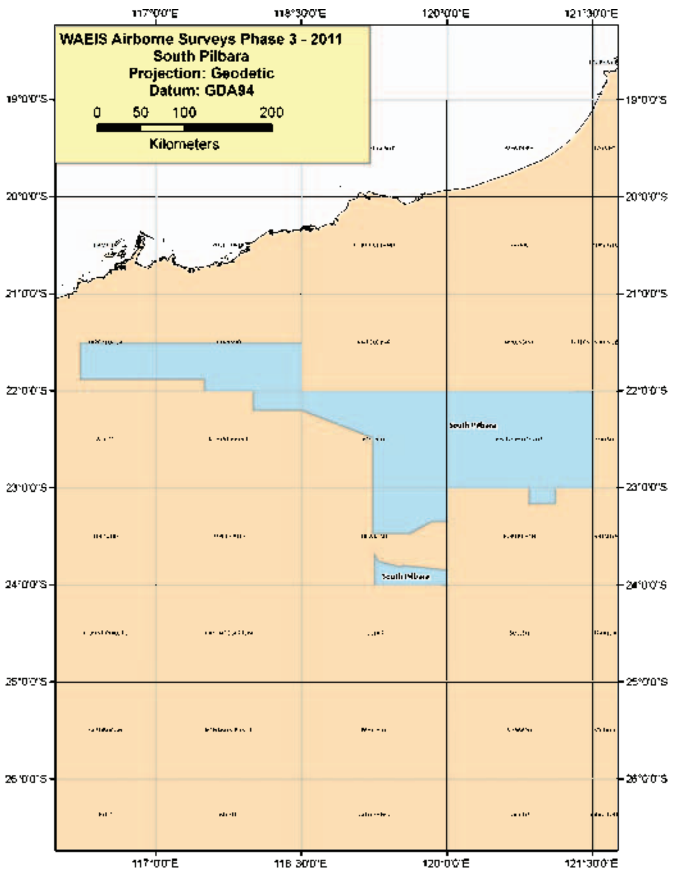


Fig. 6. *Location diagram for the South Pilbara airborne mag/rad survey.*

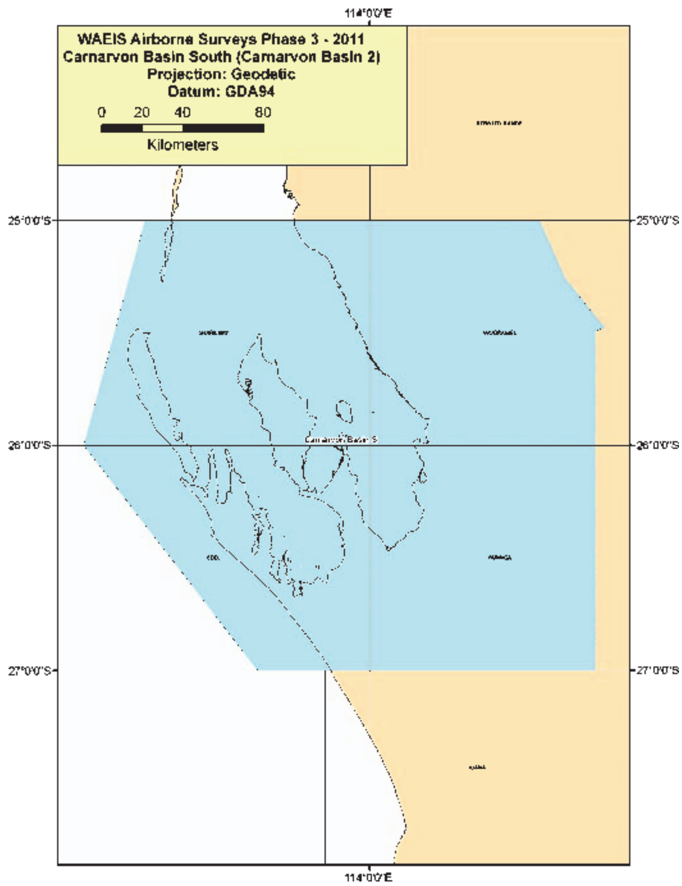


Fig. 8. *Location diagram for the Carnarvon Basin South airborne mag/rad survey.*

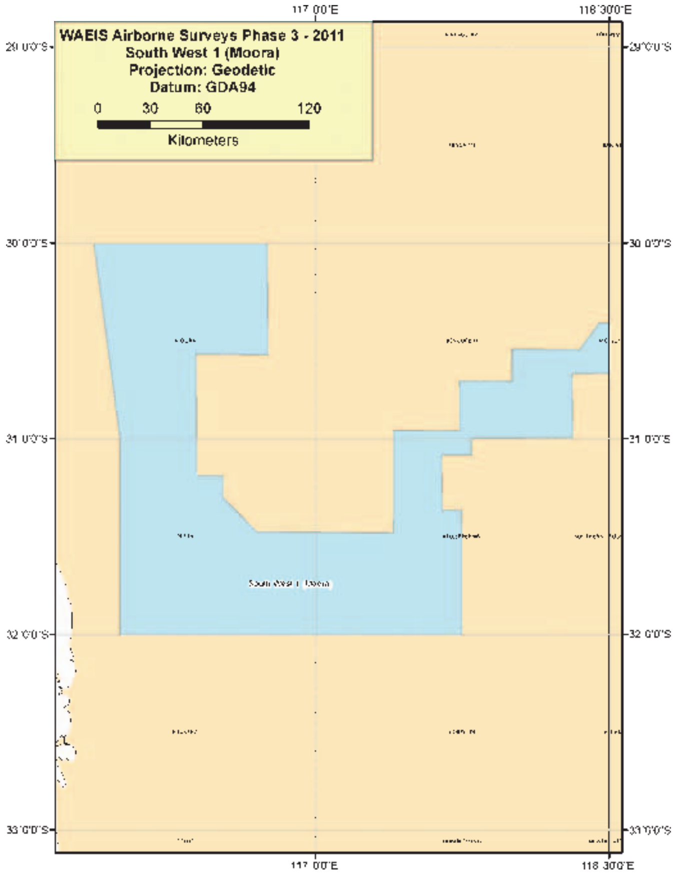


Fig. 9. *Location diagram for the Moora airborne mag/rad survey.*

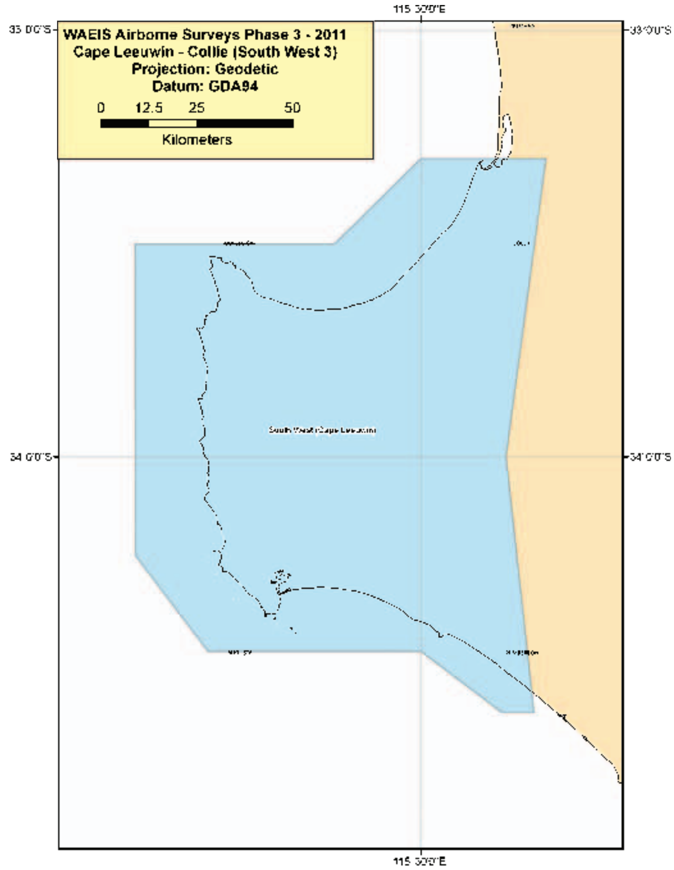


Fig. 11. *Location diagram for the Cape Leeuwin – Collie airborne mag/rad survey.*

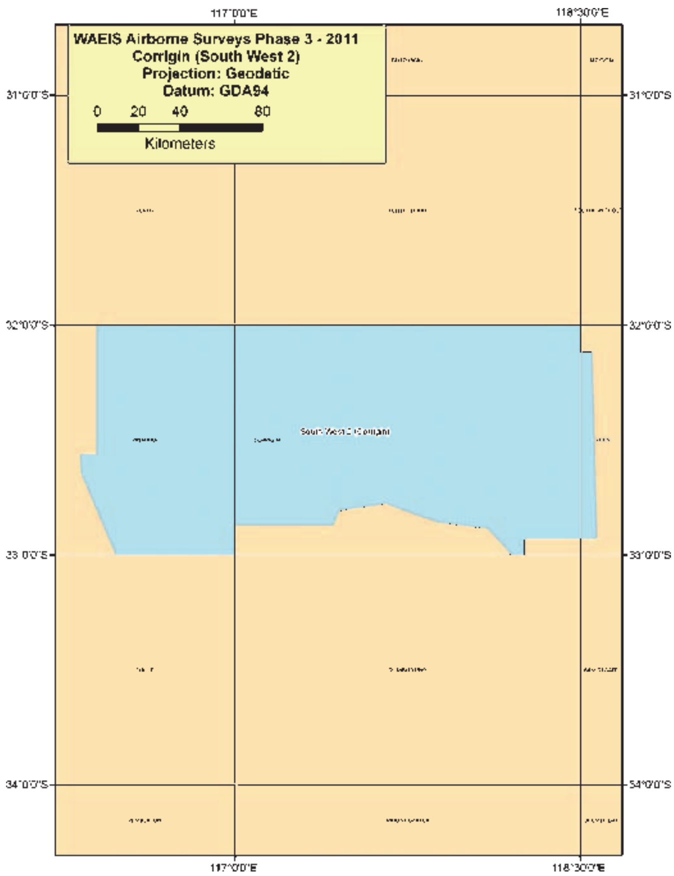


Fig. 10. *Location diagram for the Corrigin airborne mag/rad survey.*

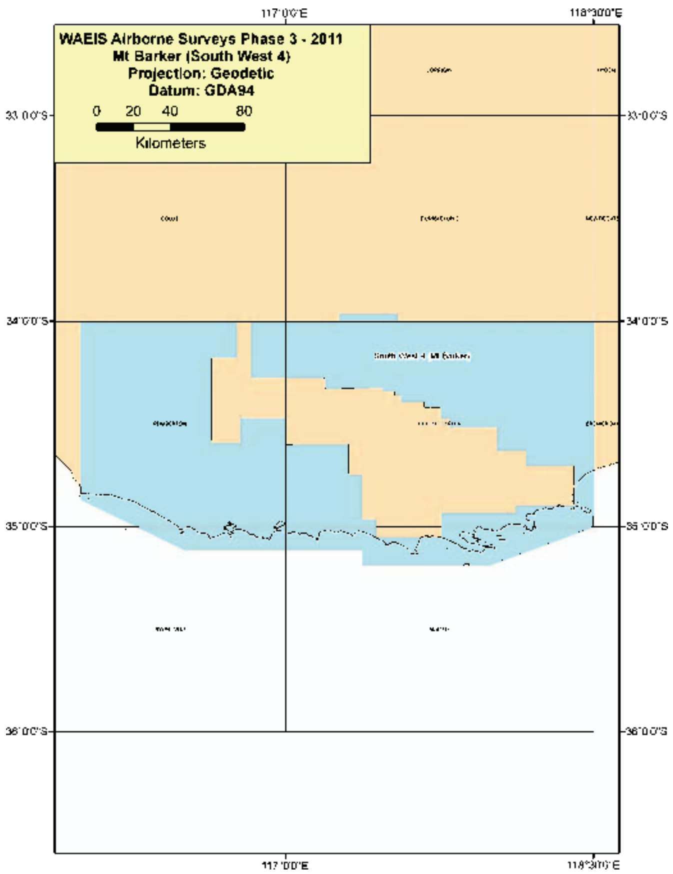


Fig. 12. *Location diagram for the Mt Barker airborne mag/rad survey.*

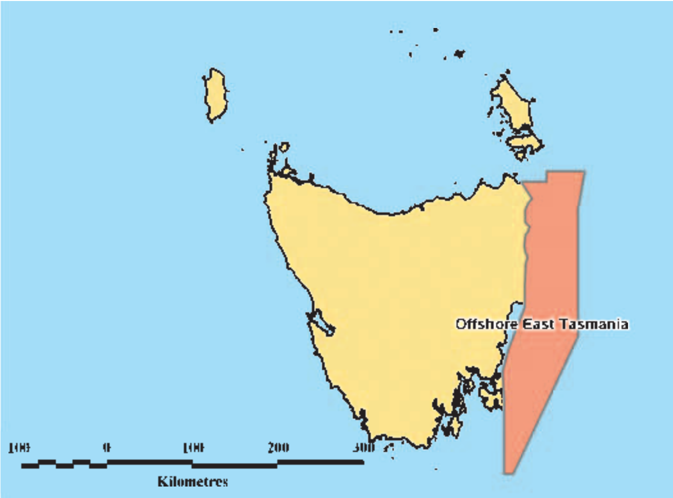


Fig. 13. *Location diagram for the Offshore East Coast Tasmania airborne mag/rad survey.*

Resource industries prospered in 2010

Resource stocks provide solid growth

Resource companies continued to recover in 2010 from the 2008/09 Global Financial Crisis, but there was significant volatility in the first half of the year. However, from May onwards the upward trend stabilised. Figure 1 shows, for the period 2006 through 2010, the total market capital of the resource stocks listed in the ASX's top 150 companies, the All Ords Index and the results for the two largest resource companies BHP and RioTinto.

Notice that the resource companies out-performed the All Ords Index throughout 2010. In fact the All Ords index fell by 0.7% during 2010 whereas the market capital of the resource stocks in the top 150 grew by 10%. By the end of 2010 there were 38 resource companies involved in minerals and energy exploration listed in the top 150 companies on the ASX. This compares with 33 at the start of 2010 and only 17 at the end of 2006.

When there are 38 companies there are bound to be winners and losers. The big winners were the rare earth company, Lynas Corporation Ltd (up 227%, to $3.4 billion), the coal company, Riversdale Mining Ltd (up 189% to $4.0 billion), and another rare earth player, Iluka (up 155% to $3.8 billion). There were not many losers, but the RioTinto owned uranium company, Energy Resources of Australia Ltd, fell by 53% to $2.1 billion, Aquarius Platinum fell by 27% to 2.5 billion, and RioTinto itself fell by 18% to $37.2 billion. Of the other majors, BHP only managed steady growth of 10% to $151.9 billion, while gold producer, Newcrest, grew by 81% to $30.9 billion and Fortescue Iron grew by 48% to $20.4 billion.

More companies, more takeovers

With so many smaller companies entering the resource business it was not surprising that there was an increase in takeover activity, particularly by overseas companies and in the second half of the year. In August 2010, Queensland based LNG company, ***Arrow Energy***, valued then at $3.4 billion was acquired by Shell and PetroChina. The takeover followed an offer in March to purchase all the shares of Arrow on a 50/50 basis. Arrow joined the Top 150 companies in February 2008 and its value rose rapidly with the recent interest in coal seam gas (see *Preview* November 2010).

Australia's top gold miner, Newcrest Mining, finally acquired ***Lihir Gold Ltd*** in September. It paid $9.5 billion for Lihir to create the world's fourth-largest listed gold miner. Lihir Gold Ltd was first listed on the ASX in October 1995 and since 2000 its market capital rose from approximately $700 million to $10.6 billion in September this year (see *Preview* December 2010).

In November, Thailand's Banpu Plc bought ***Centennial Coal*** for $2.45 billion. Centennial operated nine coal mines, mainly in the Hunter Valley, NSW. Ironically Banpu, which launched the bid in July 2010, does not operate any coal mines in Thailand because of environmental restrictions.

Canada's Goldcorp acquired ***Andean Resources*** for $C3.6 billion in December. Andean operated the Cerro Negro epithermal gold deposit in Argentina and at the time of the takeover it had a market capital of $3.7 billion on the ASX. Goldcorp has its headquarters in Vancouver, employs more than 14 000 people and claims to be North America's fastest growing senior gold producer. It operates gold mines in Canada, Mexico, Guatemala, the United States and Argentina.

Finally, in late December 2010, RioTinto bid $3.9 billion for Mozambique-based ***Riversdale Mining Ltd***. Riversdale is listed on the ASX with a market capital of $4.0 billion and operates coal mines in southern Africa. At the time of writing the purchase had not been finalised because the parties are still discussing the price.

Overall, 2010 was a very good year.

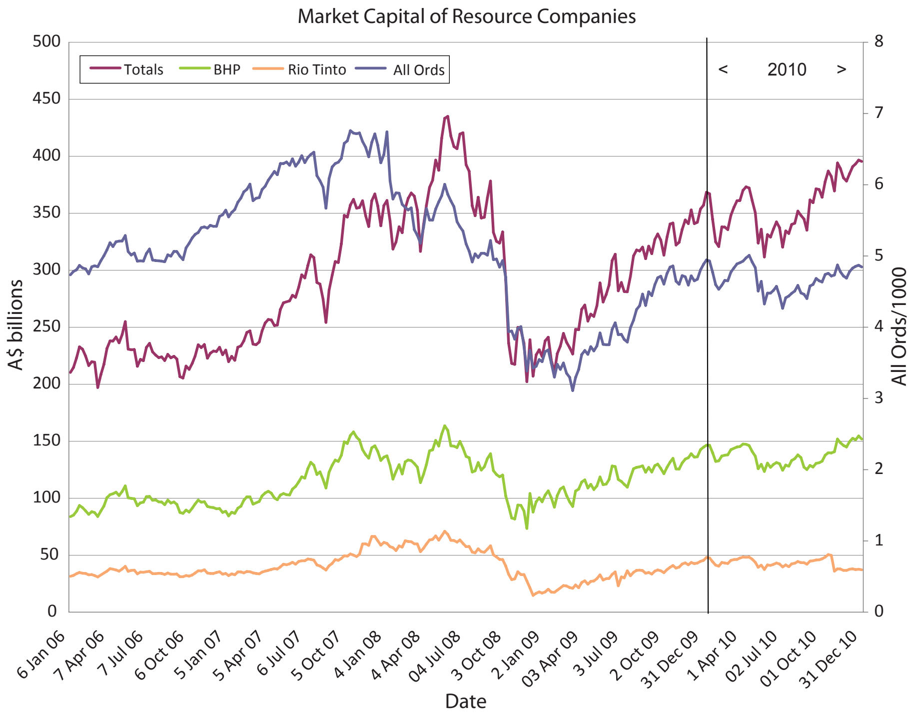


Fig. 1. *Total market capital (in $billions – left hand axis) of resource companies in the top 150 companies listed on the ASX (red), together with plots for the two largest resource companies, BHP and RioTinto. The All Ords index is plotted in blue (right hand axis). Notice that the resource companies out-performed the All Ords throughout 2010. None of the data have been adjusted for CPI increases.*

How real is Real Section IP?

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Introduction

This article was inspired by a news item broadcast on the SEGMIN (SEG Minerals Group) news server in mid 2009, alerting subscribers to a publicity release regarding the Zeus IP system. The system had been a topic of discussion earlier in the forum but a lack of information about it had stymied discussion. The publicity was grandly titled *The Future of Oyu Tolgoi Exploration – Zeus* and included several sections of the kind shown in Figure 1. Geophysicists familiar with CSAMT will have seen a lot of this kind of section and know that they are not an accurate representation of the geology. The thrust of the publicity was that the anomalous zone was real and that the company only had to drill deeper to find more ore. This impression was reinforced by summary figures of the kind shown in Figure 2, suggesting every known deposit was just the tip of a very steep sided iceberg of ore.

About the same time, the promoters of this technique spoke at conferences and in talking about the resolution of Zeus, they made comparisons with not only being able to find a Volkswagen Beetle buried 3 km below the surface but to be able to tell its year of manufacture from the shape of its bumper! While this is obviously colourful exuberance, the effect of the apparently deep looking sections and hyperbole was immediate on many geologists and they wanted to have it – *now!* Geophysicists from all over the world started fielding calls from hopeful clients and staff geologists asking why they weren't using this new technology. The consensus of the SEGMIN forum was that the Zeus sections did not represent geology. Surprisingly, consensus amongst geophysicists is rarely comforting to geologists, who needed simple explanation as to why they should not be spending money or trading equity by doing these surveys. This led to a suite of modelling, with the results presented to SEGMIN as a PDF to enable other geophysicists to field queries from enthusiastic Volkswagen hunting geologists. In order to bring this material to a wider audience it has been edited into this article.

What is Zeus?

It is difficult to get any technical information direct from the promoters. However, the following information has been gleaned from SEGMIN submissions, Ivanhoe presentations at conferences and discussions with Ivanhoe staff. Zeus is an expanding gradient array where the potential electrodes are fixed in a rectangular grid, as with conventional gradient array, but the current electrode expands in a series of steps. In the case of the Zeus system, the current electrodes start at 6.6 km and extend out to an impressive 20 km A–B separation. This is achieved with a containerised 100 kVA transmitter with a maximum voltage tap of 10 kV and a maximum output current of 60 A. The current is delivered into the electrodes using a wire that appears to be around 5 cm diameter. It is an impressive system. Near surface information is acquired with conventional gradient arrays. Expanding gradient arrays are not new. Although they were popular amongst some explorers in the 1970s, their popularity waned through lack of success. More recently the method was 're-discovered' by certain Canadian contractors who

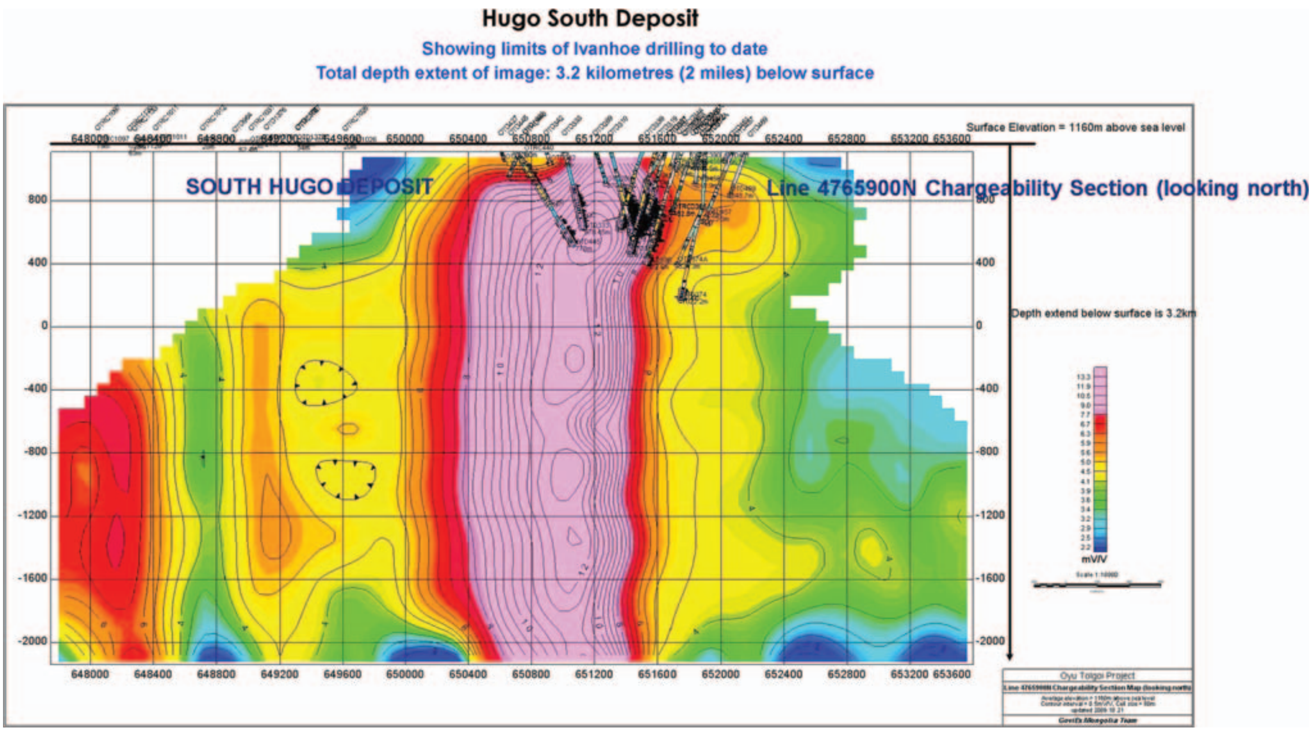

Fig. 1. *Example section from Zeus publicity.*

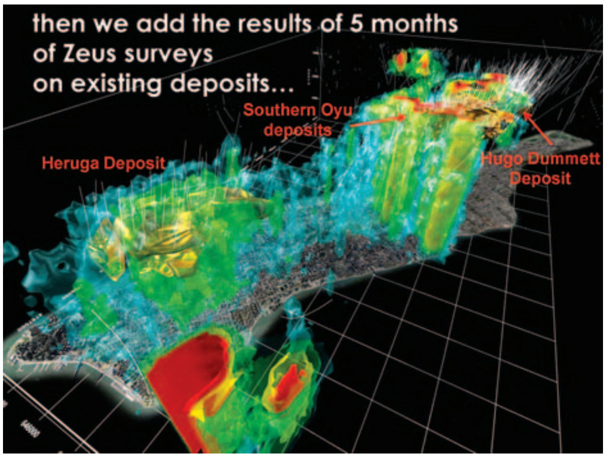

Fig. 2. *Example summary diagram from the Zeus publicity.*

packaged it with a pseudosection plotting method and badged it as Real Section.

What is Real Section?

Real Section is a pseudosection plotting method developed by Perparim Alikay and is described in a paper by Langore et al. (1989). It was originally based on a Schlumberger array but has been generalised more recently to gradient arrays. It assumes the plot depth for the pseudosection is between 0.125 and 0.2 of the current electrode separation A–B. According to the Langore paper, the factor to use in a given area was derived empirically from drill hole control. These values compare well with those given earlier by Edwards (1977) of 0.103 near the edges of the array to 0.192 at the centre. These are the depths at which, for a half space, half the signal comes from above the plot point and half from below. Despite the prevalence of relatively cheap 3D inversion software, the Zeus data is plotted in Real Section form for presentation to geologists rather than as inversions with sensitivity cut offs.

The modelling presented here aims to replicate the presentation format, rather than invert the modelled data. For the shallow targets, at least, inversion is likely to recover a model similar to the upper part of the input data set.

Information collected for the Oyu Tolgoi survey suggests that the gradient array used 100 m potential dipoles (M–N), which were read with a commercial Elrec six channel receiver. From published dipole–dipole inversion sections, the target appears to have a resistance of around 500 Ohm m, with a chargeability of 30 mV/V, in a host of 1000 Ohm m and 10 mV/V. The anomalies on the Real Section plot included in the publicity suggested bodies of about 400 m dimension in plan.

The aims of the modelling were to address four principle questions;

1. What is the effective depth of investigation?
2. How well can it resolve the base of depth limited targets?
3. How sensitive is it to vertical discontinuities in vertical targets?
4. How sensitive is it to changes in dip?

The modelling was undertaken using Geotomo's Res3Dmodx64 (Loke and Barker, 1996). The 64 bit version was required because of the size of the model and the consequent memory requirements. The finite element mesh was regular, with 50 m square cells covering 21 000 m × 2000 m in plan and extending to 6487 m in depth. The mesh had 13 layers, steadily increasing in thickness from 50 m at the surface to 2162 m at the base. A target body 400 m × 400 m in plan was buried at the centre of this mesh and an array of potential electrodes 5000 m × 1800 m with a dipole and line spacing of 100 m was then placed on top of this. Current electrodes were modelled in regular 1200 m steps from 6.6 km out to 21 km separation. All electrodes were contained within the mesh.

The following presentations all follow a common format. They are for a Real Section display along line 1000, over the centre of the body. A depth conversion factor of 0.2 × A–B was used in all cases. All have the same ingredients:

- a colour image of the chargeability, using a non-linear lookup table with each image individually stretched from its minimum to maximum to show fine detail;
- overlain with contours of chargeability, using a 0.5 mV/V contour interval, which is an appropriate interval for the accuracy and resolution of currently available commercial IP receivers and shows what would be recordable as distinct from what is theoretically possible;
- the plot points are shown as crosses and the true location of the body is shown in blue.

All data have been included in the presentation and no attempt has been made to remove readings with primary voltages below the resolution of current receiver systems. No noise has been added i.e. these are best case plots. The upper section of the display is blank because the minimum A–B spacing modelled was 6.6 km, resulting in a minimum pseudo depth of 1320 m. Presumably, published pseudo sections around Oyu Tolgoi use older conventional gradient array data to fill this gap.

Depth of investigation

Figures 3 through to 6 show the results obtained by varying the depth to the top of a vertical prism, which extends to the base of the mesh. It is clear that the target could not be seen at a depth of 2000 m and in the presence of real geological noise it is unlikely it could be seen at 1000 m depth. Although increasing the contrasts between the target and host would improve the depth of investigation, the improvement will not be significant for realistic contrasts.

Ability to resolve the base of depth limited bodies

Figure 7 shows the Real Section plot for a 200 m thick body with a depth to top of 400 m. This is not dissimilar to the previous figure and has a lot in common with the figures in the Zeus publicity. The Real Section presentation does not resolve the base of the target at all.

Sensitivity to vertical discontinuity

Based on the results from the previous test, it should come as no surprise that the presentation is not sensitive to breaks in the body. Figure 8 shows the results for a model with a 600 m break between the upper and lower sections. This is extended to 1400 m in Figure 9, with no significant change in the output results. The presentation does a poor job of imaging breaks in a vertical target.

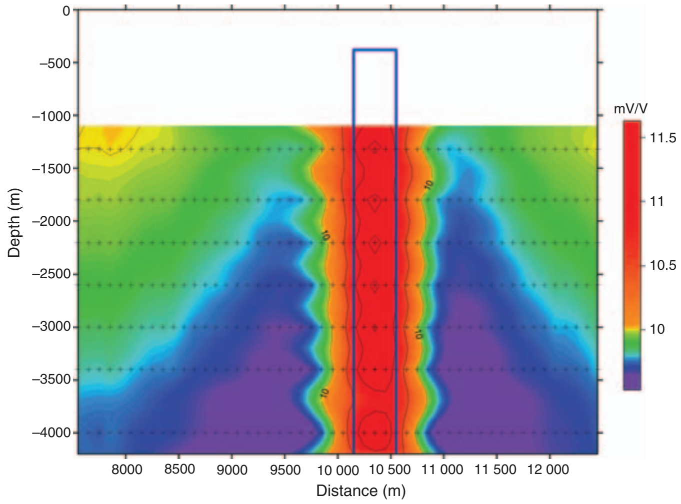

Fig. 3. *Real Section chargeability plot for a vertical prism starting at a depth of 400 m.*

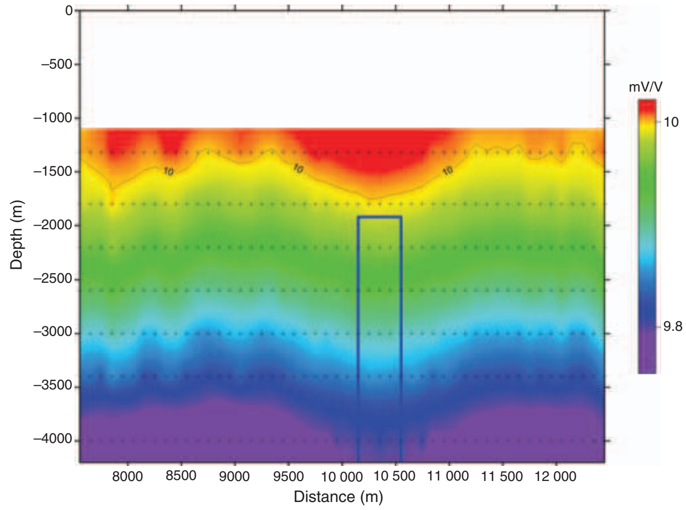

Fig. 6. *Real Section chargeability plot for a vertical prism starting at 2000 m depth.*

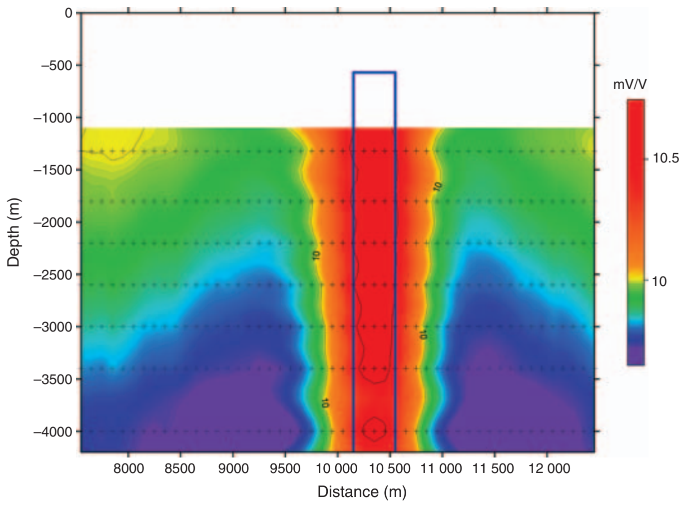

Fig. 4. *Real Section chargeability plot for a vertical prism starting at 600 m depth.*

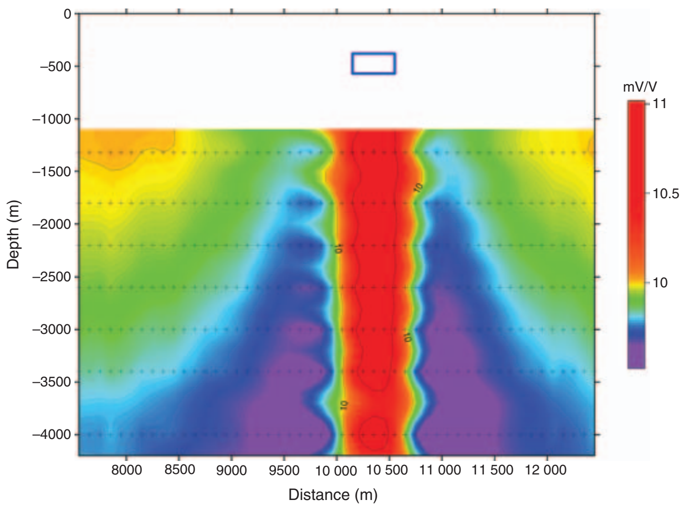

Fig. 7. *Real Section chargeability plot for a 200 m thick body at 400 m depth.*

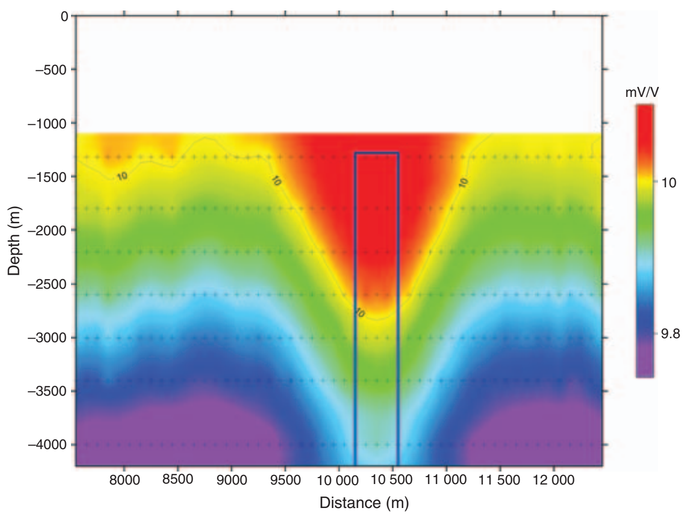

Fig. 5. *Real Section chargeability plot for a vertical prism starting at 1300 m depth.*

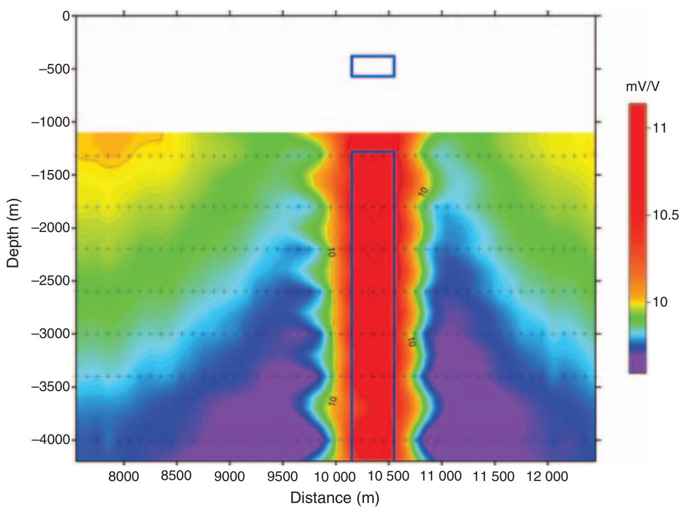

Fig. 8. *Real Section chargeability plot for a body with a 600 m break from 600 m depth.*

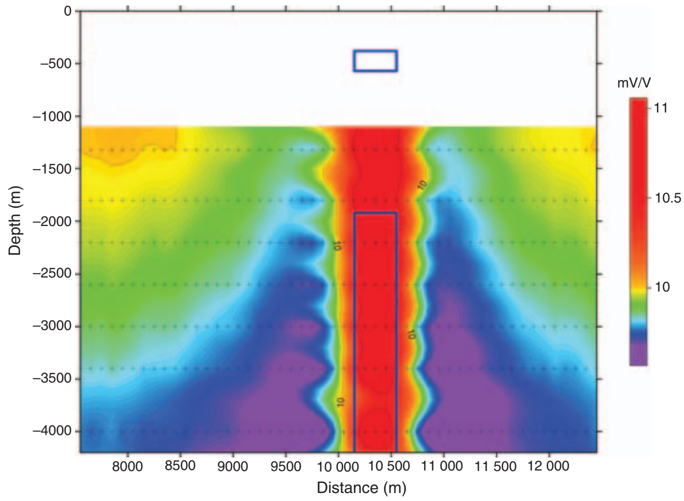

Fig. 9. *Real Section chargeability plot for a body with a 1400 m break starting at 600 m depth.*

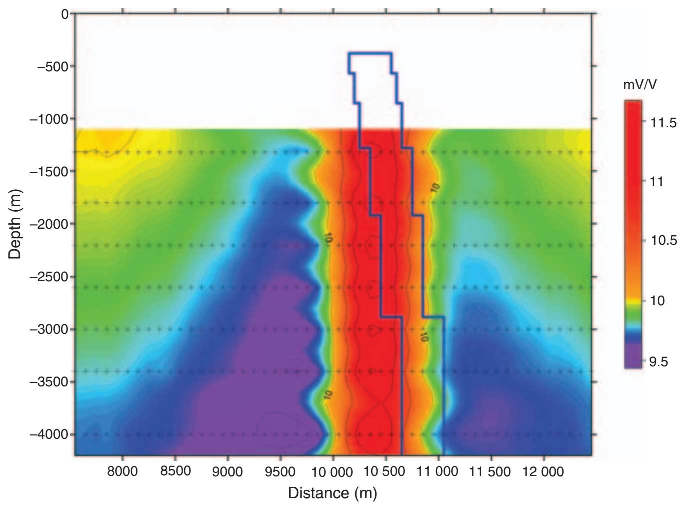

Fig. 10. *Real Section chargeability plot for a body dipping at 80° to the right.*

Sensitivity to dip

Gradient array is known to be insensitive to dip and Figure 10 shows this clearly. The body dips at 80° to the right (discretised to the mesh) while the modelled response looks like all the previous figures. Although the image shows asymmetry which reverses as the dip reverses, the amplitude of those variations are below the level of resolution of commercial receivers.

Many more models and variations could be shown. However, despite significant changes to the model geometry, the forward modelled response changes little and the majority of the response comes from the shallowest part of the body. This should come as no great surprise as the gradient array has maximum sensitivity at the surface and quickly decays with depth. At large A–B spacing the depth of investigation is controlled more by the M–N spacing than increases to the A–B spacing. Increasing the M–N spacing would improve penetration at the expense of horizontal resolution. There doesn't seem to be any evidence that this was being done in the case of the Oyu Tolgoi data.

Conclusion

In conclusion, the claims made by the promoters of Zeus are not supported by modelling and any geologist wanting to use this system to look for Volkswagens at 3 km should prepare themselves for disappointment and barren drill holes.

Readers wishing to undertake further studies on these data, including inversion, are welcome to contact the author for copies of the input models and output data from Res3DModx64. The original SEGMIN presentation and the Zeus publicity are also available on request, as it appears that the latter is not as easy to find on the web as it once was. Contact the author at kim@exploregeo.com.au

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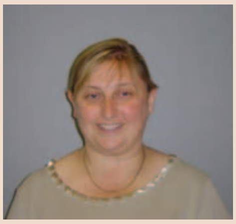
Kombolgie AEM survey images to 2 km



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Introduction

Airborne electromagnetic (AEM) data are being acquired by Geoscience Australia (GA) under the Australian Government's Onshore Energy Security Program (OESP) in areas considered to have potential for uranium or thorium mineralisation. The surveys are managed and interpreted by members of GA's AEM Acquisition and Interpretation Project. In contrast to deposit-scale investigations carried out by industry these surveys are designed to reveal new geological information at a regional scale. The Pine Creek AEM survey shown in Figure 1 is comprised of three survey areas: Woolner Granite, Rum Jungle and Kombolgie. The TEMPEST™ AEM system was used for the Woolner Granite and Rum Jungle surveys and the VTEM™ system was used for the Kombolgie survey.

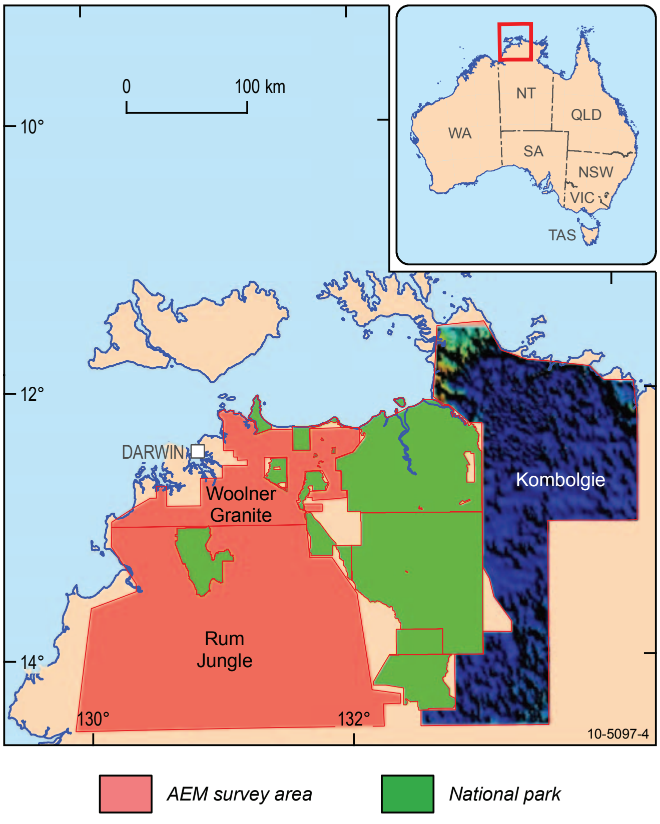

Fig. 1. *Pine Creek Survey boundary locations. The Kombolgie Survey area is highlighted with an image of the estimated conductance to 2000 m. Geoscience Australia funded 5000 m line spacing across the entire Kombolgie survey and an infill area at 1666 m line spacing.*

The Kombolgie survey, in the Pine Creek Orogen of the Northern Territory, covered sections of the Alligator River, Cobourg Peninsula, Junction Bay, Katherine, Milingimbi and Mount Evelyn 1 : 250 000 map sheets (Costelloe et al., 2009). A total of 8800 line km of VTEM™ data were acquired in 2008, covering an area of 32 000 km^2. In 2009 the processed response data and conductivity estimates to 600 m depth were produced by the survey contractor Geotech Airborne using EM Flow™ (version 3.30) (Macnae et al., 1998; Stolz and Macnae, 1998), and were made available to the public in the GA Phase-1 data release.

In this article we present an enhanced set of conductivity estimates which are now available from the GA website free of charge. These conductivity estimates reveal new geological information to depths approaching 2 km in the more resistive portion of the survey area. They were generated by GA using a more recent version (version 5.23-13) of EM Flow™.

AEM system selection

GA selected the VTEM™ system to fly the Kombolgie survey from the various candidates submitted by members of the Panel of AEM contractors after an assessment of the probability of detecting hypothetical geological targets in the presence of a given background. This assessment was based on a methodology developed by Green and Lane (2003). In this methodology a geological scenario representing the likely background and target conditions is sketched out and then transformed into an equivalent geo-electric model. From forward model responses, with and without the target unit present, an anomalous response is determined. Then, using the estimated system noise levels, the anomalous response is converted to an anomaly-to-noise ratio, from which a probability of detecting the presence of the target can be derived.

While the success of this method is strongly dependent on the assigned conductivities and system noise levels, it does give an objective measure of system suitability for a particular exploration task. The assigned system noise levels for each AEM system were those specified as maximum allowable noise levels in survey contracts. These are determined from sample high altitude and repeat line data (Green and Lane, 2003) provided to GA as part of the requirement of becoming a member of the contractor panel. Geo-electrical models were synthesised from prior knowledge of conductivity ranges for the targeted geological units.

The West Arnhem Land region is highly prospective for uranium mineralisation (e.g. Ahmad, 1998; Beckitt, 2003; Lane et al., 2007). The architectural elements essential for unconformity uranium systems in this area include an

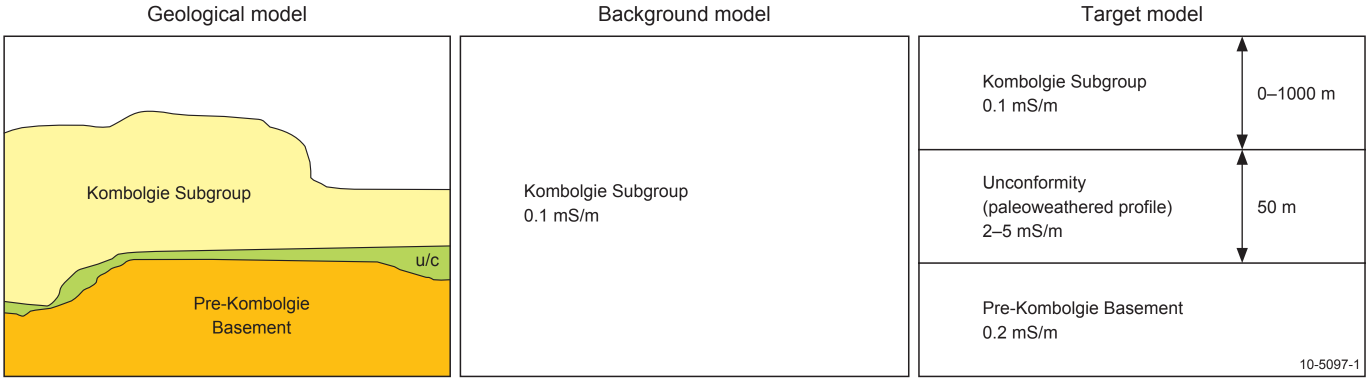

Fig. 2. *An example of a geological scenario and corresponding geo-electric model for the Kombolgie unconformity.*

Table 1. Conductivities used in the forward modelling

Geological unit	Conductivity (mS/m)
Regolith	5
Kombolgie subgroup	0.1
Unconformity (u/c)	2–5
Pre-Kombolgie basement	0.2

unconformity surface, domes/inliers of Archean granite-gneiss; paleo-regolith surfaces and basement faults (Jaireth et al., 2007). The main geological target in the Kombolgie survey area was the Paleoproterozoic Katherine River Group metasediment unconformity. An example geological scenario and corresponding geo-electric model for the Kombolgie Subgroup – Pre-Kombolgie Basement unconformity is shown in Figure 2. The conductivity ranges were compiled from information provided by companies that have tenements in the Kombolgie survey area (Table 1).

The forward modelling of this scenario indicated that two of the AEM systems considered would successfully detect the hypothesised unconformity under 500 m of 0.1 mS/m Kombolgie Subgroup sediments. Further modelling predicted the VTEM™ system would detect the unconformity to 1000 m under a thin (5 m) 5 mS/m regolith overlying 0.1 mS/m Kombolgie Subgroup sediments (Richardson et al., 2008). When all scenarios were deemed of equal relevance, and when other survey factors were taken into account (such as survey logistics, availability, safety, cost, etc.), the VTEM™ system was expected to be more likely to be successful in the Kombolgie survey area.

The new EM Flow™ results

The commercial Version 3.30 of EM Flow™ was used by Geotech Airborne in the generation of the originally released Phase-1 Kombolgie conductivity estimates. Further work has been carried out in order to extract additional value from the electromagnetic data. In this process, Richard Lane (Geoscience Australia) and Professor James Macnae (RMIT) discovered that in parts of the survey area, geologically plausible conductivity estimates could be generated to depths exceeding 1500 m.

The differences between the new Phase-2 Kombolgie EM Flow™ data release and the previous Phase-1 release can be summarised as follows:

(i) Use of the most recent research version of EM Flow™ (v5.23-13) developed through AMIRA project P407b with additional enhancements added by RMIT staff;
(ii) Extension of the maximum depth of conductivity estimates from 600 m to 2000 m;
(iii) A different received waveform;
(iv) Corrections made to the window time definitions and amplitude scaling factors;
(v) A different range of Taus (time constants); and,
(vi) A different range of discrete conductivities.

The research version (Version 5.23-13 – *STEM Flow_FULL523-13.exe*) was used to generate the Phase-2 Kombolgie results. In contrast to the earlier version, the version used for this work facilitates a greater number of discrete conductivities to be employed (250 instead of 20). This enables a wider dynamic range of discrete conductivities to be used, that are more suitable for the survey area, while still allowing for a gradual transition between conductivities.

The later version also allowed for a negative Tau ($\tau = -25\,\mu s$) to be used in the fitting process so that the parasitic capacitance component of the signal could be accounted for (Macnae and Baron-Hay, 2010). This is a relatively new innovation for the EM Flow™ software that has been added by staff from RMIT. Since fitting of the parasitic response is better constrained when early-time data are used, we used all 30 available time windows (beginning at centre-time 62.5 µs) in place of the 27 used by Geotech (beginning at centre-time 99.0 µs).

For this work we used a different waveform to that employed by Geotech Airborne for the Phase-1 Kombolgie data. We chose the waveform that we assessed to be the most representative of the 272 waveforms acquired at high altitude during the survey. After selecting the most representative waveform, recorded by monitoring the time derivative of the transmitter current rather than the actual dB/dT received waveform, we filtered it using parameters supplied to GA by Professor James Macnae. This filtering simulates the effect of the receiver-side electronics and has the effect of slightly delaying and filtering the 'transmitter-measured' waveform so that it more closely represents a true 'receiver-measured' waveform that is actually required.

Figure 3 shows EM Flow™ sections to 2 km for three consecutive 1666 m spaced flight lines proximal to areas where the Kombolgie unconformity has been mapped at surface near the Nabarlek uranium deposit. Surface geology and total magnetic intensity (reduced to the pole) data are also provided at

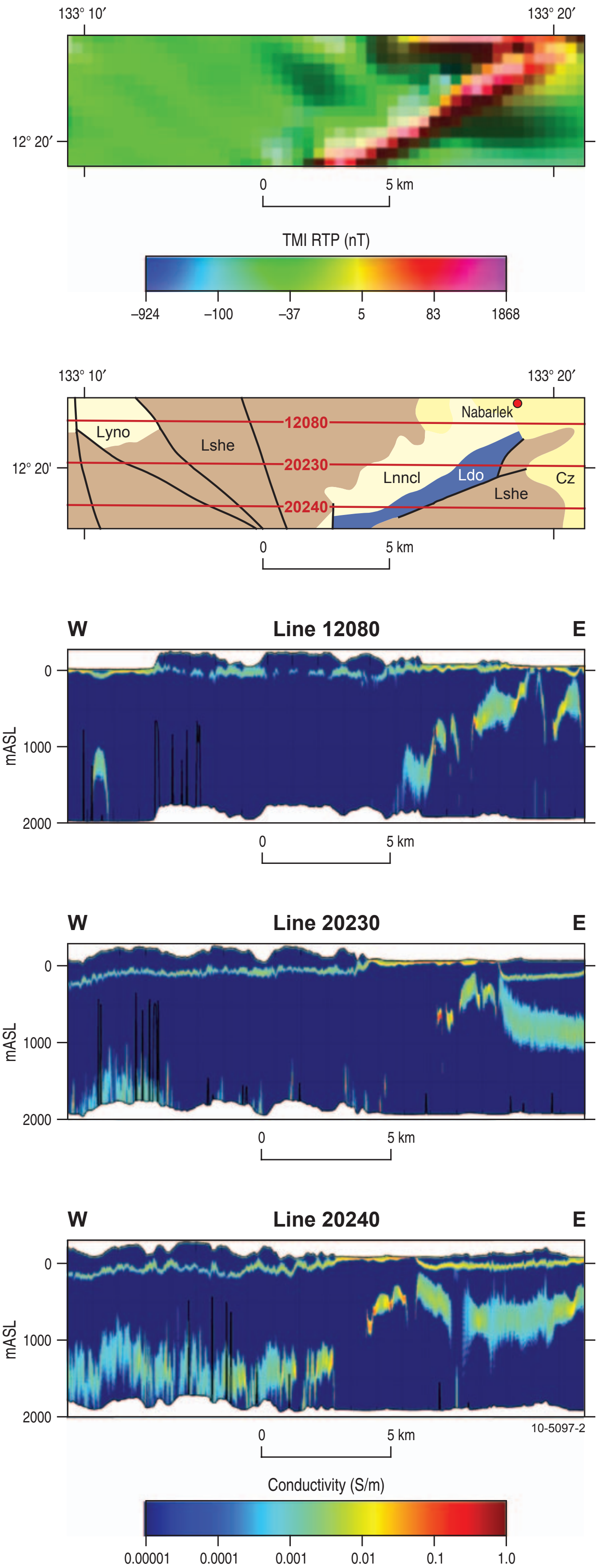

Fig. 3. *TMI RTP, Geoscience Australia Surface Geology of Australia Map, and EM Flow*^{TM} *sections for three lines near Nabarlek showing conductivity features to 2000 m.*

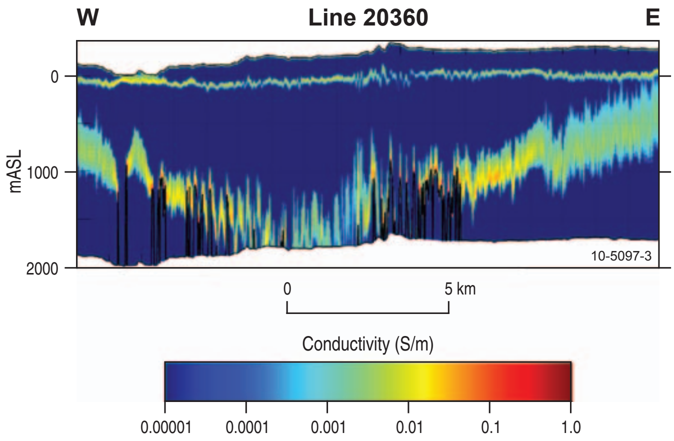

Fig. 4. *Kombolgie survey line 20 360 subsection showing a coherent conductivity feature to 2000 m.*

the top of the EM Flow^{TM} sections. The estimated depth of penetration line depicted in these sections is calculated by EM Flow^{TM}. The interpreted Kombolgie – Pre-Kombolgie Basement unconformity appears in the sections as a thin, weakly conductive, sub-horizontal feature mid section. In this resistive area, conductivity estimates relating to basement architecture are coherent below 1500 m (Figure 4). Forward gravity modelling and 3D geological mapping undertaken in West Arnhem Land (Lane et al., 2007) confirms qualitative agreement between the proposed architecture and the conductivity estimates.

Implications for exploration

The outcomes of the Pine Creek AEM Kombolgie survey include mapping of subsurface geological features that are associated with unconformity-related as well as sandstone-hosted Westmoreland-type and Vein-type uranium mineralisation. The products are also suitable for interpretation focussed on other commodities including metals and potable water as well as for landscape evolution studies. The improved understanding of the regional geology to depths greater than 1500 m in selected areas that has resulted from careful application of the enhanced EMFlow software will be of considerable benefit to mining and mineral exploration companies.

The Kombolgie survey results shown here illustrate a significant improvement in mapping conductivity in greater detail and identifying features such as unconformities and major structures at much greater depths than has previously been published.

Acknowledgements

We would like to acknowledge the significant contributions of Richard Lane. We also thank Professor James Macnae (RMIT) who greatly assisted GA through technical advice, provision of the most recent EM Flow^{TM} research version software and help to determine the most appropriate waveform and program settings.

Geoscience Australia would also like to acknowledge the contributions of the following groups: Northern Territory Geological Survey (NTGS); National Water Commission Natural Resources, Environment, The Arts and Sport (NRETAS), in particular Jon Sumner; Cameco Australia, in particular Geoff Beckitt and Tyler Mathieson; and Energy Resources of Australia Ltd for field support as well as land access, access to open bore hole and lithological logs supporting the conductivity logging phase of the program. Subscription companies Crossland Uranium Mines Ltd, Hapsburg Exploration Pty Ltd, Rio Tinto Exploration Pty Ltd, Rum Jungle Resources Ltd (prev. Rum Jungle Uranium), Southern Uranium Ltd, Thundelarra Exploration, United Uranium Ltd, and Uranex NL for their support of the AEM project by funding additional lines, supplying historical data and providing geological support. The Northern Land Council, for granting access to traditional lands. We also thank the Geophysics Group and the Groundwater Group at GA, in particular Camilla Sorensen and Pauline English.

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Geoscience Australia Kombolgie AEM survey data releases

Kombolgie Phase-1 VTEM™ data and processing report. The complete VTEM™ data set and processing report are only available from the Sales Centre on DVD due to the size of the files.
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71372

Kombolgie Phase-2 Revised EM Flow™ conductivity estimates to 2 km depth, subsampled along line by a factor of 5, are available for download from the web.
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=71371

The complete second generation EM Flow™ conductivity data set for the entire survey is available without any subsampling along line from the Sales Centre on DVD.

EM Flow™ development

The commercial version of EM Flow™ was developed by AMIRA Projects P407 and P407a in CRCAMET during the 1990s. As part of the process implemented in the software, data from an arbitrary AEM system are converted to a time-constant domain by fitting of basis functions contained in an 'aot' file. Since 2001, RMIT and AMIRA project P407b have enhanced the stability and accuracy of the conductivity estimates generated using the EM Flow™ software.

In the P407b project, of which Geoscience Australia was a sponsor, one developed option allowed for the fitting and subtraction of a residual primary field, effectively that part not completely removed in conventional processing. It was possible using P407b EM Flow_FULL523-13.exe software and a text editor to manually replace the primary field 'row' in an 'aot' file with a row consisting of an appropriate (negative) exponential decay, and thus fit and subtract parasitic capacitance effects exactly as the P407b code removed primary field contamination effects.

Confidentiality restrictions on the P407b software developments have now expired. A recent minor amendment to the P407b software was carried out by Professor James Macnae at RMIT to allow the research version of EM Flow™ used in this work (STEM Flow_FULL523-13.exe) to directly fit a rapid decay of negative amplitude in order to approximate the effect of parasitic capacitance without the need to manually edit the 'aot' file.

The history of seismic resolution

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Measurements of achieved resolution on data recorded in 1941 show better resolution than typical data recorded in 2007, and the data in intervening years are generally consistent with the long-term trend, though there may be a slight increase in resolution from a low point in the 1970s. Possible explanations include the use of increasing reflection angles, increased use of surface sources, and the use of multiple-fold techniques.

Keywords: history, resolution.

Introduction

How have we done at improving the resolution of seismic reflection data over the last eighty years? The very first seismic reflections were recorded using techniques, determined by trial and error, which produced usable reflections. For the next few decades, field techniques were designed in the same empirical manner. Then, as seismic data processing became a reality, we began to develop a more scientific understanding of signal, noise, and how to separate the two. The objective of this paper is to measure how much we, as an industry, have managed to improve resolution.

Measuring resolution

Various measures of seismic resolution have been proposed over the years, but they are all based on the concept of the dominant period of a reflection event; so comparisons of the resolution of different data sets can be made simply by measuring the dominant period of reflections on the two data sets: the resolution is inversely proportional to the period. For example, a reflection with a dominant period of 20 ms has twice the resolution of a reflection with a dominant period of 40 ms.

This is not really helpful in comparing many data sets, though. Different surveys have different objectives: the field techniques for a survey (whether designed empirically, or designed scientifically to optimise resolution) always balance resolution, signal-to-noise ratio, and cost. A deeper target will usually have a longer dominant period than a shallow one in the same area. We needed a way to normalise the resolution measurements.

An empirical observation is that the frequency content of a seismic reflection is inversely proportional to the reflection time. So we propose a resolution constant K, given by $K = tf$, where t is two-way reflection time in seconds, and f is the dominant frequency of the reflection. This constant usually varies with time within a data set (so it is not really a constant), almost always increasing with reflection time. The variation takes place to some slight extent due to geology, but largely because field and processing techniques are usually designed for a specific target depth. Reflections shallower than this depth often have degraded resolution because the parameters are not optimum. Deeper reflections (if any) may have degraded resolution because increasing noise has been removed by filtering.

With many of the data sets used for this study we have had no information on the intended target, so we have simply measured the value of K for reflection from the shallowest visible reflections to the deepest reflections, and used the largest value, K_{max}, as the inherent resolution of the data set.

The data

A historical perspective on data requires historical data. We have used four basic sources:

- Current or recent projects on which we have worked. This has provided mainly data from about 2000 to 2007, but several projects gave us access to data as old as 1972. In general, confidentiality requirements prohibit us from identifying this data other than in very general terms.
- Published data: the published data we have used was recorded between about 1930 and 1985. In most cases we can identify the location of this data precisely, though the exact date of recording may be uncertain. We have only used data where we can determine its approximate age. Most of the data used came from:
  - Data lodged with the Australian Government from 1959 to 1974 under the conditions of the *Petroleum Search Subsidy Act* of 1957.
  - Old paper records donated to the museum committee of the Geophysical Society of Houston. We know exactly when these were recorded, because they have the date on each record, but because the records are usually separated from the support data we often do not know where they were recorded.

For the older data, there is no choice of the version: the paper record is the only record (see Figure 1). For data since about 1965, data which has had at least some processing, the form we have used is the processed data set which would have been used

Fig. 1. *Seismic data on paper records.*

for structural interpretation. In other words, we have not considered derived attributes at all, but have used stacked data when it is available, and migrated data when available. We did not attempt to use any of the modern data processing techniques which attempt to extract a sparse reflector sequence from a seismic trace.

The earliest data is all land data, mainly recorded in the Gulf Coast. The data from the late 1950s onward includes some from Australia and Africa. The data from 1980 and later includes recordings from several different areas, both onshore and offshore, including North America, Latin America, Asia and Africa.

Measurements

The measurement of dominant frequency had to be one which could be applied with equal validity to 2D paper records from the 1930s and 3D digital recordings from 2009. In effect we made all the measurements on paper, though for the recent data we made the measurements on an image, rather than on paper.

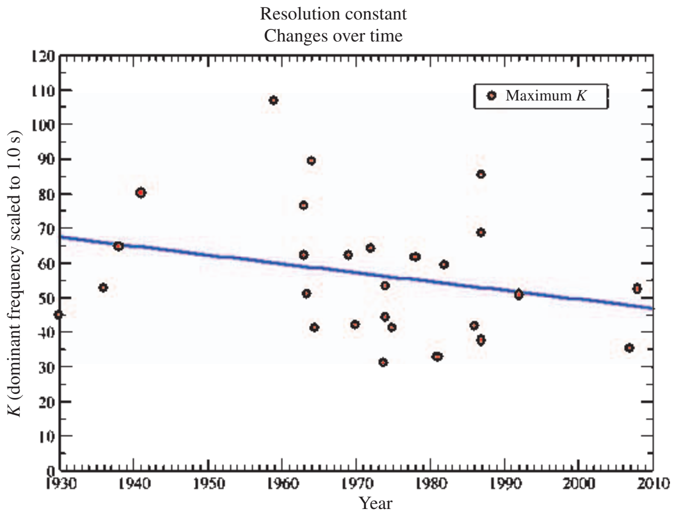

Fig. 2. *The changes of seismic resolution with time.*

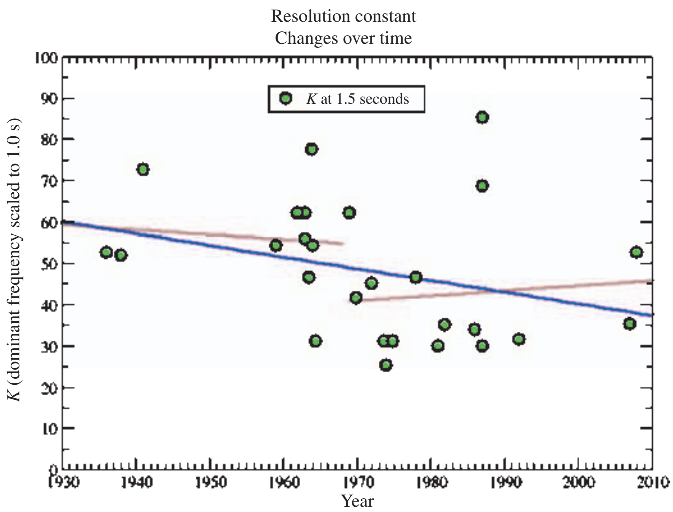

Fig. 3. *The changes of seismic resolution at 1.5 s since the 1930s.*

The actual measurement was a count of cycles – usually a count of either peaks or troughs – in a measured time interval, typically 0.1, 0.2 or 0.5 seconds, between timing lines. On the early data, we made a measurement on every trace of a record (all twelve of them). Once there was a record section, we measured at intervals along the section. In each case, we looked at reflections from the shallowest we could identify to about 4.0 seconds (or the end of the record or the deepest reflection).

A typical measurement found about 20 cycles total (with nine counts of cycles over a 0.2 s time interval) which gives a precision of ±5% for the measurement of *f*. The measurement of

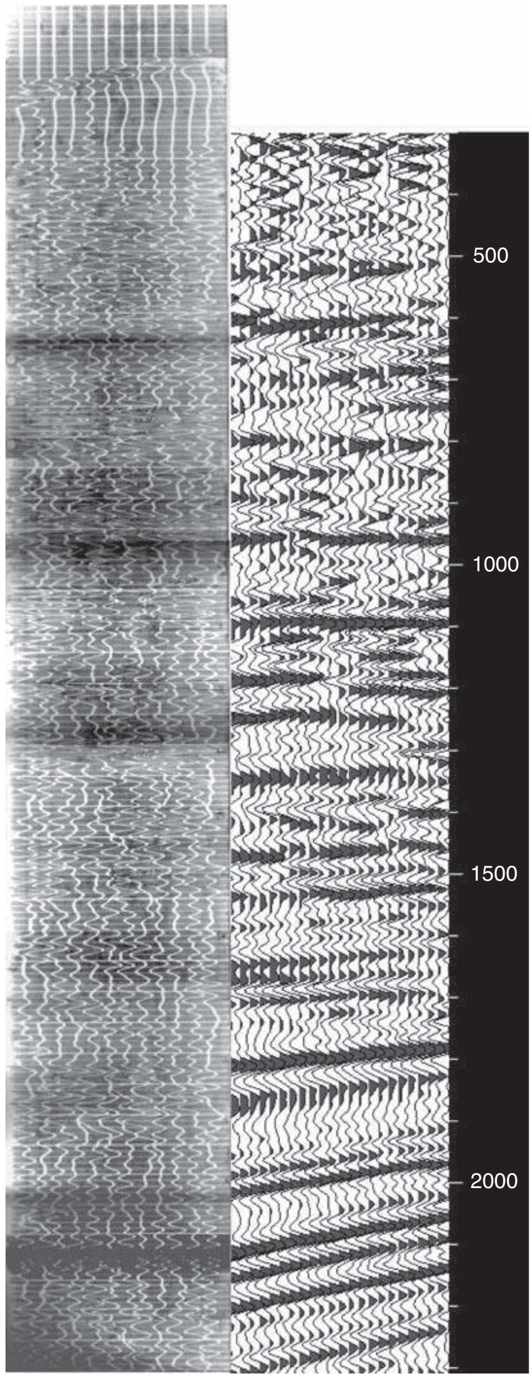

Fig. 4. *On the left, a land record from 1941, on the right, a marine 3D record from 2006. The display is scaled so that the times are the same on both recordings.*

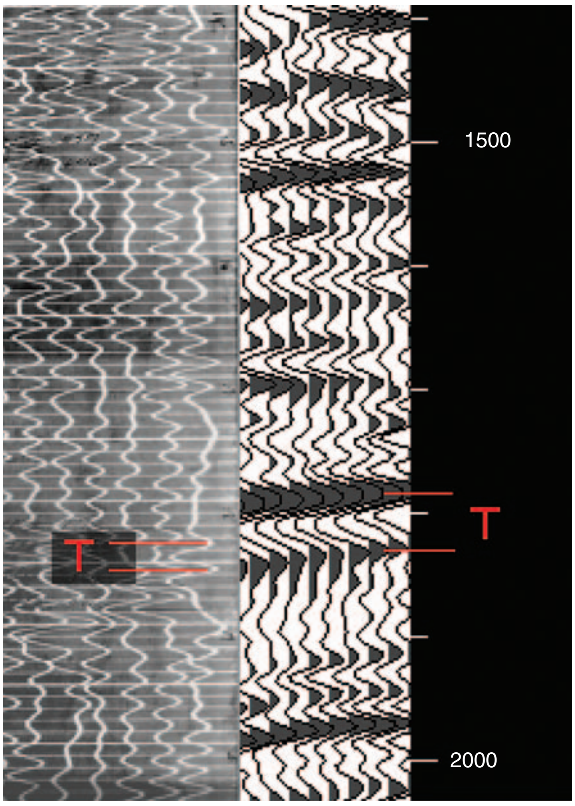

Fig. 5. *A closer look at the data in Figure 3. The period T of the reflection closest to 1.8 s is shown for each record.*

t, the centre of the time window, was better than ±1%, so the accuracy of K_{max} calculated from these measurements is about ±5%.

Results

The results are shown in Figures 2 and 3. In spite of all our technological advances over the years, seismic resolution has not improved. It even looks as if it has deteriorated. A direct comparison between 1941 and 2006 is shown in Figures 4 and 5. The 1941 recording is believed to be a shothole record from the Gulf coast, probably from Texas. The 2006 record is from offshore West Africa. Even if we try to make the comparison more equal by just considering the dominant frequency at 1.5 s

Fig. 6. *Historical field acquisition photographs.*

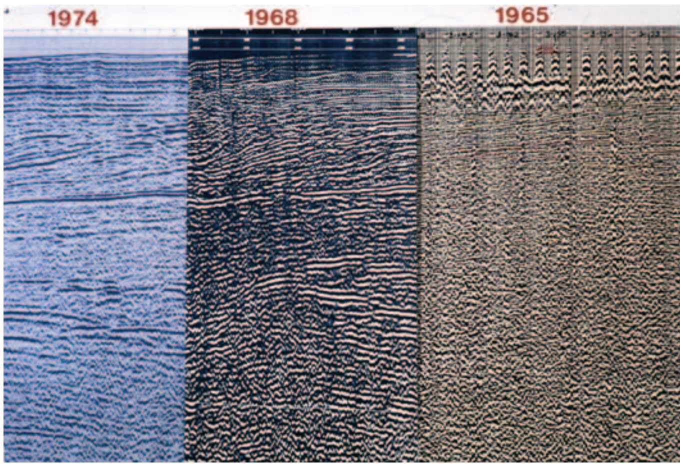

Fig. 7. *A comparison of three surveys in 1965, 1968 and 1974 along almost the same line in the offshore Gippsland Basin.*

(Figure 3), we find the resolution typically achieved in 2007 is worse than it was more than sixty years earlier.

Figure 3 shows the trend in resolution in two ways: the long term straight-line trend, and the data split into two segments: 1930 to 1968, and since 1969. This separates the data recorded single-fold (all the points before 1969) from those recorded multifold. While some data was recorded multifold before 1969, and some recorded singlefold after 1968, there is no overlap in the data sets we have been able to use for this study. With the exception of the abnormally low point in 1964, which used a vibrator energy source, all the data before 1969 is land data with a shothole energy source.

Discussion

For at least thirty years we have consciously tried to improve the resolution of seismic data (Denham, 1981; Knapp and Steeples, 1986; Taylor, 1989; Knapp, 1990; Levin, 1998; Blache-Fraser and Neep, 2004) – and it appears to be worse than it was before we were born. What has gone wrong?

Firstly, there are physical constraints on what can be done about improving resolution: the earth attenuates seismic signals in proportion to the number of wavelengths in the path (Schoenberger and Levin, 1978), so increasing resolution is inherently difficult. But this affects both old and new data equally, and today we have the advantage of many more techniques to improve resolution.

Table 1. Comparison of typical seismic survey parameters in the 1940s and 2000s

Parameter	1940s	2000s
Source	Shothole	Vibrator
Source array	Single point	Array
Receiver type	10 Hz EM geophone	8 Hz EM geophone
Receiver array	Single geophone	Array
Fold	100%	4800%
Geometry	2D	3D
Maximum reflection angle	15°	60°

The area where the data were recorded is also important. The Gulf Coast, where much of the old data comes from, is generally favourable for seismic resolution. But some of the new data is from offshore areas, where data is generally better in resolution than onshore.

Different field acquisition techniques are probably the most important factor (see Table 1 and Figure 6). There are valid reasons for changes in field techniques in the last seventy years, but almost all of these changes can reduce resolution.

The change from an explosive source in a drilled shothole to a surface source such as vibrators almost certainly reduces resolution: the signal has to pass through the near-surface velocity variations (which contribute much of the high frequency losses) twice instead of once. Associated with this is usually a large source array, which also acts as a high-cut filter (even under ideal conditions) for non-vertical propagation.

The receiver type has not changed drastically (in most cases – none of the data we had available used three-component digital detectors, which are now available): modern geophones are similar in response to those used before World War 2. But the new geophones are much smaller and generate much less distortion. That should allow better resolution; but the almost universal use of receiver arrays reduces resolution by mixing signals with varying time delays, with differences coming from the variation in normal moveout, in static correction, and in dip moveout across the array. The effect of this is shown by Sheriff and Geldart (1982, p. 151).

Single-fold recording does not mix data with different propagation paths; multifold recording does. While this is excellent for discriminating against many types of noise, even with perfect dynamic and static corrections (which are never achieved in real data) the signals being mixed will have different wavelets (due to the variation of a reflector's response with reflection angle).

The adoption of 3D techniques for many modern surveys has certainly improved the uniqueness of interpretation. But mixing data from varying azimuths without taking anisotropy into account is sure to reduce resolution, and the lack of short-offset, narrow-angle raypaths in many bins also reduces resolution.

The reflection angle is also important: early reflection surveys only recorded narrow-angle reflections; today, many surveys record reflection angles up to 60°. A reflection raypath at that angle can be up to twice as long as the raypath for coincident source and receiver, and the longer raypath inherently cuts high frequencies. A worse effect is the stretching of the wide-angle trace so that the reflection times coincide with the narrow-angle trace. Figure 7 shows a comparison of three surveys, where the improvement in reflection quality is obvious – but closer examination shows that resolution has actually decreased. The three sections are almost the same line, and are from the offshore Gippsland Basin.

Conclusions

Actual time resolution achieved in typical seismic exploration has not improved since 1930. There appears to be an abrupt drop in resolution at the time when multifold techniques were introduced about forty years ago, and since then there may have been a slow improvement in resolution; but the achieved resolution is still not as good as that achieved in the very earliest reflection surveys. Many of the techniques used to improve other aspects of the data – signal-to-noise ratio, horizontal resolution and lithology discrimination, in particular – probably limit time resolution. In most projects there is a trade-off between cost, resolution and noise. The chosen techniques always seem to result in similar resolution, and this suggests that the cost – in money or other desirable signal characteristics – of improving resolution beyond this level is very high.

Acknowledgements

Data used in this study has come from a variety of sources, but particular help came from the Geophysical Society of Houston, Geoscience Australia and Queensland Department of Mines.

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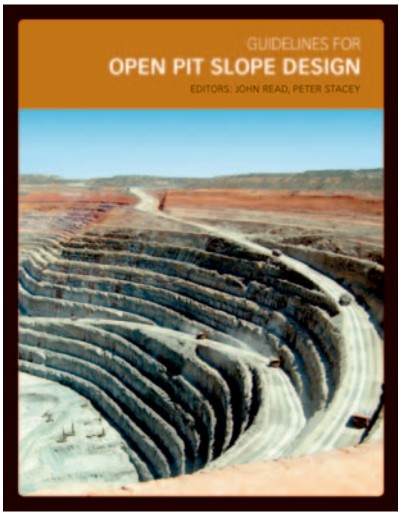
Guidelines for Open Pit Slope Design

Editors: John Read and Peter Stacey
Publisher: CSIRO Publishing, Australia, 2009, 512 pp.
RRP: $195.00 (hardback), $170.00 (ebook)
ISBN: 9780643094697



Being an underground mining engineer, geotechnical engineer and geologist I only have a few years experience in pits. The operational experience I have obtained in Western Australia, Queensland and Papua New Guinea is a broad mix of just about everything of relevance. I later obtained consulting experience in pit design, optimisation and financial sensitivity analyses. With this background in mind, I have had the pleasure of reviewing this textbook.

I found the book a concise and comprehensive collation of all the important facts you need to know from pre-feasibility study level through operations and closure of open pits. This is quite a feat as there is so much to know these days, but Read and Stacey have achieved this by recruiting some highly esteemed colleagues to contribute chapters on their areas of expertise.

The book flows like an engineers' design flowchart. It starts with raw data collection, geological and structural modelling, rockmass modelling and hydrogeological modelling, then geotechnical modelling (based on all the above).

In recognition of the variability of Mother Nature, the next section is on 'data uncertainty'. A pit design is only as good as the data it is based on. To avoid surprises, the design must be based on comprehensive and consistent geological and geotechnical field work (the same can be said for underground mine designs).

Following this the book delves into the world of 'acceptance criteria', which in old fashioned terms was 'Factor of Safety' but today is more like 'Probability of Failure' if you are leading practice. The risk modelling process is explored, aimed at cost–benefit and slope angle decision making.

The book then moves into the more hands-on engineering topics of slope design methods, design implementation (such as blasting, excavation, scaling and support) and then the equally vitally important process of assessing and monitoring pit performance during operations.

The next chapter on risk management, co-authored by the eminent Ted Brown, is in keeping with the times. Regulatory bodies are increasingly trending to risk based approaches to minimising hazards in the workplace, preferably through designing out the hazards. The mining industry in general should be working to remove reactive cultures and replace them with proactive/resilient cultures on mine sites and in mining company boardrooms.

Appropriately the final chapter is on pit closure. It encompasses all you need to consider from a safety and environmental perspective after you leave a big hole in the ground.

This book is full of informative tables, charts, diagrams and checklists that are a must-have for all open pit mining professionals, whether they be geologists, mining engineers or geotechnical engineers. It is a highly visual presentation of information, which will appeal to the visually stimulated types (non-readers). The level of detail provided in all chapters is excellent, providing a great source for revision as we get rusty on certain topics. This book will definitely reside in my professional library, right next door to *Underground Mining Methods: Engineering Fundamentals and International Case Studies*, edited by W. A. Hustrulid and R. L. Bullock (Society for Mining, Metallurgy and Exploration, 2001).

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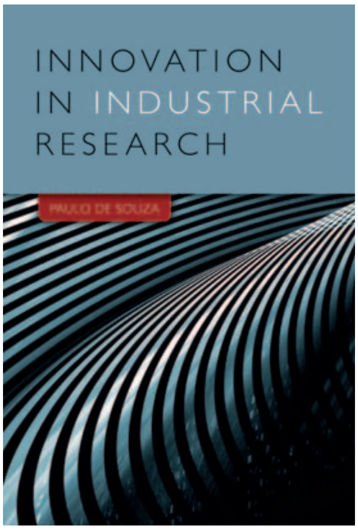
Innovation in Industrial Research

by Paulo de Souza
Publisher: CSIRO Publishing, Australia, 2010, 135 pp.
RRP: $44.95 (paperback), $38.95 (ebook)
ISBN: 9780643096431



This book is written by a physicist and research director at CSIRO in Tasmania. When I opened it I had the impression of lots of words. Clearly, this was a person who had run the research gauntlet around the world. The book is aimed at researchers in companies, and being in Australia, I really wondered if there would be any market. As I read on I realised that much of what was said would actually be useful to university students. Indeed, much of the text is devoted to explaining the basics of how you go about the method of research, and why a researcher needs to do a good literature review. But this came from the basic concept that the researcher is given funding for whatever comes to mind which in reality, is not the case (maybe this is how CSIRO Tasmania operate?).

Chapter 5 discusses the use of various management tools, but seems to me to be a bit old hat – stuff practised by industry in the 90s and perhaps CSIRO is the only research house in Australia which can afford to continue these practices. Chapter 4 on statistics is very enlightening and would be useful to any aspiring PhD student who might want to have a simple explanation for the various ways one can present data, while Chapter 6 on secrecy applies to few in Australia (although universities do practice the concepts) since little Australian research is game changing – clearly it is at CSIRO.

When I finally arrived at the end of this book, I totally agreed with the notion that in order to improve innovation, researchers should be paid according to their performance. This is a very informative little book, which would be more useful to the starting PhD student rather than the practising industrialist.

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March			**2011**
21–22 Mar	West Australian Geothermal Energy Symposium http://www.wageothermalsymposium.com.au	Perth	Australia
April			**2011**
3–8 Apr	European Geosciences Union General Assembly 2012 http://meetings.copernicus.org/egu2011	Vienna	Austria
10–14 Apr	SAGEEP 2011: Information Exchange for Near-Surface Geophysics http://www.eegs.org/sageep	Charleston	USA
May			**2011**
9–13 May	Recovery 2011: CSPG, CSEG, CWLS Joint Annual Convention http://www.geoconvention.org	Calgary	Canada
11–12 May	DEVEX: The Productions & Development Conference & Exhibition http://www.devex-conference.org	Aberdeen	Scotland
23–26 May	73rd EAGE Conference & Exhibition incorporating SPE EUROPEC 2011 http://www.eage.org	Vienna	Austria
June			**2011**
22–24 Jun	International Workshop on Advanced Ground Penetrating Radar 2011 http://www.congressa.de/IWAGPR-Workshop-2011	Aachen	Germany
28 Jun – 7 Jul	IUGG 2011: Earth on the Edge: Science for a Sustainable Planet http://www.iugg2011.com	Melbourne	Australia
August			**2011**
28 Aug – 2 Sep	Geosynthesis 2011: Integrating the Earth Sciences Conference & Exhibition http://www.sbs.co.za/geosynthesis2011	Cape Town	South Africa
September			**2011**
12–14 Sep	Near Surface 2011 http://www.eage.org	Leicester	UK
18–23 Sep	SEG International Exposition and 81st Annual Meeting http://www.seg.org	San Antonio	USA
October			**2011**
24–26 Oct	IGCP 5th International Symposium: Submarine Mass Movements and Their Consequences http://landslide.jp	Kyoto	Japan
30 Oct – 2 Nov	Society of Petroleum Engineers ATCE 2011 http://www.spe.org/atce/2011	Denver	USA
November			**2011**
15–17 Nov	2011 International Petroleum Technology Conference http://iptcnet.org/2011	Bangkok	Thailand
December			**2011**
5–9 Dec	AGU 2011 Fall Meeting http://www.agu.org/meetings	San Francisco	USA
February			**2012**
26–29 Feb	22nd ASEG Conference and Exhibition 2012: Unearthing New Layers http://www/aseg2012.com.au	Brisbane	Australia
August			**2012**
5–10 Aug	34th International Geological Congress http://www.34igc.org	Brisbane	Australia

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