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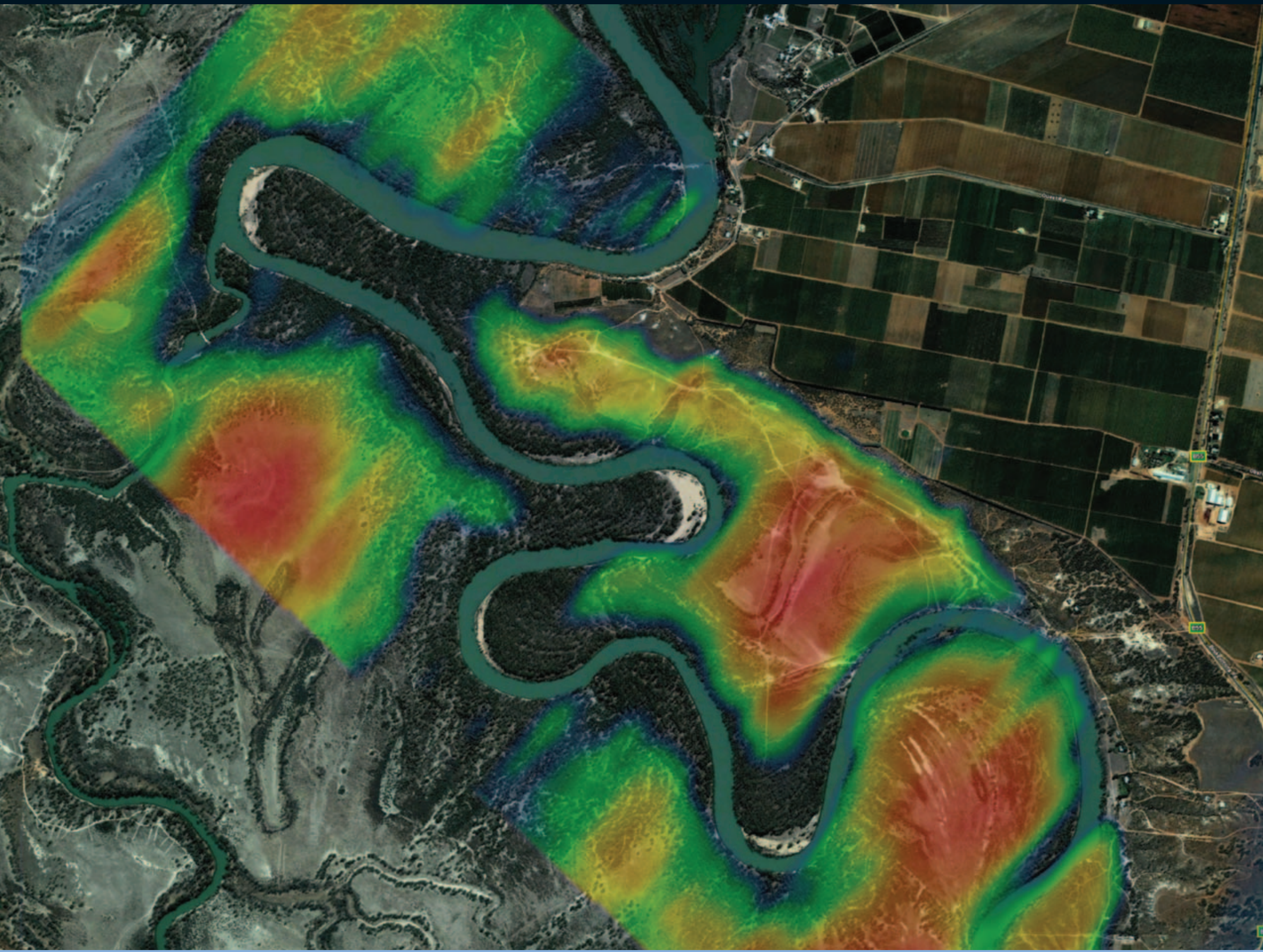
PREVIEW

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS



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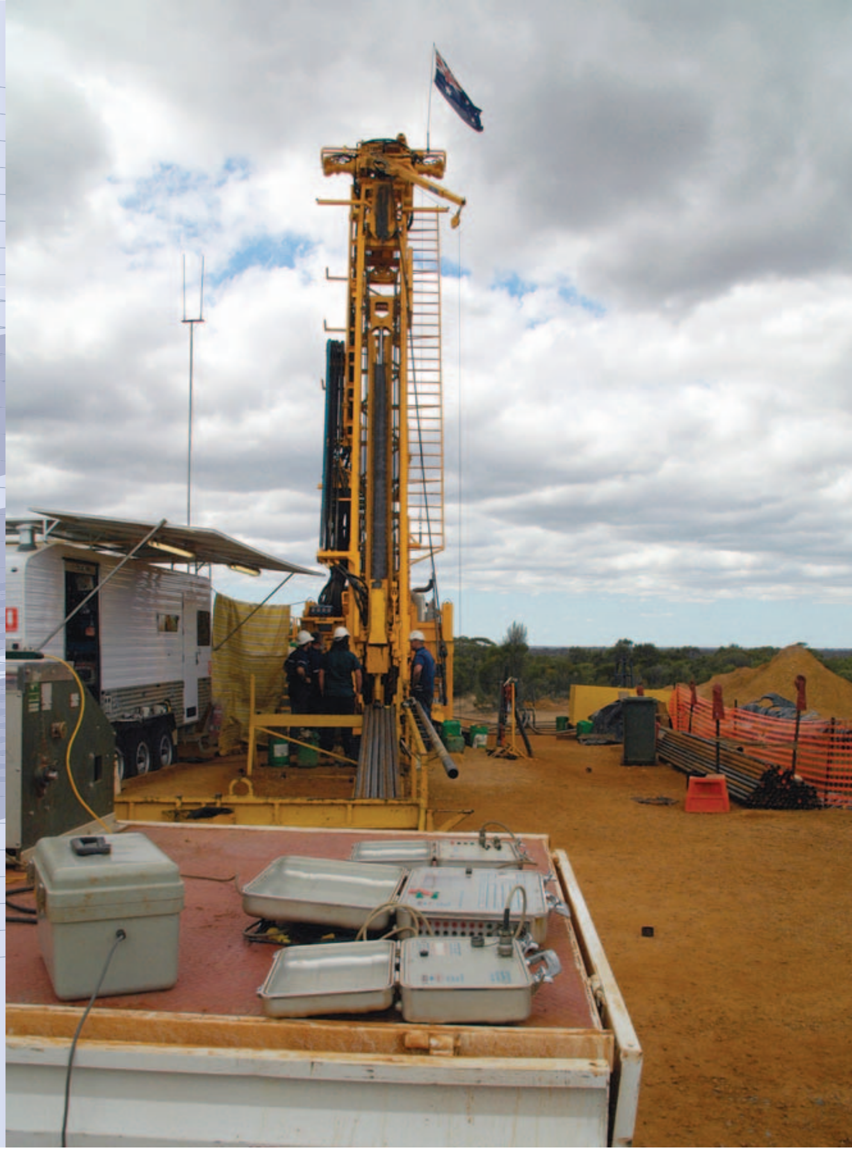

PREVIEW

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FRONT COVER

Horizontal slice at 4 m depth through the conductivity model obtained from 3D inversion of RESOLVE data over the Bookpurnong Irrigation District in South Australia *(see p. 29 of this issue).*

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Ann-Marie Anderson-Mayes

Last year, Jim Leven asked me if I would be interested in printing some features based on the seminar 'Geophysics and Geohazard: Defining Subsea Engineering Risk'. In the wake of the West Atlas incident in the Timor Sea, it seemed very appropriate to devote some *Preview* space to this topic. Now as we go to press, the slick in the Gulf of Mexico as result of the explosion and sinking of the Deepwater Horizon offshore oil rig is threatening shorelines in Louisiana, Florida, Alabama and Mississippi. In our search for oil in deeper and deeper water and challenging marine environments, managing subsea engineering risk is a significant issue. Geophysics is an important data set in these risk analyses, but as you will see from the short features in this issue, there are real challenges in acquiring geophysical data at sufficiently high spatial resolution and accuracy for engineering analysis. I hope you find the features by Bob Whiteley and Magnus McNeil-Windle of interest. In the October issue of *Preview*, a further two extended abstracts by David White and Bill Russell-Cargill will be published. Jim Leven has also summarised the presentations of the other speakers. These articles introduce an application of geophysics with which many of us are not so familiar.

In another big news story in recent weeks, the Australian Federal Government has come up with a proposal for the Resources Super Profit Tax. I found myself catching a fair amount of commentary on this issue, and living in WA where the resources industry is so significant, much of it was very negative. Fortunately, a chance referral to Geoff Muers, Research Analyst with Shaw Stockbroking, yielded an article for *Preview*. This article is well worth a read – it gives a brief overview of the tax and its possible implications. It's not all good news, but perhaps it is not all bad either.

As promised in the last issue of *Preview*, in this issue we are publishing a profile of AuScope. CEO, Bob Haydon, provides a comprehensive overview of AuScope achievements to date and plans for its last year of operation. We also have an interesting feature article from Glenn Wilson *et al.* on practical 3D inversion of airborne EM surveys. AEM data quality has improved significantly in the last decade or so, but the sheer volume of data presents significant data processing challenges, especially when try to achieve effective 3D inversions. Using their 3D inversion methodology, the authors show that it is possible to run a 3D inversion of an entire survey in less than a day. Also, in a continuation of the new Profile column, this issue's interview is with Bill Peters. Consultants form a major sector of the geophysical industry and it was interesting to learn about Bill's personal journey after consulting for 25 years.

We have plenty of ASEG News in this issue: the Treasurer's report from the AGM held in April; an introduction to President Elect, Dennis Cooke; an update on Research Foundation activities; and all the usual Branch News. **Don't forget to register for the ASEG-PESA conference in Sydney – registrations are now open online at www.aseg-pesa2010.com.au.**

Finally, I would like to offer warm thanks to Hugh Rutter who has been Book Review Editor for *Preview* for the last 12 months or so. Hugh has stood aside because he just has too much work on – always a good thing! Mike Middleton has kindly agreed to take up the reins and I offer him a very warm welcome to the *Preview* team.

Mike Middleton – new Associate Editor: Book Reviews

Mike graduated from Sydney University in 1973, and has had over 35 years experience as an active geophysicist. He has worked for CSIRO, the Geological Survey of Western Australia, Curtin University, Chalmers University (Sweden), ECL (Australia) Limited, Central Petroleum and BPC Limited. He is currently employed by the Western Australian Department of Mines and Petroleum in role of championing unconventional petroleum and geothermal energy resources.

His vision for the Book Reviews Editorial role is exposition and development of critical debate around new literature in exploration geophysics through the eyes of active participants in the profession. Mike is especially keen to encourage new graduates and research students, as well as established geophysicists, to participate in the Book Review segment of *Preview*. Critical review, discussion and debate of new literature, with exchange between willing reviewers, will form an ongoing experimental process in the book review process. To achieve this, comment and debate over various selected works will be encouraged and solicited.

Volunteers are now called upon to indicate interest in being either an ongoing or occasional reviewer. Please contact Mike via email at mike.middleton@dmp.wa.gov.au if you are interested to participate.

What does the ASEG mean to me?

As the newly appointed ASEG President I am looking forward to a busy and interesting year. Like most of us, I am a member of a number of different professional societies. However, since I signed up as a student in 1970, the ASEG has always remained closest to my heart. This is in spite of the fact that my career in Australia and overseas has taken me down paths that on the face of it, have led me away from the actual 'coal face' of geophysics. I have often reflected on 'why is it so' and what makes the ASEG unique in my mind. Why is it that for me it is more than just writing out a cheque every year? I believe it can be boiled down to several factors: common purpose, shared values, commitment and last but not least, friendship.

Our common purpose is about 'exploration' in the broadest sense. The challenge of discovering new natural resources using geophysical methods has always been our principal 'raison d'être'. Making measurements at the earth's surface and predicting what is going on at depth is what we are all about. It takes people with a special sense of imagination and adventure to do this. During my time in the ASEG I have seen Australian geophysicists take their place among world leaders in the development of new technologies and in their application to exploration and discovery. It is not only about technology and 'bump finding'; it is about placing our measurements in a geological context to enable us to make more robust predictions about the quality of the targets that we interpret.

Our shared values are driven by the challenge we face. We all come from different backgrounds be they mathematical or geological. There is nothing easy about discovering economic mineral or hydrocarbon deposits in spite of what the general public might believe. If it were easy we would all be out of a job! This gives us collectively a sense of greater purpose and a set of values that are about sharing information and problem solving while remaining professionally competitive on behalf of our employers. Nowhere is this seen better than at our regular conferences where there is a free exchange of ideas, not only in the formal program but also in the extensive informal networking behind the scenes, be it in the exhibition area during coffee and lunch breaks, or perhaps over a few too many glasses of red consumed in the early hours of the morning. No matter what our background, we are all geophysicists for a few days.

Commitment is demonstrated by the healthy state of a Society almost entirely run by volunteers. This has seen the ASEG thrive for 40 years. During this time it has provided a technical forum for Australian and international geophysicists through its publications *Exploration Geophysics* and *Preview*, and also through conferences, workshops, distinguished speakers and state branch meetings. The society has also contributed significantly to the development of students through the Research Foundation and recognises significant contributions to the profession through its Honours and Awards program.

Probably more than any of these, I value the friends I have made through this profession. Jobs and companies come and go but I known many people in the ASEG over a professional life-time. I value the great times we have had together either as professional colleagues or as acquaintances.

As I look forward to my year as President, I see an exciting time with the highlight being the Sydney conference 22–26 August. The theme of the conference is 'Future Discoveries are in Our Hands'. Mark Lackie and his organising committee have been working hard and things are on track for a successful meeting with more than enough papers submitted and a significant number of exhibition booths already booked. It looks like it will be a fantastic conference and I look forward to seeing you all there.

I would also like to remind you all to nominate a candidate for an Honour or Award. It is important for the spirit of the ASEG that we recognise our members who have made significant contributions both to the profession and the society.

Finally for this edition, reflecting on the future direction of the ASEG in its 40th birthday year, I am aware that many of my contemporaries are applying for 'retired' status and that within 10 years it will probably be the majority. Also the Federal Executive and many of the standing committees are dominated by people from my generation. If the ASEG is to continue as a viable society into the future then we need to see the progressive phasing in of a new generation. The challenge I see then is to keep the ASEG relevant to a new generation of geophysicists and explorers for indeed, while currently 'Future Discoveries are in Our Hands' more and more it will be in 'Theirs'.

Get your conference registrations in early and see you in Sydney.

Phil Harman
President
phil.harman@bigpond.com

Treasurer's annual report for 2010 AGM

Audited financial statements for the year ended 31 December 2009 for the Australian Society of Exploration Geophysicists are presented.

The financial statements refer to the consolidated funds held by the society as a whole, including the State branches. An audited version of the profit and loss statement and end of year balance sheet will be placed on the Society's web site.

The Society's funds are used to promote, throughout Australia, the science and profession of geophysics. In 2009 this was achieved by:

- funding the publications: *Exploration Geophysics*, *Preview* and the Membership Directory;
- supporting the functions of State Branches;
- funding the national administration of the Society;
- by funding continuing education programs;
- provision of loans and grants for conventions;
- provision of subsidies for student members; and
- support for the ASEG Research Foundation.

The Income Statement for the year shows a net surplus of $234 847. The end of year balance shows a Total Equity of $961 260 as of 31 December 2009, compared to $726 414 to the end of 2007. The result is a vast improvement over the budgeted surplus of $18 965, largely due to the record success of the 2009 Conference and Exhibition.

The Society's revenue source continues to be derived from:

- conferences – $309 000 (124% of budget);
- membership subscriptions – $139 000 (122% of budget);
- publications advertising – $135 000 (182% of budget);
- events and sponsorship – $82 000 (86% of budget);
- interest from accumulated investments – $31 000 (78% of budget); and
- donations to the Research Foundation – $23 000 (100% of budget).

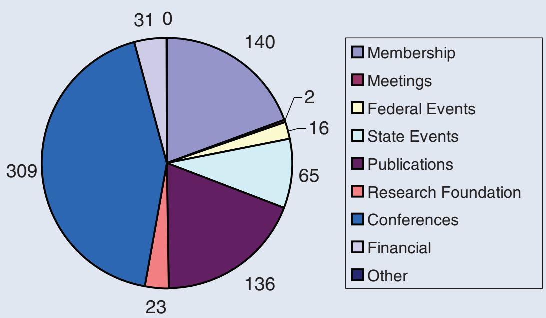
Overall the actual income for the year was 120% of the budget figure. The increase in membership is also very pleasing along with the much improved contributions from publishing advertising and institutional subscriptions to our publications.

The major expenses for the Society include:

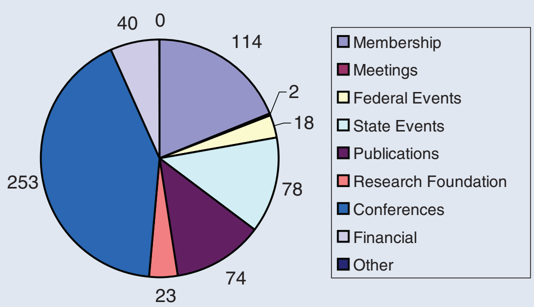
- publications – $220 000 (93% of budget);
- secretariat fees – $78 000 (93% of budget);
- events – $75 000 (88% of budget);
- financial and other expenses – $46 000 (115% of budget); and
- conferences – $29 000 (121% of budget).

The overall expenditure was 83% of the budgeted figure. Most budget lines were largely close to budget. There was a contingency of $66 000 in the 2009 budget for web costs. However,

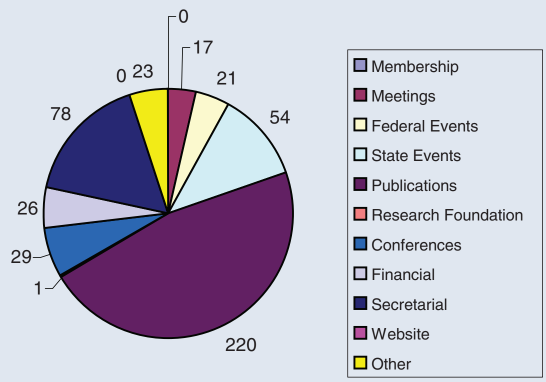
2009 INCOME ACTUAL ($'000s)



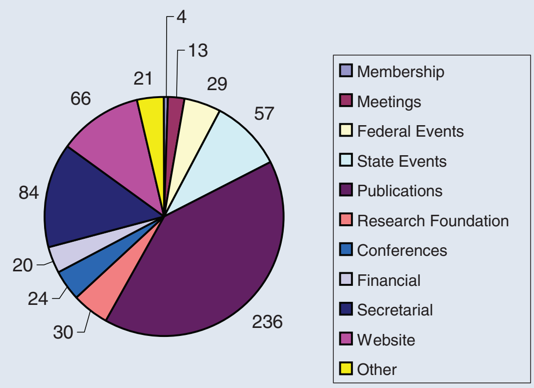
2009 INCOME BUDGET ($'000s)



2009 EXPENSES ACTUAL ($'000s)



2009 EXPENSES BUDGET ($'000s)



these funds were not called upon, all web functions being undertaken by our webmaster on a voluntary basis.

A complete restructure of the 2009 budget and Chart of Accounts was done to facilitate a better reconciliation of portfolio allocation and reporting. In addition, a cashflow was developed for the 2009 budget, enabling better financial management and reporting on a monthly basis, in line with recommendations in the 2008 Wyndham Price review.

Attempts were made to model the financial position of the society for the next four years, considering potential future conferences. This included a potential conference with the Indonesian geological society, HAGI in Bali in 2011 and the International Geological Congress in Brisbane in 2012. This financial modelling, as well as consideration of geophysical membership attendance, indicated that another ASEG conference in late 2011 or early 2012 would be appropriate.

Similar financial modelling was done to consider a potential publication on aeromagnetic interpretation, by David Isles and Leigh Rankin. This modelling continues to be refined in light of SEG's likely involvement in distribution of the publication.

An information package for State ASEG Branch Treasurers has been prepared to assist them in the running of state financial matters and liaison with the Federal body on financial matters. Imprest accounts have been opened by WA and Queensland branches of the society to assist in local payments of meetings and other *ad hoc* expenses. This follows on from the imprest accounts that have been approved and created by the NSW, SA and Victoria branches.

The timing and amount of payments to the Research Foundation have been a matter of considerable confusion. A major change to the system of payments has been proposed and recently approved by the Federal Executive to clarify the situation and make it considerably simpler. This will be implemented in 2010.

The Society is in a very sound financial position going into 2010. The equity held will cover the uncertainty of income from future conferences, particularly the involvement in international events. Continuous improvement in financial management is being undertaken to maintain/enhance this position for the benefit of the Society and its members.

C David Cockshell
Honorary Treasurer
13 April 2010

Research Foundation supports five new projects in 2010

The Research Foundation was pleased to receive eleven high quality proposals to support research projects commencing this academic year. Congratulations to students and supervisors. The projects submitted were all of high quality. After careful consideration and ranking by the technical committees and taking account of our financial resources, at the time of writing, the Foundation has offered to support five as follows:

- At the University of Western Australia, 'Closing the loop – reconciling 4D seismic data to update reservoir models' by Matthew Saul (PhD);
- At the University of Western Australia, 'The combined use of 4D seismic, gravity and electromagnetic data for reservoir monitoring: a feasibility study' by Wendy Young (MSc);
- At the University of Tasmania, 'Gravity survey optimisation procedures' by Michael Tomlin BSc (Hons);
- At Curtin University of Technology, 'Application of vertical seismic profiling for characterisation of hard rock' by Andrew Greenwood (PhD);
- At Curtin University of Technology, 'Geophysical imaging of water-migration through different soil profiles at the Gnangara mound, WA' by Elmar Strobach (PhD).

We wish all of these students well with their research and look forward to hearing about the results of their work at the completion of their studies.

This is typical of the role that the Foundation has played over the years since its inception. While relatively low key, funding is specifically directed towards facilitating the field work and data acquisition necessary to make such projects worthwhile and meaningful.

At the beginning of each year the Research Foundation seeks proposals in exploration geophysics from students and their supervisors in various Australian tertiary institutions. The level of support depends on two main factors, the quality of the projects submitted and the capacity of the Foundation's financial resources.

Support of this year's projects commits the Research Foundation to a total of $71 710 over the next 3 years in addition to $44 200 over the next 2 years for the on-going carry over projects previously committed.

This highlights the need for the Research Foundation to continue to raise funds so that it can carry on supporting the development of the professional geophysicists of the future.

The Research Foundation is funded from several different sources including corporate membership fees, grants from the ASEG Federal Executive and importantly, generous donations from the ASEG membership. We have been particularly fortunate over the past 2 years in that the Melbourne Mining Club has supported us with a donation of $20 000 per annum.

We are always looking for additional funding so that we can continue this very worthwhile activity of the ASEG. Donations may be made to the Foundation at any time through the ASEG executive in Perth or at the time of membership renewal.

Phil Harman, ASEG RF Chairman

News from the AGM

The Annual General Meeting of the ASEG held on Tuesday 13 April installed the new Federal office holders unopposed. Phil Harman is the new President (and continues as Chairman of the ASEG Research Foundation) and Dennis Cooke is the new President Elect. The full listing of the current Federal Executive is in the table below.

The formal proceedings also required that a number of changes to the Constitution be adopted. These changes were designed to streamline the operations of the Society, to encourage more Active Members, and to bring the Constitution up to date with current practice. All changes (see *Preview* Issue No. 144, pp. 5–6 for a full summary) were adopted unopposed.

Michael Asten presented his report as outgoing President. Michael noted that

- membership is steady (1268 with 99 student members);
- publications are continuing to be strong;
- planning for the Sydney conference in August 2010 is progressing very well;
- collaboration with sister societies continues to be a vital part of the Society's activities;
- representation through the Australian Geoscience Council succeeded in improving rankings of applied geosciences journals;
- the ASEG Research Foundation continues its valuable role;
- and a new Committee of the ASEG has recently been formed under Chairman Barry Long to document the history of the ASEG.

Michael concluded by noting that the ASEG celebrates its 40th anniversary this year. 'I invite all members to be sure to be at the Sydney Conference to raise a toast to the past 40 years, and to participate in building our programs for the next 40 years.'

Incoming President, Phil Harman, also spoke to the meeting. His comments were largely covered in the article published in the last issue of *Preview* (Issue No. 145, p. 7).

The AGM was attended by approximately 20 members. Most of those present repaired to the Brisbane Hotel for an enjoyable meal following the conclusion of formal proceedings.

Past, present and future – from L to R, Dennis Cooke (President Elect), Phil Harman (President), and Michael Asten (Immediate Past President).

Preview past and present – former Preview Editor and now Secretary, David Denham, passes on words of wisdom to current Editor, Ann-Marie Anderson-Mayes.

Michael Asten chats to Koya Suto (Vice-President) and David Cockshell (Treasurer).

Phil Harman presents Michael Asten with a thank you gift.

ASEG News

ASEG Federal Executive 2010–11

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The passing of Shanti Rajagopalan

It is with great sadness that *Preview* reports the passing of Dr Shanti Rajagopalan. Shanti died very recently aged 49 after the recurrence of an illness. Shanti was well known for her work in potential field analysis and interpretation and was responsible for innovations which earned her ASEG's Laric Hawkins award in 1987.

She came to Australia from India for PhD studies as an overseas graduate student in the Department of Economic Geology at Adelaide University during the 1980s and on return to Australia was active in industry working for major companies (Rio Tinto and BHP Billiton), conducting training courses and also operating a private consulting practice. A more comprehensive tribute to Shanti will be published in the October issue of *Preview*. If you would like to contribute, please email Ann-Marie Anderson-Mayes at preview@mayes.com.au.

The ASEG extends its sincere condolences to Shanti's family and the many friends and colleagues who will miss her enthusiasm and talent.

New South Wales

In April, **Bob Whiteley** from Coffey Geotechnics spoke on geophysics and desalination plants. Bob outlined how geophysics contributed to the successful completion of two of Australia's largest desalination plants, one at Kurnell, Sydney and the other at Tugun, Gold Coast. Bob presented case studies showing aspects of the land, borehole and marine geophysics technologies that were applied during the design and construction phases of these desalination plants. Much discussion occurred during and after Bob's talk.

In May, **Pat Connolly, the SEG Spring Distinguished Lecturer**, spoke about robust workflows for seismic reservoir characterization. Pat spoke about how the workflows have evolved to meet a number of criteria: such as robustness and repeatability, and allowing most steps to be carried out by nonspecialist geophysicists. In his talk, he outlined the concepts behind the main steps in the seismic characterization workflow and discussed approaches to uncertainty estimation. Seismics and red wine were well mixed and the presentation was enjoyed by all.

Do not forget the ASEG–PESA conference in 2010 in Sydney, 22 to 26 August

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

Mark Lackie

Queensland

Apologies for not having a meeting since the Joint meeting with PESA in March but behind the scenes there has been a lot of activity because the Federal Executive has decided to convene an ASEG Conference and Exhibition in late 2011 or early 2012 in Brisbane. A conference organising committee chaired by Andrea Rutley and Wayne Mogg has been formed and we are tendering for a Professional Conference Organiser to do the legwork. The committee as it currently stands is:

Chair: Andrea Rutley
Chair: Wayne Mogg
Technical: Binzhong Zhou
Exhibition: Jon Turner and Dave Burt
Sponsorship: Vacant
Publicity: Henk van Paridon
Finance: Noll Mortiarty
Social: Janelle Kuter
Students: Shaun Strong

We still need a volunteer to chair the Sponsorship sub-committee. If you are interested in lending a hand to any of the sub-committees please contact either Andrea (andrea_rutley@urscorp.com) or myself (wayne.mogg@originenergy.com.au). All help will be gratefully received.

Wayne Mogg

South Australia

The South Australian Branch recently welcomed ASEG president Michael Asten who gave a talk titled: 'Electromagnetic Induction Detection and Discrimination of UXO Using an Array of Fluxgate Magnetic Sensors'. The talk was well received and Michael also gave a brief talk about his work as ASEG president. The next technical meeting is our annual Industry night. Our guests will be John Parker from Lincoln Minerals, Bob Duffin from Western Plains Resources, and Graham Bubner from AsIs International/ Western Desert Resources who will be talking about SA Iron exploration.

The following meeting will be given by Patrick Connolly – the SEG 2010 distinguished lecturer – who will be talking about Seismic Reservoir Characterisation. Other events for 2010 include a talk by Colin Sayers from the SEG, our annual wine tasting, Melbourne Cup lunch and Student night.

The SA branch holds technical meetings monthly, usually on a Thursday Night at the Coopers Ale House beginning at 5:30 pm. New members and interested persons are always welcome. Please contact Philip Heath (philip.heath@sa.gov.au) for further details.

Philip Heath

Western Australia

The WA branch was pleased to host this year's ASEG Federal AGM and also fortunate to have outgoing ASEG President, Michael Asten, present a technical talk in April. Michael first gave a brief overview of the ASEG and its activities during the past year or so. Then he presented a short technical talk on the topic of 'Electromagnetic Induction Detection and Discrimination of UXO Using an Array of Fluxgate Magnetic Sensors'. This very interesting talk showed that an array of fluxgate magnetometers could be configured to enable unexploded ordinance (UXO) targets to be discriminated from ancillary scrap metal in the survey area.

The May technical evening was presented by Guy Holmes from SpectrumData and Adam Martin from the Geosoft Inc. on the topic 'Data Management – Tales from the Crypt'. These two excellent presentations discussed data management issues for the petroleum and mineral sectors respectively. It was a timely reminder that good data management processes can save a lot of time and money by making sure that both new and historical data are properly archived, easily found, and readily retrievable.

On the afternoon of Saturday 24 April, the WA branch hosted the second annual WA social event at the Botanica Bistro. This was again a big success, with almost double the attendance from last year. I thank all those who helped organise the event, and those that were able to attend. Graham Jenke was the winner of this year's door prize, a bottle of 2007 Wyndham Estate Cabernet Sauvignon. I look forward to seeing everyone again next year for another great afternoon.

Reece Foster

ASEG News

The ASEG extends a warm welcome to 24 new members to the Society (see table below). These memberships were approved at the Federal Executive meetings held in March and April 2010.

Name	Organisation	State	Member grade
Faisal Alonaizi	Curtin University	WA	Student
Alan Anderson		SA	Active
Mehdi Asgharzadeh	Curtin University	WA	Student
Allen Benter	Charles Sturt University	NSW	Student
Brock Bolin	Newmont Mining Corporation	USA	Active
Bradley Peter Bye	University of Adelaide	SA	Student
Patrick Carr	Maquarie University	NSW	Student
Adrian Elsner	Coffey Geotechnics	NSW	Associate
Ashley Ezzy	Chevron	WA	Active
Joanne Henry	GeoConsult	QLD	Associate
Simon Holford	University of Adelaide	SA	Active
William Vincent Jones	Macquarie University	ACT	Student
Roderick Lawrence	Macquarie University	NSW	Student
Bonnie Ann Lodwick	The University of Sydney	VIC	Student
Tyler Mathieson	Cameco Australia Pty Ltd	NT	Active
Mark Maxwell	Queensland Mines & Energy	QLD	Associate
Christopher Medlin	Monash University	VIC	Student
Brendon Mitchell	WesternGeco	WA	Active
Sanjeev Rajput	CSIRO	WA	Active
Erin Shirley	Beach Energy	SA	Associate
Jeffrey Shragge	University of WA	WA	Active
Jaco Smit	Anglo Operations Ltd	South Africa	Active
Wanitcha Wichatarden	Austhai Geophysical Consultants (Thailand) Co. Ltd	Bangkok	Associate
Wendy Young	University of WA	WA	Student

We also congratulate the following two members whose Membership was upgraded to Emeritus at the Federal Executive meeting in March and April 2010.

Name	State	Member grade
Brian Spies	WA	Emeritus
Wes Jamiseon	NSW	Emeritus

We would like to welcome ***Southern Geoscience Consultants Pty Ltd*** (SGC) as a new corporate member of the ASEG. SGC is a group of experienced geophysicists specialising in serving the mineral exploration industry, worldwide. Established in 1985 and based in Perth, WA, the group consists of 8 independent consultants and a service core of 10 staff geophysicists, soon to be expanded. The company is owned by a group of the consultants and staff and is directed by Bill Peters and Bruce Craven (see p. 27 of this issue for an interview with Bill Peters).

SGC works with all types of surface, airborne, and downhole geophysical surveys as well as some marine surveys. The company offers the following services: geophysical project design and management; data processing and imaging; geophysical interpretation; geophysical data compilation and review; remote sensing processing and interpretation; GIS – digitising, compilation and map creation; equipment rental; and multiclient data sales. SGC geophysicists have extensive experience throughout Australasia, Southeast Asia, and Africa as well as working on projects in the Americas, Europe, the Middle East, Russia, the Arctic and Central Asia.

Contact details are:
Southern Geoscience Consultants Pty Ltd
Level 1, 183 Great Eastern Highway
Belmont, WA 6104
Tel: +618 6254 5000
Email: geophysics@sgc.com.au
Website: www.sgc.com.au

Dennis Cooke – President Elect

Dennis Cooke
dennis.cooke@santos.com

Hello, I'm Dennis Cooke, your new ASEG President Elect. It is customary that the ASEG President Elect write a short self-introduction for the ASEG membership – which is the purpose of this short article.

The important things in my life are my family, friends, work and sport ... plus I have a passionate interest in geophysics. I live and work in Adelaide where I am the Chief Geophysicist for Santos. Many of you who have heard me speak will have noticed my North American accent. I have citizenship in three countries: Australia, Ireland and the United States – but my wife and I consider Australia by far the best place to live! We have been here almost 11 years and plan to retire here.

I started my career in 1978 with Phillips Petroleum after receiving a BS degree in Geology/Geophysics from the University of Colorado. Phillips had me working at their research lab in Oklahoma where I quickly recognized that a BS degree in a research lab was a bit 'career-limiting'. So after a year I headed back to school, this time to the Colorado School of Mines. At CSM I received a MS degree in Geophysics in 1982 and a PhD in 1987. While in graduate school, most of my attention was focused on the signal processing part of petroleum exploration, but the course requirements included a minor subject (geology, which I barely passed) and TWO 'foreign' languages – French and FORTRAN. I still don't understand how FORTRAN qualifies as a foreign language, but I did not debate the point. My grad school efforts in geophysics were more fruitful than my efforts in geology and foreign languages; my MS thesis was published and turned into a technique still frequently used today: model-based seismic inversion.

I have worked for four petroleum exploration companies (most now extinct): Phillips Petroleum, Amoco, Arco and now Santos. I chose to study geophysics because I wanted an international career. That worked out quite well and I'm pleased to have lived and worked in Australia, Alaska, Indonesia, Colorado, Texas, and Oklahoma. During that time, I have done prospect generation, field development, seismic processing, research, and technical management. A weak spot in my background is potential fields and the minerals industry in general. I trust my fellow ASEG officers and the membership will help me out there.

My history with the ASEG and SEG includes serving on the last two ASEG–PESA conference organizing committees, representing the ASEG on the SEG's Global Affairs Committee, organizing a few DL and DISC courses and organizing a significant grant from my employer to the SEG's 'Geoscientists Without Borders' program. That grant will be used by the University of Adelaide's Geology Department to study ground water supply for indigenous communities in the Northern Flinders Ranges of South Australia.

What direction would I like to see the ASEG go over the next few years? It's still a bit too early to make any commitments in that space as I'm learning what the membership wants from the ASEG, and what the ASEG's organisational capacities are. However, my initial thoughts are that one major focus for the ASEG should be education – education for the membership and potentially for the Australian public in general.

Some of the drivers behind education for ASEG membership education are:

- Rapidly changing technology in the petroleum and minerals industries.
- Australia's rapidly increasing importance in supplying mineral and energy resources (especially LNG) to the rest of the world.
- Increasing demand for trained Australian geoscientists to work on the above.
- Problems with supplying sufficient trained geoscientists due to an aging workforce, and a history of boom-and-bust cycles in the petroleum and minerals industries scaring off students considering a career in the geosciences.

The main driver behind education of the Australian public would be the climate debate. There are many different *competing* climate models being used to predict our climate future. The believability of those competing climate models could and should be evaluated by comparing their ability to 'history match' climate cause and effect over geologic time. Geoscientists could do more to educate the public about significant past climate change, and help climatologists 'ground truth' their models using the geologic climate record.

The above is a very short summary of me and some brief thoughts about where the ASEG might go. I look forward to discussing the ASEG's mission and direction with you!

Geophysics and Geohazard – Defining Subsea Engineering Risk

Thursday 25 March 2010
Co-hosted by SUT & ASEG

'Geophysics and Geohazard – Defining Subsea Engineering Risk', held on Thursday 25 March 2010, attracted a capacity audience of 79 for this full-day seminar, and gave an excellent overview of this important, but under-publicized, area of offshore activity.

Two presentations have been included as extended abstracts in this issue, starting on p. 35. These are from Dr Bob Whiteley, Coffey Geotechnics Pty Ltd, and Magnus McNeil-Windle, Advanced Geomechanics. Two more extended abstracts by Bill Russell-Cargill, DOF Subsea Australia Pty Ltd, and David White and James V. Hengesh, Centre for Offshore Foundation Systems, UWA, will be published in the October issue of *Preview*. A brief summary of the other presentations follows here.

Appropriately, the keynote address was delivered by **Paul Handidaja, Head Geotechnical Dept, Braemar Falconer Pty Ltd**, on the subject 'Do we have adequate site survey data for Jack-up installation and location approval?' As Paul showed, site survey reports for rig installation or rig moves often have insufficient information, poor data quality or unreliable results. Paul outlined the main objective of a rig site survey, and gave examples of improper site investigation plan, insufficient geo-hazard information, and poor quality control. Such shortcomings create delays and impose substantial risk for jack-up installation. Paul's presentation demonstrated the importance of understanding the site survey report requirements, both to minimise these delays and mitigate the risk.

Julie Gale, Gardline Marine Sciences Pty Ltd, illustrated the use of swathe bathymetry data as a guide to the early identification of potential geohazards, using the data acquired by the Gardline Geosurvey during a 2D regional survey in the North Carnarvon Basin. For this survey, approximately 7000 line kilometres of 2D seismic reflection data were collected alongside swathe bathymetry data in water depths ranging from ~1200 m to 4000 m. Julie demonstrated how regional scale bathymetry data is invaluable for the initial assessment and prediction of potential deepwater geohazards that may be encountered in continental slope/rise settings. Examples of potential geohazards include confined and unconfined sediment gravity flows, regions of potential seabed slope instability which may lead to slope failure.

Steve Wardlaw, Fugro GeoConsulting Pty Ltd, advocated caution when using 3D exploration seismic as the prime dataset for site investigation for deep water wells. Usually, these exploration datasets have seismic acquisition parameters optimised for exploration purposes rather than site investigation, and should only be utilised for the assessment of top-hole drilling hazards with a thorough understanding of the limitations of the data. Steve's presentation looked at typical data limitations, applicable data reprocessing techniques, and the identification and ranking of the different geohazards that impact deep water wells. He stressed the importance of integrating 3D seismic with other sources of available data, including nearby high resolution seismic and geophysical logs and/or geotechnical borings at offset wells. Steve recommended several enhancements to conventional well site reporting, including a prediction of formation pressures from the seafloor to reservoir depths.

Douglas Bergersen, Acoustic Imaging Pty Ltd, illustrated how new visualisation techniques can improve geohazard identification and mitigation. He provided examples of the greater facility of the interpreter to garner information by combining all data in a 3D/4D virtual environment wherein the interpreter had the ability to efficiently navigate around the dataset.

Sheila Mackay, Woodside Energy Ltd, provided a perspective on Woodside's approach to assessing wellbore geohazards. This involves an integrated approach to shallow geohazard assessment, with an integrated pore pressure prediction and wellbore stability analysis. Woodside's aim is to drill safer, smarter, and therefore cheaper wells. Shallow hazard assessment identifies not only geohazards, but also drilling constraints. Sheila provided examples to illustrate the benefits of this approach. Overpressured 'kicks' in the Cretaceous Toolonga Formation have been predicted by identifying the source of these events; allowing the planning of casing points and the design mud weights for safer drilling. The second case study illustrated that by predicting the thickness and percentage of chert in the chert rich beds of the Oligocene/Eocene Upper Walcott Formation, allowed the selection of the most suitable drill bit for the expected drilling conditions, and maximised the ROP for the drilling.

Nicholas Smith, Geophysicist, Fugro Survey Pty Ltd, provided a case study on the application of a four-sensor magnetic gradiometer survey to identify small WWII ordnance in Caution Bay, Papua New Guinea. The proposed pipeline route for the PNG LNG Project runs through an area previously used as a WWII artillery testing range. The possible presence of unexploded ordnance (UXO) posed a hazard to this development, and Fugro Survey Pty Ltd was contracted to identify any potential UXO within the proposed pipeline corridors and infrastructure development areas. The survey area was particularly difficult due to the presence of reef outcrops, strong currents, dense seaweeds and shallow intertidal areas. The magnetic gradiometer calculates the magnetic gradients in the vertical, horizontal and longitudinal dimensions, and produces a total gradient, which has several advantages over standard magnetometer surveys. The gradiometer can detect smaller targets (to 0.1 nT/m, depending on background noise level). It also locates targets directly over their source bodies, removing the bi-polar effect of anomalies and improving positional accuracy. The survey corridors were 100 m or 200 m wide, with a survey line spacing of 8 m. The magnetometer was towed at a constant height of between 2 m and 4 m above the seabed in order to ensure all ferrous objects were detected.

Fiona Fitzpatrick, Marine Geologist, RPS Energy, stressed the need for adequate QC in the geophysical interpretation for geohazards and

Bob Whiteley delivers his presentation (image courtesy of Diversified Exhibitions).

David White delivers his presentation (image courtesy of Diversified Exhibitions).

engineering site surveys. Fiona expressed concern that despite the technological advances in data acquisition and increasing sophistication in data processing and imaging software, interpretation expertise in engineering site surveys had declined and development of interpretation skills stalled. She reflected that there seems to be an industry-wide deterioration of interpretation capability. Often a fundamentally flawed interpretation is repeatedly copied without due geological consideration, and lessons learnt are routinely forgotten. Fiona illustrated some costly interpretation failures that could have been avoided with independent QC on the geophysical interpretation. Regrettably, sometimes emphasis is placed on QC only during data acquisition. Often, the data interpretation, assessment of hazardous conditions and reporting are costed together in one lump sum; immediately constraining interpretation to a time frame rather than the prevailing geological complexities. However, the final site survey results can only be as good as the expertise behind the interpretation. Fiona emphasised that to minimise costly errors, post survey QC is a necessity to identify interpretation shortcomings.

Jim Anderson, Fugro Survey Pty Ltd, demonstrated the application of Fugro's seismic refraction technique for geohazard infrastructure investigations. Variable geological characteristics in shallow seabed substrate, particularly in Western Australia, represent a significant geohazard, but conventional geophysical techniques have struggled to identify and quantify this hazard. Marine seismic refraction surveys are gaining increasing acceptance as a prime geophysical tool for the analysis of sub-seabed conditions. In-situ acoustic velocities measured utilising the seismic refraction technique are related to material strength, and can therefore be used to optimise subsequent geotechnical programmes, such as the assessment of trenchability, dredgeability or other foundation engineering properties. Equipment improvements over the past 10 years allow greater acquisition efficiency in water depths from 1 m to 70 m. A suitable acquisition line spacing allows the velocity information to be gridded and contoured to identify anomalies, or to determine areas which exceed a threshold velocity. Jim illustrated results from recent projects, and showed how these data can be integrated with other geophysical and borehole information.

PDF files of these presentations are available on the SUT website – www.sut.org.au.

Jim Leven
Session Chairman
Department of Commerce, WA

News

Update on Geophysical Survey Progress from the Geological Surveys of Western Australia, Northern Territory, New South Wales and Geoscience Australia (information current at 9 May 2010)

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 five new surveys reported in this issue as well as an indication that a further ten mag/rad surveys are planned under the WA Exploration Incentive Scheme – Phase 2.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Eucla Coast (Eucla Basin 6)	GSWA	UTS	24 Sept 09	121 645	200 m (onshore); 400 m (offshore); 50 m N–S	27 400	100% complete @ 26 Dec 09	TBA	141 – Aug 09 p. 19	8 Apr 10
WA Exploration Incentive Scheme Phase 2	GSWA	TBA	TBA	Ten surveys totalling 1.1075 million line km	TBA	TBA	TBA	TBA	TBA	TBA
Southeast Lachlan	GSNSW	Fugro	1 Mar 10	107 037	250 m (NSW) 500 m (ACT) E–W	24 660	43%	TBA	144 – Feb 10 p. 15	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
Southern Cross	GSWA	Atlas	19 Jan 10	7000	2.5 km regular	41 250	100% complete @ 1 Mar 10	29 Apr 10	143 – Dec 09 p. 21	13 May 10
Gascoyne North	GSWA	Atlas	16 Mar 10	7400	2.5 km regular	45 410	59%	TBA	144 – Feb 10 p. 15	TBA
Albany – Fraser North	GSWA	TBA	Quotation request released mid-May	9200	2.5 km regular	50 980	TBA	TBA	This issue	TBA
Sandstone	GSWA	TBA	Quotation request released mid-May	6300	2.5 km regular	35 640	TBA	TBA	This issue	TBA
South Gascoyne	GSWA	TBA	Quotation request released mid-May	9700	2.5 km regular	55 760	TBA	TBA	This issue	TBA
West Arunta	NTGS	TBA	Mid-May 2010	12 426	4, 2 and 1 km	89 985	TBA	TBA	This issue	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	TBA	Mid-May 10	34 986	5000 and 2500 100 m E–W	95 450	TBA	TBA	This issue	TBA

TBA: To be advised

Figures 1–3 show the locality diagrams for three new gravity surveys in WA – Albany-Fraser North, Sandstone and South Gascoyne. All three surveys will measure gravity on a regular 2.5 km grid. A fourth new gravity survey is planned for West Arunta in the Northern Territory (Figure 4). Over 12 000 stations on a variable survey grid of 4, 2 and 1 km will cover a survey area of almost 90 000 km^2.

Figure 5 shows the locality diagram for a new AEM survey in Frome, South Australia. Almost 35 000 line km of data will be collected on E–W flight lines with spacings of 5 km, 2.5 km and 100 m.

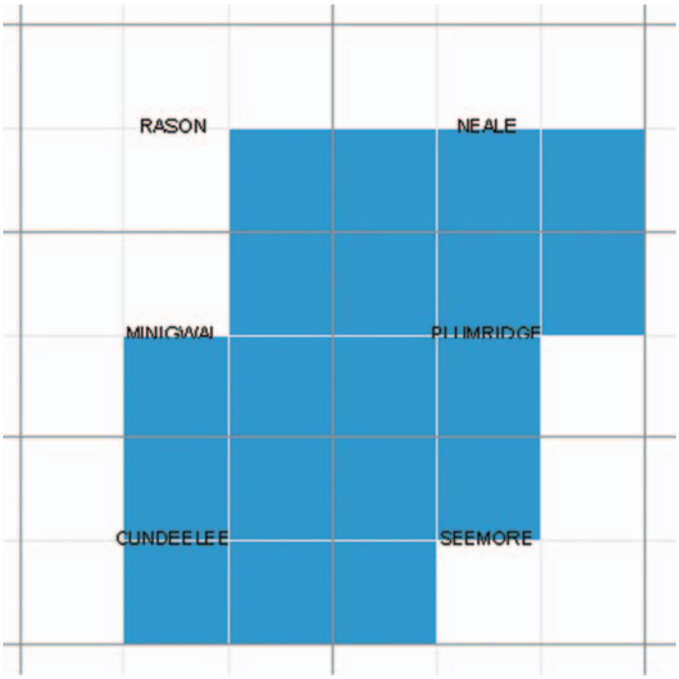

Fig. 1. *Location diagram for the Albany-Fraser North gravity survey in WA.*

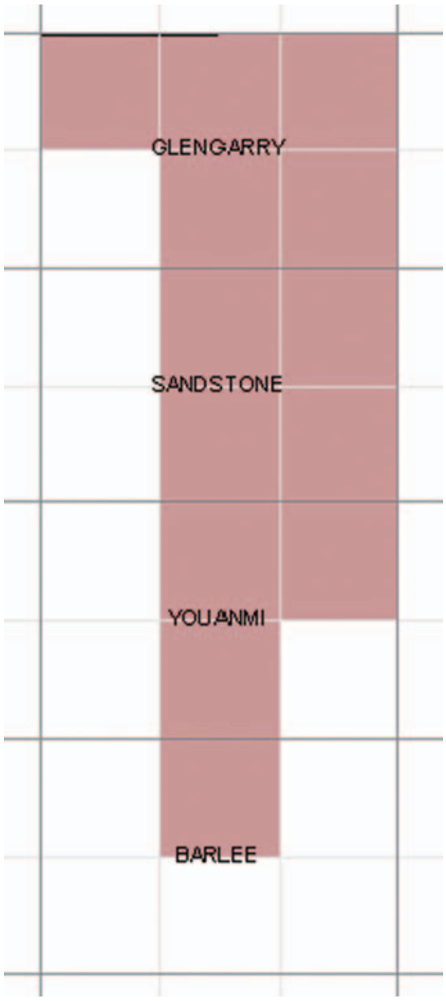

Fig. 2. *Location diagram for the Sandstone gravity survey in WA.*

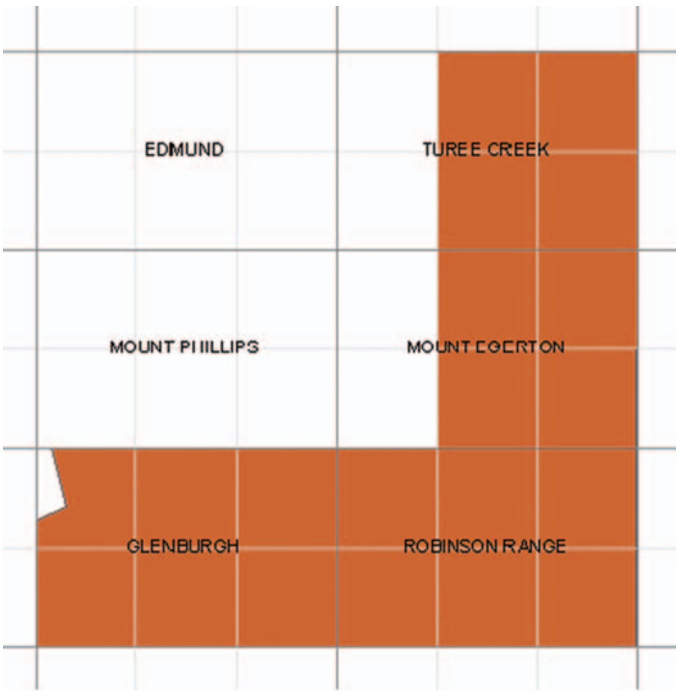

Fig. 3. *Location diagram for the South Gascoyne gravity survey in WA.*

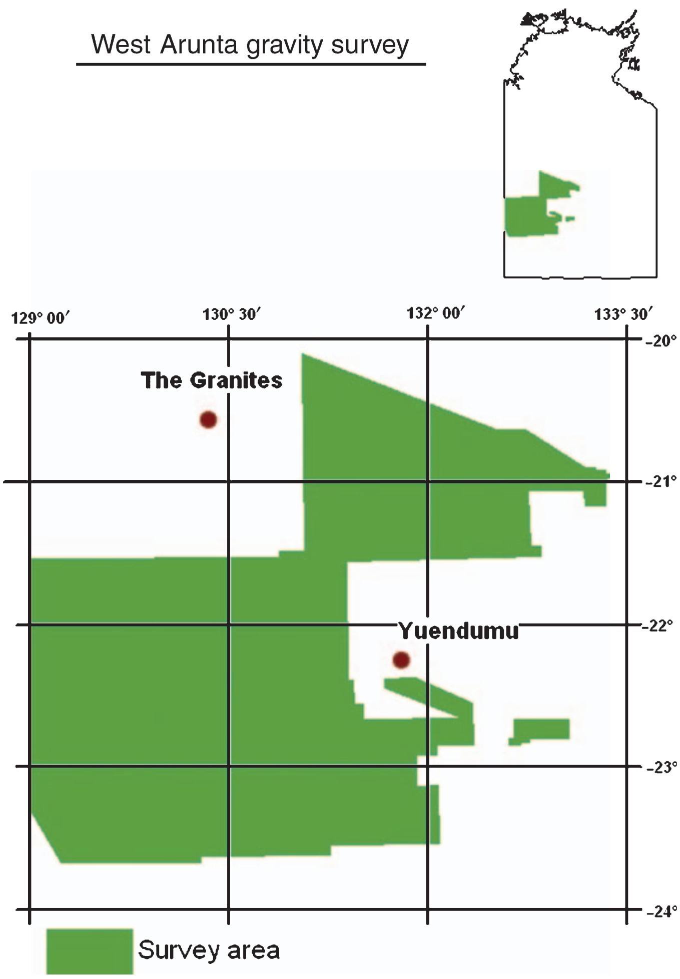

Fig. 4. *Location diagram for the West Arunta gravity survey in NT.*

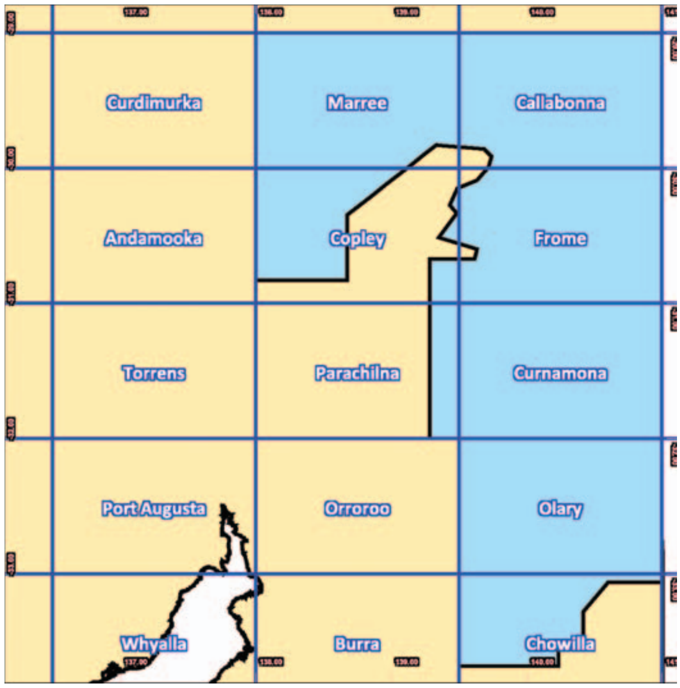

Fig. 5. *Location diagram for the Frome AEM survey in SA.*

Recent PIRSA geophysical activities

Radiometric streaming surveys are continuing with a further 8210 km recently completed, covering a total of 32 airborne surveys. Areas covered include, the South East, Yorke Peninsula, Tallaringa and the Flinders Ranges to Curnamona region. The resulting levelled datasets will be merged into the next State radiometric map release. The processed line data gathered to date compliments the recent AWAGS2 data acquired by Geoscience Australia (see Figure 6). Field acquisition has been extended to include detailed vehicular grids, and preliminary surveying for GSB project areas.

Geophysical maps and interpretations have been completed to assist both the Tallaringa-Ooldea and Mingary Solid Geology map productions. These interpretations include gradient strings (worms), Magnetotelluric (MT), and basement depth calculations.

A geophysical interpretation has been completed in order to provide additional data for a 3D geological model currently being produced for the Athabasca Basin in Canada. A comparative study has been commenced between this basin, and the Carriewerloo Basin in South Australia. Preliminary geophysical interpretations have been completed and planning of an AEM survey is in the final stages. The stratigraphy of interest within the Carriewerloo Basin is the base of the Pandarra Formation.

During this period, the Mount Deception Gravity Survey report has been released. This survey comprised the acquisition of 400 new stations over a tenement held by PIRSA under Section 15.

The collection of new Magnetotelluric Data within South Australia has continued. Previously 15 soundings had been acquired along the Curnamona–Gawler Seismic line in 2009. This data has been complemented with a further 18 stations that were acquired during April of this year. The station spacing for the entire 33 soundings is 10 km.

This new MT data will compliment the current deep seismic data recently collected, and results will provide a further insight into the subsurface structure ranging from the near surface down to depths approaching the mantle.

A new depth to crystalline basement grid, based on current open file drill-hole data, has been produced. Additionally, investigations into new basement depth determination methods are continuing.

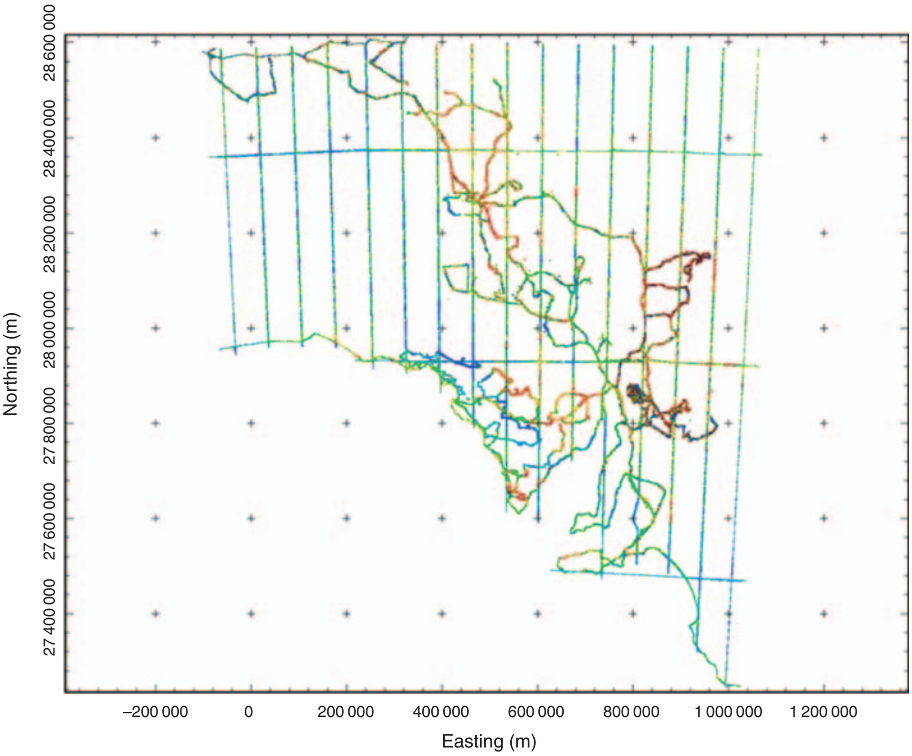

Fig. 6. *Merged AWAGS2 and vehicular streamed traverses over South Australia. Note: recently acquired data is not indicated on this figure.*

Data is currently being collated to assist in the development of a new Petrophysical database. This information will aid in the production of constrained inversions of existing potential field data, which in turn, will compliment future 3D Geological models.

Lastly, the annual South Australian Resources and Energy Investment Conference (SAREIC), was held in Adelaide during the first week of May. This conference was an outstanding success with a MER Technical Forum, held on day three, and a Seismic Workshop on day four. Feedback from conference participants was extremely encouraging.

Gary Reed, PIRSA
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New southwest margin data

In April, the Minister for Resources and Energy, Martin Ferguson AM MP, released new pre-competitive data from Geoscience Australia's offshore Southwest Margin Project (see http://www.ga.gov.au/oceans/ppp_SWMargins.jsp). The data were released in the form of a data package that contained 7300 line km of new 2D seismic data, coincident gravity and magnetic data and 11 700 line km of reprocessed 2D seismic data (see Figure 7 for seismic survey line locations). These data were collected during one of two major surveys undertaken to investigate the resource potential of deep-water frontier basin areas on the southwest margin of Western Australia. In addition to the above seismic survey, Geoscience Australia also acquired 230 000 square km of new swath bathymetry data and accompanying gravity and magnetic data during a marine reconnaissance survey. Areas investigated included the Mentelle and northern Perth Basins, the southern Exmouth sub-basin (Northern Carnarvon Basin), the Southern Carnarvon Basin and the Wallaby Plateau.

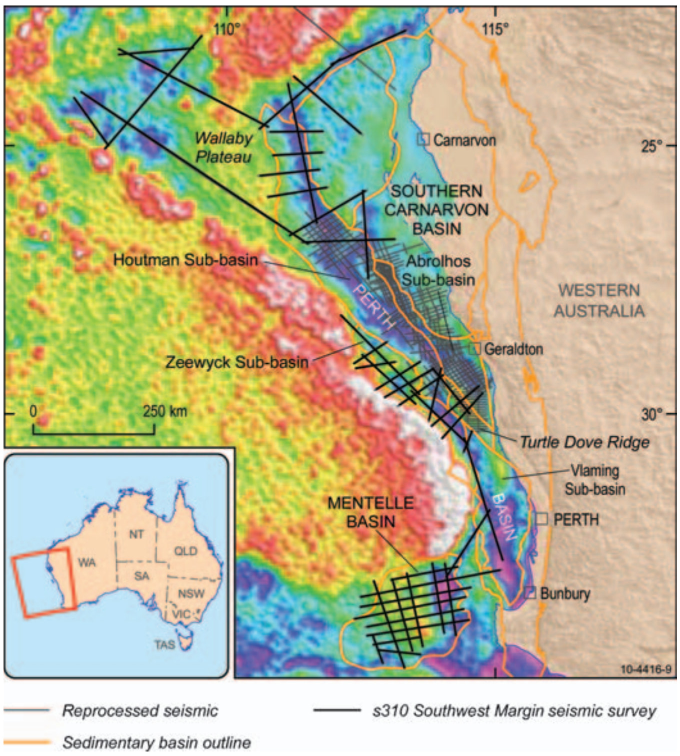

Fig. 7. *Southwest Margin seismic survey lines, reprocessed seismic and sedimentary basin outlines overlain on a residual gravity image.*

AuScope: building a science capability for the Australian continent

Bob Haydon
CEO, AuScope. Email: info@auscope.org

An infrastructure program to deliver a strategic capability for the Australian continent

A seamless, accessible and fully integrated system of technology, data and knowledge – this was the vision of Australian Earth and Geospatial community for the future requirements for earth science research when, in 2007, the Australian Government supported a major investment into strategic research infrastructure to understand the structure and evolution of the Australian continent. AuScope was established to manage the creation and development of this geoscience infrastructure system that would see Australia maintain a leading position in earth science and geospatial research, and position it to meet challenges facing Australia in the future that are critically dependent on integrated research in the earth sciences. As the final year of the program approaches much of the contracted infrastructure is established and accessible to the science community. This represents a first major step in meeting future requirements and is a solid starting point for ongoing investment.

The proposed AuScope Research Infrastructure was designed to deliver excellence in the following ways:

- **Acquisition of targeted world-class technology** – for example: constructing three world class radio telescopes, a national roll-out of innovative CSIRO hyperspectral logging systems, and contributing to the new generation Ion Microprobe facility.
- **Building on existing excellence** – for example: enhancing earth imaging facilities, developing simulation and modelling software, and supporting world-class facilities for determining age and composition of Australia's geology.
- **Integration and collaboration driven by high-profile national programs** – for example: facilitating the National GeoTransects Program and major improvements to the National Geospatial Reference Framework.
- **Building world leading data/information management, interoperability and accessibility systems** – by building on SEEGrid, APAC Grid, Earthbyte and other developments; accelerating development of GML, XMML and other languages designed to deliver broad-scale interoperability; and delivering seamless data/information access to researchers for the first time.
- **Taking advantage of investment scale provided by other national programs** – for example: modest investment by the National Collaborative Research Infrastructure Strategy (NCRIS) in Earth Imaging to deliver access for the research community to arguably the most ambitious national seismic/MT profiling program ever undertaken in any country (through Geoscience Australia's Energy Security program and ongoing investment by State and Territory agencies and industry), and integration of National Geospatial Reference Framework into ongoing investment in high-resolution spatial systems by states and industry.

Collaboration is a key for success

This ambitious program had its roots in 2004 when the Australian Government recognised (*Backing Australia's Ability: Building Our Future through Science and Innovation*) that a prosperous economic future in Australia would depend on a world class science base for improved and sustainable discovery, development and management of its minerals, energy and groundwater assets. In turn, this science base would be dependent on world class research infrastructure. The NCRIS was initiated to fund 13 national capabilities through a 5 year investment of over $500 million. The 'Structure and Evolution of the Australian Continent' was one of the 13 capabilities and received $42.8 million. This program of investment into the Australian Continent was developed through a consultative process lead by facilitator Dr Mike Etheridge and managed through AuScope Ltd on behalf of 23 collaborating partners across Australia including CSIRO, Geoscience Australia, 11 universities, and state government agencies involving all geological surveys and lands departments. In addition to the NCRIS funding, over $70 million in co-investment has been committed by the partners in AuScope making the total investment of almost $120 million one of the most significant recent investments to support research into the Australian continent.

The AuScope vision and Infrastructure System

The vision for AuScope was to create 'A National Geoscience and Geospatial Infrastructure that would provide the data, technology and analytical tools to transform our understanding of the Structure and Evolution of the Australian Continent'.

The cornerstone to the vision was recognition that infrastructure for the Australian continent not only included major items of physical equipment and instrumentation, but also significant datasets requiring large investments; software infrastructure to model and analyse these data and a grid computing infrastructure that would facilitate discovery and access to data across the Australian continent held in a variety of forms in a range of institutions. A major shift was required in relation to organising and providing ready access to the data, information and knowledge that result from use of the infrastructure and making it available inside and outside the research community.

The AuScope Infrastructure System was designed to enable easy access to data and information to enable construction of a multitude of models for the Australian continent and its immediate environs. The system and the derived models aim to transform the research landscape in earth science. The AuScope Infrastructure System is built from five functional components:

- Earth Composition and Evolution;
- National Virtual Core Library of rock materials and properties;
- Earth Imaging and Structure;
- Simulation, Analysis and Modelling;
- Geospatial Framework and Earth Dynamics – all enabled by the AuScope Grid.

The system is shown diagrammatically in Figure 1.

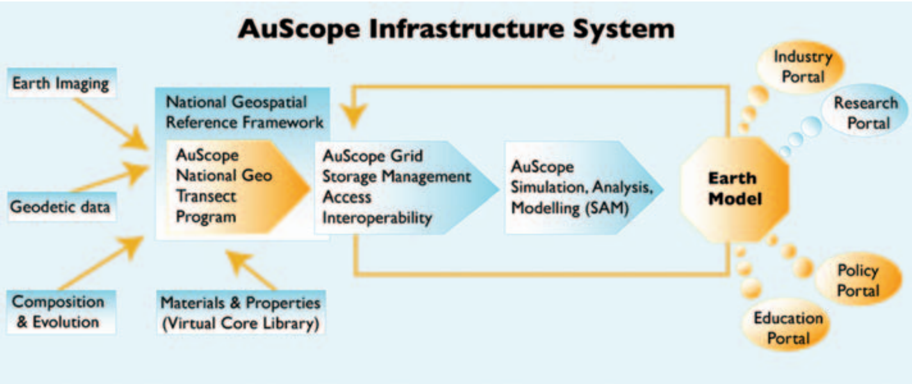

Fig. 1. *AuScope's Infrastructure System.*

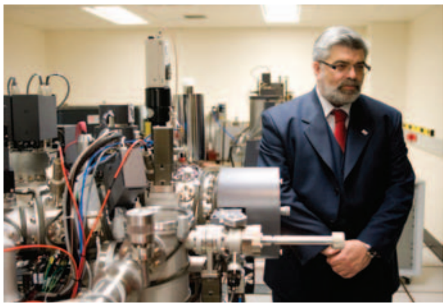

Fig. 3. *The Hon. Kim Carr, Minister for Innovation, Industry, Science and Research, cuts the official ribbon at the launch of the Cameca 1280 ion microprobe.*

Current progress and outcomes

As AuScope approaches its final year, there is strong evidence of the importance of the many partnerships across the nation in delivering the infrastructure and providing the platform for future research of both a fundamental and applied nature.

The main objectives and some highlights from each of the components are summarised for each infrastructure component.

AuScope Grid

The Grid has to date developed an interoperable spatial information service that is the basis for implementing a range of web-based data delivery services via the AuScope Portal. Although not fully implemented and populated yet, examples of these webservices include: Geodesy Global Navigation Satellite Systems (GNSS) workflow and portal map products; Virtual Rock Laboratory; National Virtual Core Library; AuScope Geotransects data and imagery (Figure 2); GPlates simulation software; mineral occurrence mapping; 3D mineral map of Australia through C3DMM WA CoE; geothermal simulation using AuScope Underworld software.

Core Grid infrastructure is now operational and ready for incremental improvement and uptake over the remaining term of AuScope.

Earth Composition and Evolution

This component has provided new geochemical instrumentation and improved access to existing geochemical infrastructure.

The major infrastructure was acquisition and establishment at the University of Western Australia (UWA) of a new-generation Cameca 1280 ion probe that was installed and opened by the Hon Kim Carr on 28 August 2009 (Figure 3). Routine operation has commenced.

In addition to this new equipment, technical and other operational support for the provision of national access to existing instruments, infrastructure, expertise and technical support at key Australian geochemical research centres is part of the program and includes:

- Access to instruments at the John de Laeter Centre of Mass Spectrometry at UWA/Curtin University, for the principal purpose of undertaking high precision geochronology through access to SHRIMP ion probes and mass spectrometers.
- Access to the range of thermochronology facilities at the University of Melbourne where the specific facilities include the Ar/Ar, fission-track and (U-Th)/He laboratories.
- Access to the TerraneChron® facility at Macquarie University for *in-situ* analysis of zircon to obtain the age and the isotopic and trace-element fingerprint of each grain.

National Virtual Core Library

The infrastructure to be built and deployed in the National Virtual Core Library project will consist of seven robotic, automated spectroscopic machines in each of seven nodes housed in each State and Territory Geological Survey. Each robotic instrument consists of high-sensitivity visible and infrared spectrometers, a linescan camera, laser profilometer, robotic x/y table, control software, and a control and data management computer.

Six HyLogger systems (Figure 4) have been commissioned and installed at GS NSW, PIRSA, GSWA, GSQ, MRT and NTGS. Core scanning has commenced

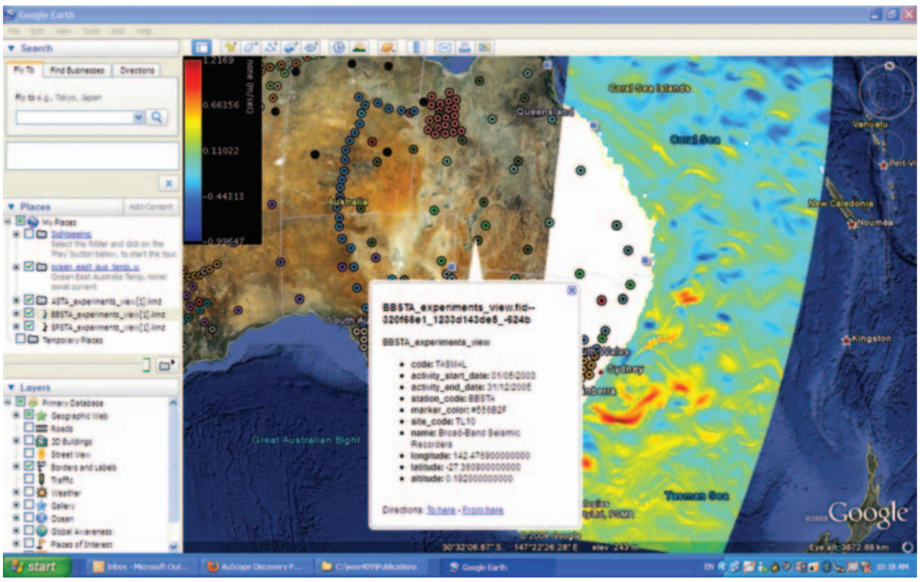

Fig. 2. *Portal release showing just the Earth Imaging seismic recorder locations and the pop-up showing some of the information available about that particular project (project name, start and end date).*

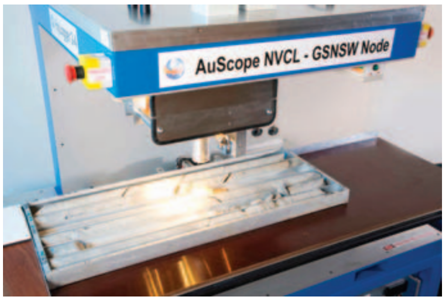

Fig. 4. *GS NSW HyLogger was installed at Londonderry NSW, 15 May 2009.*

and some 50 000 m scanned to date representing the start of an exciting program to develop a virtual core library for the Australian continent. The seventh Hylogger for GSV is due for installation late in 2010.

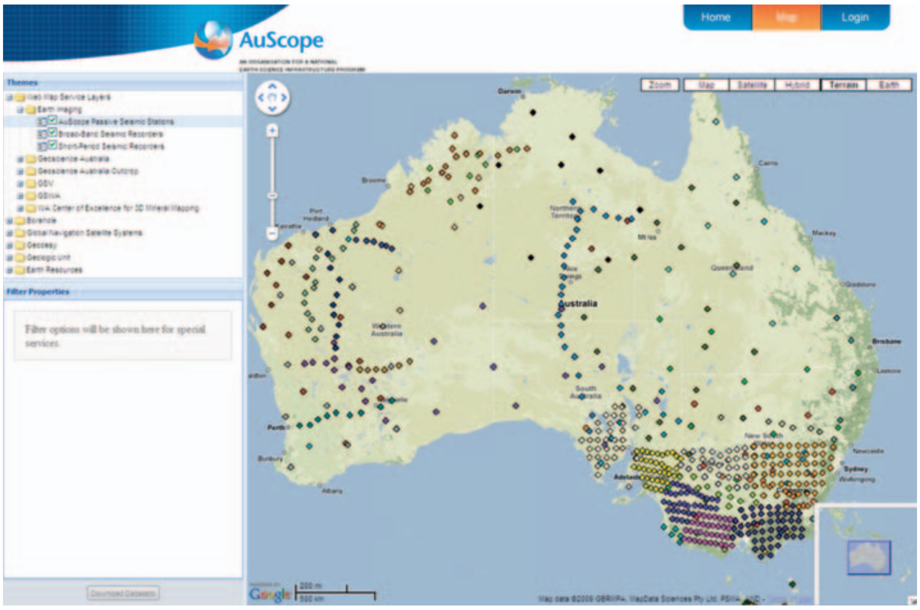

Fig. 6. *Seismic station locations and projects from AuScope's Earth Imaging component.*

Earth Imaging and Structure

Earth Imaging is the core component of the AuScope National GeoTransects Program through which seismic and MT data acquisition and imaging has been undertaken along transects, together with the swaths of passive seismic arrays that straddle the transects (Figures 5 and 6). These techniques provide images of the subsurface along sections through the Australian continent, and thereby provide the essential framework for building earth models. Australia is a world leader in these techniques and their application to continental structure and evolution.

The AuScope funding has provided for upgrade of equipment pools of existing passive seismic and MT equipment to present state-of-the-art. Acquisition of ~250 line-km per annum of seismic reflection and MT imaging will be completed by the end of the program and investment is also made to operate and maintain the instrumentation.

To date the AuScope investment has contributed to major seismic transect programs in SA and NT, Mt Isa region and Western Victoria. One more major program in the Capricorn region in WA will be completed in AuScope's final year.

Fig. 5. *Seismic work being undertaken alongside the Ghan railway.*

Earth Simulation, Analysis and Modelling

The AuScope Simulation, Analysis and Modelling program is a toolkit that makes extensive use of software, techniques and expertise developed through the Australian Computational Earth Systems Simulator (ACcESS) Major National Research Facility and Predictive Mineral Discovery (***pmd*CRC*) activities. The NCRIS funds have been used principally for development and enhancement of software codes for numerical simulation of earth processes, plus deployment and maintenance of previously developed software (Figure 7).

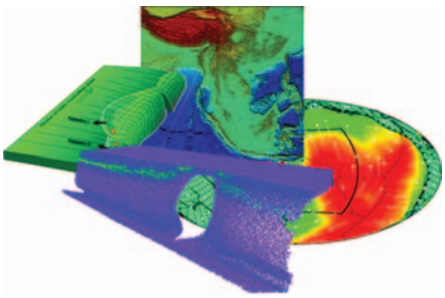

Fig. 7. *A goal for Simulation and Modelling – Tectonics and Geodynamics is to create a workflow for linking rigid plate kinematic models with mantle convection and plate deformation combined with a library of subduction process simulations.*

To date, scheduled software releases for simulation of earth processes – Underworld, Gplates, pPlates, Escript, ESyS, Particle, ESyS_Crustal – have occurred regularly during the program to provide important applications for geodynamics, mining, energy, natural hazards and exploration.

Geospatial Framework and Earth Dynamics

The geospatial component of AuScope is establishing and will operate a comprehensive national geodetic infrastructure at increased levels of accuracy and time resolution. The new geospatial infrastructure will generate a significant quantity of data that will be used to improve the accuracy of Australia's Reference Frame to facilitate better science and greater efficiencies in industry. The AuScope infrastructure enhancement will promote research into refinement of each of four key geodetic techniques and ultimately their combination into a better reference system. It will also provide a far greater temporal and spatial distribution of observations to be used in understanding the dynamics of the Earth.

The key geospatial infrastructure investment comprises new and upgraded Very Long Baseline Interferometry (VLBI) systems and Satellite Laser Ranging facilities together with GNSS ground stations and receivers, and gravity measurement instruments.

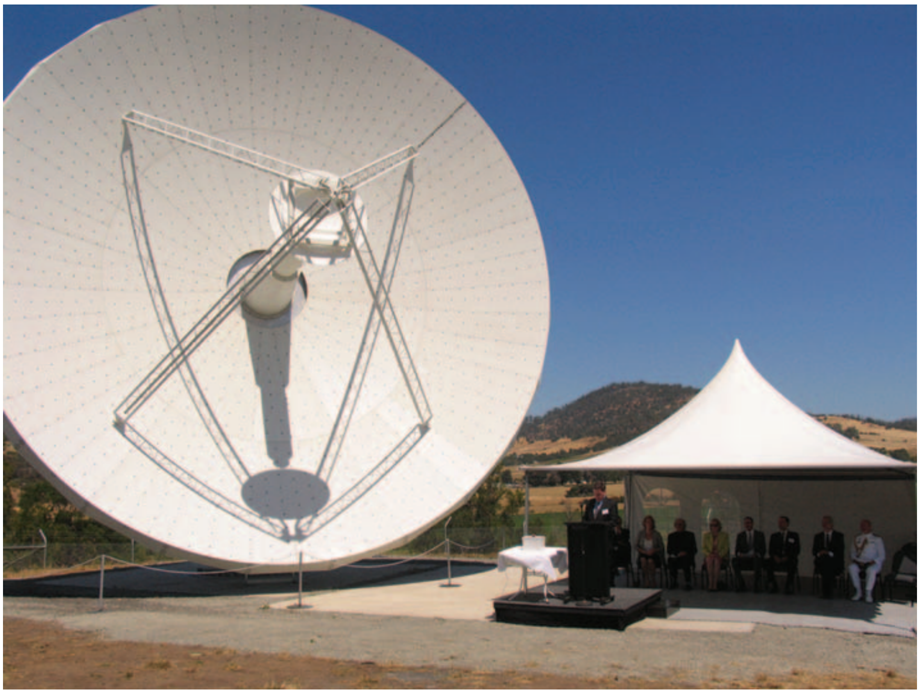

Fig. 8. *Dr Jim Lovell acts as MC at the launch of the Mt Pleasant 12 m Telescope in Tasmania on 9 February 2010.*

To date an FG5 absolute gravimeter, gPhone Earth Tide gravity meter, plus two gPhone relative gravimeters have been acquired. Installation and commissioning of the first of an array of three 12 m VLBI antennas at Hobart has been completed (Figure 8); installation of the antennas at Yarragadee and Katherine are close to completion.

In parallel with the gravity and VLBI, the GPS program will construct 85 GNSS sites across the nation. Approximately one-third of these stations have been established with the remainder to be completed in the remaining term.

AuScope promotions

AuScope will be attending a range of conferences and meetings throughout the remainder of its tenure to promote and create a fuller awareness of the developments within each component and the achievements of its infrastructure program: FIG 2010; AESC 2010; eResearch 2010; ASEG 2010; Seismix 2010; GEO-COMPUTING 2010; ASEG 2011; and IUGG 2011. These events will be attended by AuScope personnel who will be available to explain in depth the potential applications and impact of the program for Australian earth science research.

In particular, AuScope will present a 1-day Topical Symposium held as part of the AESC Program, July 2010 where it will offer a view of the progress made in each component; the integration of the infrastructure and its impact on earth science research organisations together with the implications for future earth science infrastructure needs.

AuScope post 2011

As part of the organisation's concluding activities between now and mid 2011, AuScope will engage in a process of consultation to determine future infrastructure requirements for Australian earth and geospatial science. The success of this infrastructure program to date has only been possible through the strong collaboration amongst Australian and international partners, underpinned by NCRIS funding – a visionary collaborative infrastructure program. After 2011, future Australian earth science infrastructure development will be well-positioned to build upon the positive collaboration between government, education and industry sectors developed through programs like AuScope. The AuScope Infrastructure System will help harness Australia's intellectual capacity to new physical and data infrastructure. This will help focus and direct critical components of earth and geospatial science at Australia and Australian issues in a context of the dynamics of the continent on which we live.

More information on AuScope, its activities and access arrangements for the facilities, software and data can be found on our website at http://www.auscope.org.au

Proposed new mining tax: friend or foe?

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When the government's official response to the Henry Tax Review was released on the 2nd of May, a significant proportion of directors of the almost 800 listed resource companies in Australia were quietly excited. Finally, exploration costs in Australia would be fully tax-deductible from July, 2011, regardless of success. Whilst different to the often lobbied for flow-through shares scheme whereby tax deductions are passed to the individual equity investor, under the proposal companies would be able to carry and deduct all Australian exploration costs from future tax. What's more, they would be transferable between projects and companies, thus encouraging further Merger and Acquisition activity at the small end of the market. There would also be a potential cash rebate at the company tax rate.

As the news was digested by industry executives, journalists and commentators, those with the most to lose quickly gained the front page exposure, and explorers by and large kept quiet. You can understand why. A large proportion of junior exploration companies rely on the majors for funding, and the majors would be hurt by this tax. Even those that don't have current Joint Ventures may one day, so no MD wanted to be seen crowing about how it may benefit their company. If it was bad for the industry, it was bad for everyone.

Briefly, for those not familiar with details of the proposed Resources Super Profits Tax (RSPT) the Federal Government proposes to tax gross mine profits at the rate of 40%, subject to certain deductions, and apply a reduced corporate tax rate (29% in the first year, 28% in year two) on the balance before handing back State royalties already paid. Accelerated depreciation over five years would be applied using a 'capital uplift' based on the 10 yrs bond rate (currently close to 6%). Effectively, those highly profitable iron ore projects would now be taxed at 57%, lifting Australia into one of the highest taxed countries globally.

The net benefit of the tax in the long run according to the modelling would be a 0.3% GDP uplift, and a 0.2% rise in household expenditure, so the 'average Australian' would be better off. Those marginal projects which have been sitting on the shelf might now come into production, and in times of low prices, the tax actually makes a mine more profitable, thus overall mining activity should increase. This is the theory.

The modelling appears to work well on paper, in a world where commodity prices are flat, production rates remain the same every year, and the mine has an ideal economic life (10 yrs). For a new project, with say, A$1b in upfront capital expenditure, and consistent production and cost levels, cashflow is actually improved for the first (critical) five years of the project, and the resultant Net Present Value (NPV) may rise, thus becoming a more attractive investment. Those projects which have been around for a long time, with most of their capital already depreciated or written down, would pay relatively more tax, effectively subsidising start-up projects. The impacts are very project specific however, and in general, the more profitable a project, the higher the effective tax rate.

Where the modelling runs into problems is that mines often have periods where profits are very high in the first year or two due to grade or mining reasons. Here you get hit very hard by the tax early on and then only get to carry your uplifted capital expenditure at a 6% pa rate, which is below the industry cost of capital, thus your NPV actually reduces.

Another issue is the apparent bias towards projects which have a higher state royalty (such as coal) which is rebated. For new capital allocation, an investor may be better off investing in a coal mine than a gold mine with similar 'normal' profitability, due to this distortion. The amount of royalty to be rebated appears undecided, with potential caps. Could rising State royalties potentially undermine the tax?

There are other issues which appear difficult to quantify and model, and those include the potential for the complexity and 'face value' of the tax to deter foreign investors, who compare projects on a global basis; the cost of cancelling or delaying multi-billion dollar projects which may be worse off by commencing production ahead of the tax introduction; and the impact of rapidly fluctuating commodity prices and currencies.

Any tax which reduces the amount of capital available has the potential to lower levels of investment in new projects and exploration. Reported profits by some mining companies under this scenario could be dramatically reduced, hence less money available for franked dividends, and less money for shareholders to potentially reinvest in the industry (of course anyone who invests

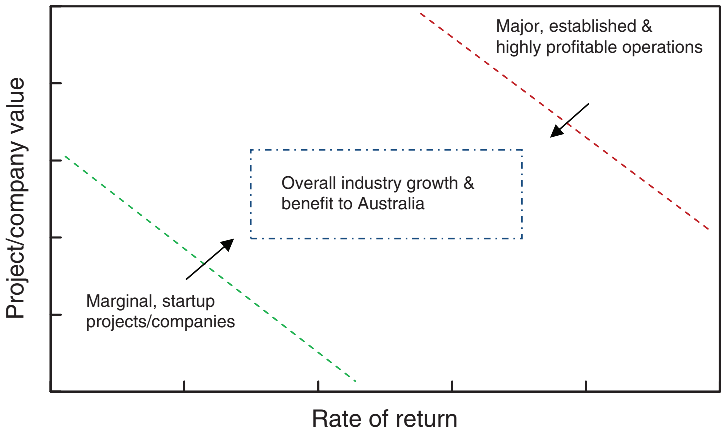

Fig. 1. *A schematic representation of the RSPT.*

in a mining business in the hope of dividends should have learnt their history lesson by now).

The government paper referenced Norway and the United States as peers. Norway is a unique situation due to the rich oil reserves, however employment levels and GDP contribution in the United States from the mining and quarrying sector continues to decline as mining becomes less cost-competitive on a global basis.

Mining companies and the shareholders who back them take huge risks compared to other investment opportunities. There are already insufficient shareholders in Australia to support the ever-growing number of resource companies either with or seeking a stockmarket listing, and the proposed new tax does represent a further hurdle for investors.

Can the industry afford to pay more tax? Yes, I think it can, and a compromise may be achievable centred around treatment of existing projects, and the capital uplift rate. However we are treading a fine line here. The 0.3% GDP impact highlights just how fine, and perhaps this may be attributed to the additional work going to accountancy firms as they seek to structure new methods to reduce the impacts. So if the tax works? A small economic impact. And if it doesn't work? We could end up like the United States, with an industry in decline.

Geoff Muers is a Research Analyst with Shaw Stockbroking. He has a background in consulting to the mining and engineering sectors, and qualifications in geology and finance.

Bill Peters – Consulting Geophysicist and Managing Director, Southern Geoscience Consultants

Bill Peters was one of the founders of Southern Geoscience Consultants in 1985. He has been working as a consulting geophysicist for over 25 years and is well known to many in the exploration industry. The following interview was conducted at SGC's new and spacious offices in Belmont, WA. As I was leaving, one of Bill's colleagues, David Isles, commented that SGC was possibly one of the most exciting and interesting geophysical environments to be working in today – a pretty good testimonial I think. Warm thanks go to Bill for taking time in his very busy schedule to tell us a bit about his career so far and to share his thoughts on the big issues for mineral geophysics in the future.

How did you come to be a geophysicist and what is your educational background?

I always wanted to be a geologist and I followed that path at UWA studying geology. I discovered that I liked physics too so followed both subjects through into second year. Then I learnt about geophysics and decided that was what I really wanted to do. It was pretty hard at UWA at the time because there was no real geophysical course so I cobbled together a kind of double major in hard rock geology and physics. I completed my degree with Honours in geology but with a geophysical focus – that was in 1972.

How did your geophysical career develop after you left University?

My first job was with McPhar Geophysics doing IP and gravity surveys in the Pilbara and Goldfields. In early 1974 I quit to travel through North and South America for about nine months. I ended up back in Seattle and just started writing letters all around the world to see if I could find work. Much to my surprise I received a telegram from Anglo American offering me a job in Johannesburg, without an interview and sight unseen.

Anglo bought me a plane ticket to Johannesburg and for the first three years I worked based in their Head Office as part of a team of four or five geophysicists servicing Anglo American and De Beers in Africa and elsewhere. It was a great learning experience for me – great people, great company, and essentially I got of all my geophysical training on the job. Anglo had all their own equipment including their own DC3 survey plane – I did IP & EM surveys in what was Rhodesia, SW Africa, Botswana, etc. then with the airborne EM aircraft for a year or so around southern Africa; worked on marine diamonds seismic surveying the coastline from Oranjemund up towards Luderitz (six months dodging the seals, hyenas and jackals and towing Land Rovers out of the sea!). Then I was moved to Cape Town and made responsible for geophysics in the Cape Province – mostly looking for uranium and base metals in Namaqualand, Bushmanland and the Karoo. I actually discovered a uranium deposit while doing AEM surveys for base metals, which is now under feasibility study I believe.

So, I was in Africa for about six years during which time I met my wife and we had our first child. In 1980 we decided it was time to try and move to Australia. This was 1980. Lots of companies were hiring at that time and I chose to join BHP – I was responsible for their diamond geophysical work in WA doing mainly airborne surveys with helicopter follow up plus a little bit of work on iron and gold exploration. I was only with BHP for about two years and then I was approached to be a consultant based in Sydney spending half of my time with Dighem Australia on helicopter EM surveys and the other half doing Teck's geophysics in the eastern states. The work was interesting but it was a difficult time in the market again and it was hard to get any work for Dighem, so the role virtually evaporated and we decided to return to Perth.

So, in 1983 I started knocking on doors and offering my services as a consultant. I was spending about half my time doing geophysics and the other half writing geophysical software for companies like Esso – writing in HP Basic, which I have totally forgotten how to do now! I was working on my own at that stage – I enjoyed consulting and it was very successful. I had good clients and an interesting workload.

Can you tell us a bit about Southern Geoscience Consultants and how it got started?

At the time that I was consulting solo I was doing a lot for CRA. John Ashley was consulting in the same office for Hamersley Iron and we got talking about working together. Greg Steemson was also keen and the three of us decided to get together and establish Southern Geoscience Consultants. That happened in 1985 and we bought the building that we had in Ardross. It was a very small operation – we didn't have any employees for quite a while. SGC now comprises 25 people – 18 are geophysicists and we are in the process of hiring 3 or 4 more geophysicists. About two years ago a significant change was when we finally realised we couldn't carry on as we were, and hired a business manager.

Is the growth of bigger consulting groups, like SGC, a reflection of the way geophysics is used by the industry now? Is it more consultants rather than in-house?

Yes, much more. Back when I first started there were very few consulting firms and most of them were quite small. Most companies had their own geophysicists – AMAX, BHP, Kennecott, Anaconda, etc. – and now we would have more geophysicists at SGC than perhaps BHP and Rio Tinto combined. Very few small companies even consider having a geophysicist. It has been a big change and not many companies now retain in-house geophysicists.

So what has driven that change?

I'm not exactly sure – probably recognition that in the long run it is probably cheaper to do it this way. Also, they get the benefit of having the expertise and support of a large number of geophysicists. If the SGC geophysicist working on a particular project is not available for some reason, there is usually another geophysicist who can help the client.

And do you think the diversity of techniques and instrumentation available has also contributed to the rise of the consultant?

Yes, because we have so many people and they have a diverse range of backgrounds and experiences. We have people who are individually strong say in IP, or in EM, or airborne data processing, etc. We have people who are capable of dealing with virtually every type of geophysical technique with the exception of reflection seismic.

Did the GFC impact on your business at all?

Not as much as we thought it would. When it happened, we got butterflies like everyone else. At the time, we were six months behind with our workload anyhow, so we figured that perhaps we would experience a slowdown come March 2009. So, some of us headed out overseas and did some marketing and came back with some strong leads, none of which we followed up because we have been too busy! So, in the end we never ran out of work and it didn't have much impact at all.

From the consultant's point of view, what have been the most important technical developments over the last 10 or 15 years?

GPS and the Internet are definitely some of the most important ones. The immediate accurate positioning of data and the capability of instant data transfer from the remotest of places is an amazing advance. Of course, you can always talk about the developments in computer storage and technology. You can collect a much larger amount of data spatially in the time available at a reasonable cost, so you get a much clearer and more reliable picture – you are not just dealing with one or two points. The instrumentation is much more powerful, it enables you to see much deeper than you used to. The great thing about being a geophysicist is that the job never ends! You can always go back and do a better job on an area that has already been surveyed before. For example, if you surveyed an area with AEM fifteen years ago, you can now go back with a new, powerful helicopter TEM system and do a far better job.

Bill Peters stands next to a survey helicopter in Narsaq, Greenland, 2007.

What is the most interesting or challenging field location in which you have worked and why?

I've been to Greenland twice and look like going back again this year – organising and supervising helicopter magnetometer–spectrometer surveys looking for rare earths, uranium and iron ore. I've flown four projects for various clients over there so far. It is very interesting first of all because it is a very scenic and remote place. Also, handling the logistics yourself makes it interesting – flying the helicopter survey fuel out to the ice cap with Sikorsky helicopters, for example.

But I've travelled and worked all over the world – in the Sahara in Algeria, a lot in Vietnam, China, Laos, India, throughout Africa, Canada, etc. I've had some nice jobs – lecturing in Hawaii for CSIRO for example – and some difficult jobs. Working for the UN in Algeria was quite tough because I didn't speak French well and most people didn't speak much English, and most of the material I was using was either in French or Russian. But there was no job that was especially difficult – all jobs have their challenges and rewards.

What are the key challenges for exploration geophysics in the future?

People. Everyone knows this, but there are just not enough trained geophysicists coming through the system. In our company for instance, there is a very distinct gap between people like myself in their late 50s and the next group who are in their mid 30s. We have virtually nobody in the 40s age group. The problem that faces us is then succession planning, although we have some very good people in their 30s coming through the system.

What about the graduates coming through – have you got enough and are they good quality?

Most of our graduates used to come from Curtin, but many of them seem to be going to oil now. To be quite honest we don't know about any of the minerals graduates coming from Curtin these days – they seem to be snapped up before we even see them. In our current round of recruitment we will employ somewhere between 2 and 4 people. We've been quite pleasantly surprised to have received around 50 applications and there are some good one or two year out graduates, but most of them are not from WA. Rather they are from interstate or overseas – Canada, New Zealand, South Africa and the UK.

Finally then, are we doing a good enough job of preparing geophysicists for a role in mineral exploration, through our university programs?

We are trying to strengthen things there. I am a board member with the UWA Geoscience Foundation and we are working hard to strengthen the geophysical side at UWA. We have facilitated the appointment of a new petroleum chair, David Lumley; and another geophysicist, Luis Gallardo; and now we are looking to get someone in to support numerical and computational geoscience. From that side, we have taken it upon ourselves to try and strengthen the university programs. Curtin is already very well supported on the petroleum side, but perhaps not so well on the minerals side.

Practical 3D inversion of entire airborne electromagnetic surveys

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Introduction

Geology is 3D, yet airborne electromagnetic (AEM) data are commonly interpreted using inherently 1D methods; whether they be conductivity depth transforms, layered earth inversions or laterally constrained layered earth inversions. For all 1D methods, the 1D conductivity models for each transmitter–receiver pair are interpolated to produce a pseudo-3D conductivity model over the entire survey area, which is then interpreted for geological meaning. It has been repeatedly demonstrated that 1D methods fail in recovering simple 3D targets, let alone anything approaching geological complexity. With much ambiguity, 3D targets typically manifest themselves within artifacts or distortions in the pseudo-3D models, leaving the interpreter with much subjectivity in deciding between geology and fiction. That said, the volume of data acquired in a typical AEM survey is so large that 1D methods are generally considered to be the only practical approach to AEM interpretation.

Difficulties with 3D interpretation of AEM data stem from the complexity of 3D electromagnetic modeling, and the nonlinearity and ill-posedness of the corresponding inverse problem. 3D AEM modelling usually requires enormous computational resources and time given the necessity to solve as many forward problems as there are transmitter positions in the survey. 3D AEM inversion exacerbates the modelling problem as sensitivities also need to be computed using adjoint operators, and the whole modelling process has to be repeated for many transmitter positions and multiple iterations. A further difficulty is limited computer memory for storing the sensitivity matrix. For large-scale 3D inversion of entire AEM datasets, these problems are perceived as intractable, even with access to high performance computing resources (Viezzoli et al., 2009). Thus it is common practice to rely only on 1D methods for AEM interpretation.

While in theory the sensitivity matrix is full, in practice it is effectively sparse due to the relatively limited footprint of the AEM system. As an example for frequency-domain AEM systems, Liu and Becker (1990) determined at the inductive limit, the footprints for the horizontal coplanar and vertical coaxial components are $3.75h$ and $1.35h$, respectively, where h is the flight height of the transmitter. Reid et al. (2006) showed that the footprints may be as large as 10 times the flight height for low induction numbers, meaning that the footprint may be less than 400 m for frequency-domain AEM systems. Regardless, the area of the footprint is less than the area of the survey. In order to compute the fields and sensitivities for a given transmitter–receiver pair, one needs only to simulate a subset of the 3D conductivity model that encapsulates the AEM system's footprint (Figure 1). The sensitivity matrix for the 3D conductivity model can then be constructed as the superposition of footprints for all transmitter–receiver pairs. This effectively sparse storage of the sensitivity matrix reduces memory requirements significantly.

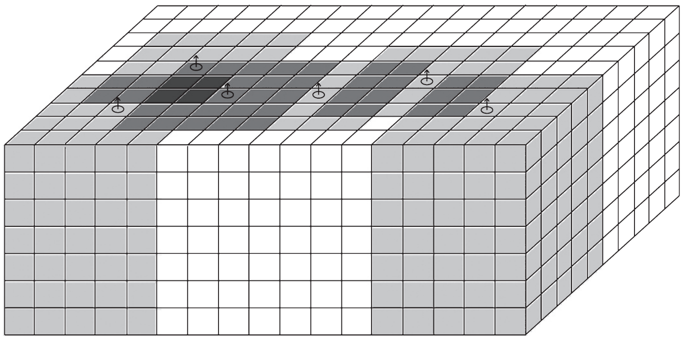

Fig. 1. *Schematic diagram of different footprints (shaded) superimposed over a 3D conductivity model. Those cells in darker shading are where multiple footprints overlap. Those cells which are not shaded have no sensitivity to the data, and are neglected from both modeling and inversion.*

Using this superposition of many footprints, or a moving footprint approach, we will show that it is practical to invert entire AEM surveys to recover 3D conductivity models with hundreds of thousands of cells within half a day on a high-end workstation. We demonstrate that this can be achieved both for frequency- and time-domain AEM data. We avoid the use of linear approximations in our modelling of fields and their sensitivities by using a 3D integral equation method, and we iterate our inversion with a regularized re-weighted conjugate gradient method. We will demonstrate that even for an environment which is arguably as close to 1D as geologically possible, our 3D inversion results are a significant improvement over results obtained from 1D methods. We will show this with a comparison of 3D and 1D inversion results for both RESOLVE frequency-domain and SkyTEM time-domain AEM data acquired for salinity mapping over the Bookpurnong Irrigation District in South Australia.

3D inversion methodology

AEM inversion is ill-posed, meaning regularization must be introduced so as to obtain a unique and stable solution. A variety of optimization methods have been discussed in the literature for 1D AEM inversion. However, conjugate gradient methods are the only practical approach to solving large-scale 3D AEM inversion, as they update the model conductivities with an iterative scheme akin to:

$$\sigma_{i+1} = \sigma_i + \Delta\sigma_i = \sigma_i + k_i \vec{F}_i r_i ,$$

where k_i is a step length, $\vec{F}_i$ is the conjugate transpose of the $N_d \times N_m$ Fréchet matrix F_i of normalized sensitivities, and r_i is the N_d length vector of the residual fields between the observed and predicted data on the ith iteration. This type of iterative scheme consists of matrix–vector multiplications.

In practice, given the limited footprint of the AEM system, not every transmitter has sensitivity to every cell. With a moving footprint, each transmitter–receiver pair is assumed only to contain sensitivity to those cells within its footprint. We exclude those cells outside the footprint by simply excluding them from the discrete summation that is the matrix-vector multiplication. We have implemented this moving footprint in the regularized re-weighted conjugate gradient method (Zhdanov, 2002, 2009). Data and model weights re-weigh the inverse problem in logarithmic space so as to reduce the dynamic range of both the data and conductivity. The inversion iterates until the residual error reaches a pre-set threshold, the decrease in error between multiple iterations is less than a pre-set threshold, or a maximum number of iterations is reached.

Our 3D modelling is based on an implementation of the contraction integral equation method in the frequency-domain that exploits the Toeplitz structure of the large, dense matrix system so as to solve the many right-hand side source vectors with an iterative method that uses fast matrix–vector multiplications via 2D FFT convolutions (Hursán and Zhdanov, 2002). This implementation of the 3D integral equation method reduces memory requirements and computational complexity, and naturally lends itself to parallelization. Moreover, once the Green's tensors have been pre-computed for the footprint area, they are stored and re-used as they are translationally invariant over the 3D model, further reducing runtime. Sensitivities are computed using adjoint operators (Zhdanov, 2002, 2009). For time-domain inversion, the model responses and sensitivities are computed at 28 frequencies logarithmically spaced from 1 Hz to 100 kHz. These are splined and extrapolated back to zero frequency. These responses and sensitivities are Fourier transformed out to several delta pulse lengths. These delta pulse responses can then be folded back into one, and differentiated if necessary, before being convolved with the transmitter waveform in the time-domain and integrated over the receiver windows (Raiche, 1998). The algorithm we have just described has been implemented in software which can be run on a desktop PC, workstation or cluster.

Case study – Bookpurnong

It is often argued that AEM interpretation for salinity mapping is ideally suited to the various 1D methods because of the high conductance of the ground, relative continuity of horizons, and their ability to rapidly generate pseudo-3D conductivity models of entire surveys (e.g. Viezolli et al., 2009). Such an example is at the Bookpurnong Irrigation District located along the Murray River, approximately 12 km upstream from the township of Loxton, South Australia. This area has been the focus of various geophysical trials to manage a decline in vegetation; largely in response to floodplain salinisation from groundwater discharge in combination with decreased flooding frequency, permanent weir pool levels, and drought. Ground-based, river-borne and AEM methods have been deployed with the intent of mapping the distribution of salinity in the floodplain soils and groundwater. We refer the readers to Munday et al. (2007) for a more detailed description of the geology, hydrology, and various river, borehole, ground and airborne electromagnetic surveys.

The area was flown with the RESOLVE frequency-domain helicopter system in both July 2005 and August 2008. We concern ourselves with the August 2008 data only. The RESOLVE system was configured with six operating frequencies: 390, 1798, 8177, 39 460, and 132 700 Hz horizontal coplanar and 3242 Hz vertical coaxial. The transmitter–receiver separation was 7.91 m for the five horizontal coplanar coil sets, and 8.99 m for the single vertical coaxial coil set. This 146 line km survey was flown as 26 lines oriented in a NW–SE direction with 100 m line spacing, and 7 tie lines. The survey data contained 43 841 stations, 4384 of which were used for 3D inversion (Figure 2). The survey was flown with a nominal bird height of approximately 45 m because of the presence of trees along the river bank.

The area was also flown with the SkyTEM time-domain helicopter system in April 2007. The SkyTEM system was configured with both low and high moment modes. We concern ourselves with the high moment data only, which corresponds to a 50% duty cycle bipolar quarter sine wave with peak current of about 90 A, and base frequency of 25 Hz. Twenty-six off-time channels of inline and vertical data were recorded out to 19.8 ms. The transmitter loop consists of 4 turns over an area of 314 m^2. The data were normalized by both transmitter and receiver moments. This 162 line km survey was flown as 29 lines oriented in a NW–SE direction as per the RESOLVE survey, with 100 m line spacing, and one tie line. Additional flight lines were acquired along the Murray River. The survey contained 5610 stations, all of which were used for 3D inversion (Figure 2). The survey was flown with a nominal bird height of

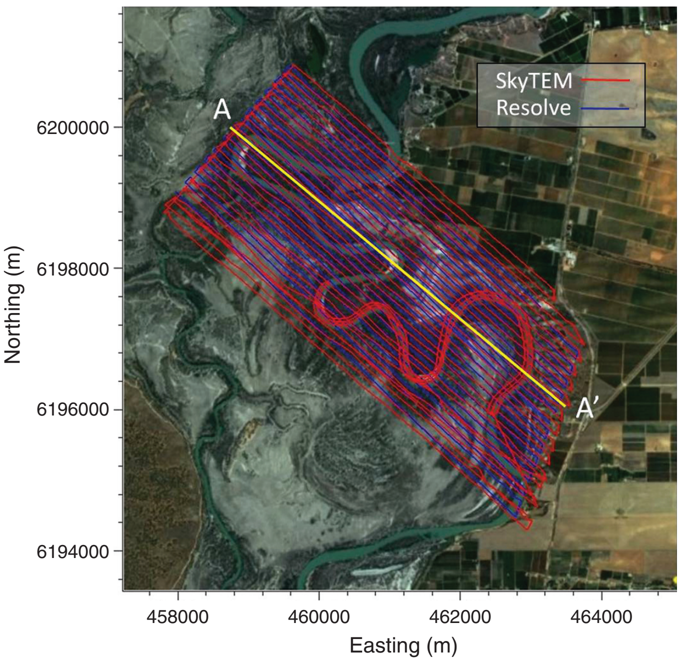

Fig. 2. *Location of the Bookpurnong Irrigation District, South Australia. Survey lines for RESOLVE (blue) and SkyTEM (red) are shown. The survey area covers most of the floodplain and parts of the adjacent highlands where irrigated agriculture has been developed. Vertical cross-sections from line A-A' (yellow) are shown in Figures 7 and 8.*

approximately 60 m because of the presence of trees along the river bank.

The RESOLVE data were inverted for a 3D conductivity model with approximately 230 000 cells that were 25 m × 25 m in the horizontal directions, and varied from 4.0 m to 25 m in the vertical direction. The footprint of the RESOLVE system was set at 200 m. The SkyTEM data were inverted for a 3D conductivity model with approximately 210 000 cells that were 35 m × 35 m in the horizontal directions, and varied from 4.8 m to 33 m in the vertical direction. The footprint of the SkyTEM system was set at 280 m. The 3D inversions for the RESOLVE and SkyTEM data converged to misfits of 20% and 30% from initial misfits of 66% and 58%, respectively. All trends in the data were fitted by the inversion, with the final misfits representing an accumulation of noise in the data.

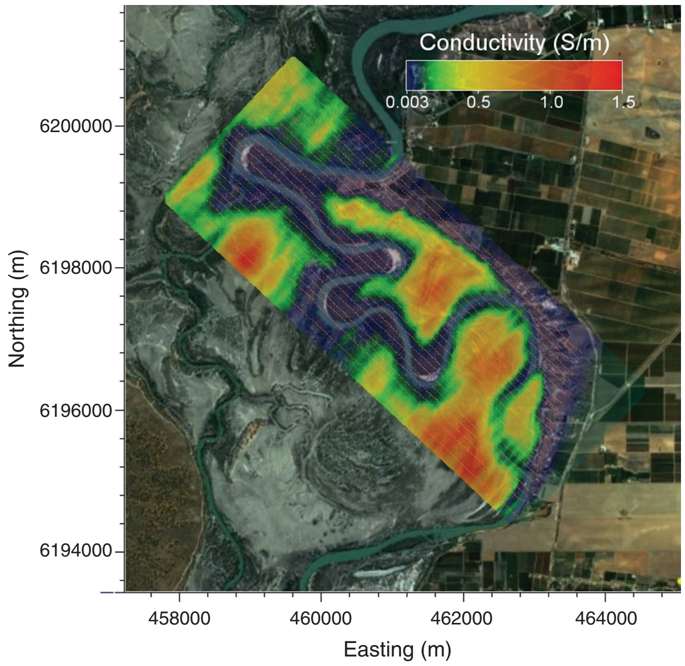

Fig. 3. *Horizontal cross-section of conductivity at 4 m depth obtained from 3D inversion of the RESOLVE data.*

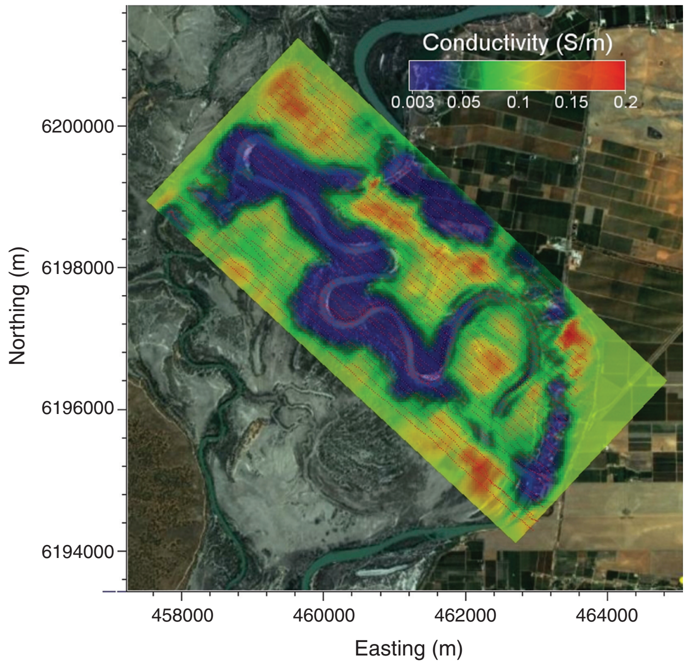

Fig. 4. *Horizontal cross-section of conductivity at 4 m depth obtained from 3D inversion of the high moment SkyTEM data.*

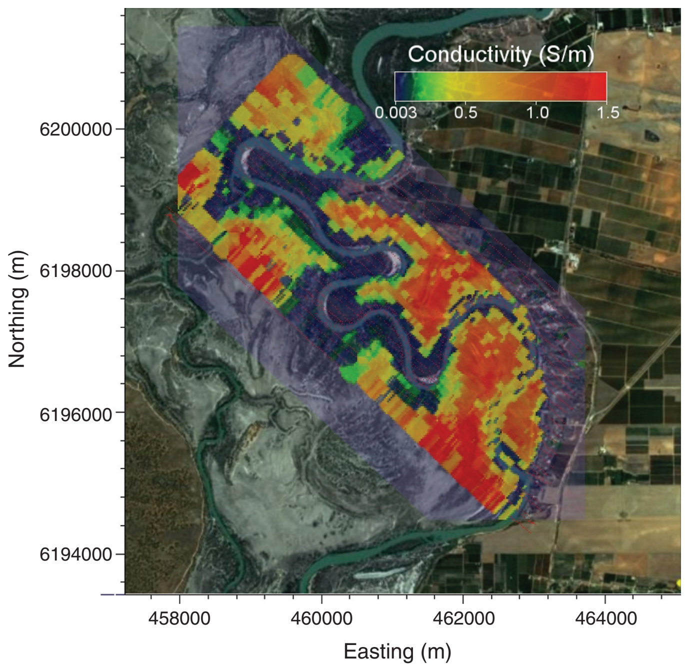

Fig. 5. *Horizontal cross-section of conductivity at 4 m depth obtained from interpolation of layered earth inversions of the RESOLVE data using AirBeo.*

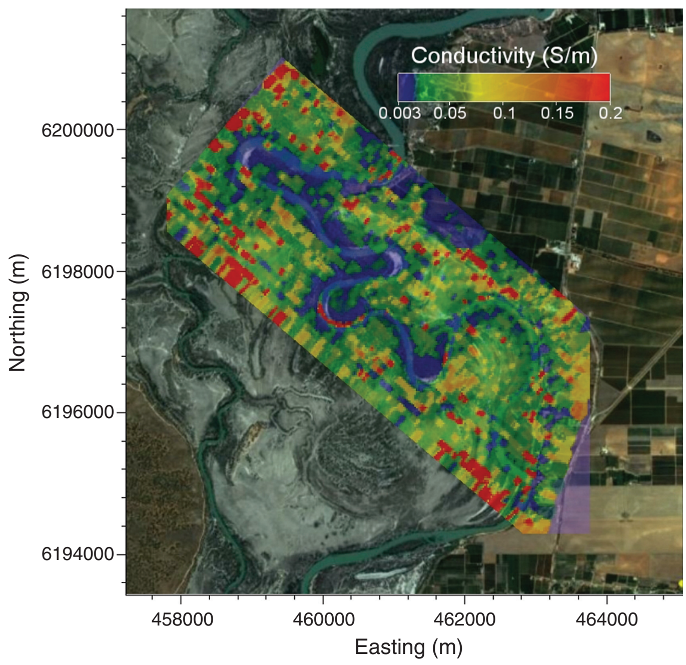

Fig. 6. *Horizontal cross-section of conductivity at 4 m depth obtained from interpolation of layered earth inversions of the high moment SkyTEM data using AirBeo.*

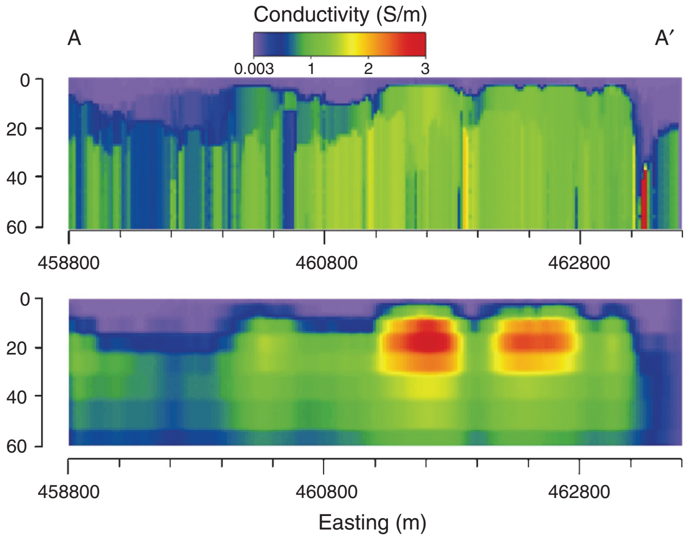

Fig. 7. *2D vertical cross-section of conductivity along profile A-A′ (shown in Figure 2) obtained from 3D inversion (lower panel) and interpolation of layered earth inversions (upper panel) of the RESOLVE data. A vertical exaggeration of 20 is applied to this image.*

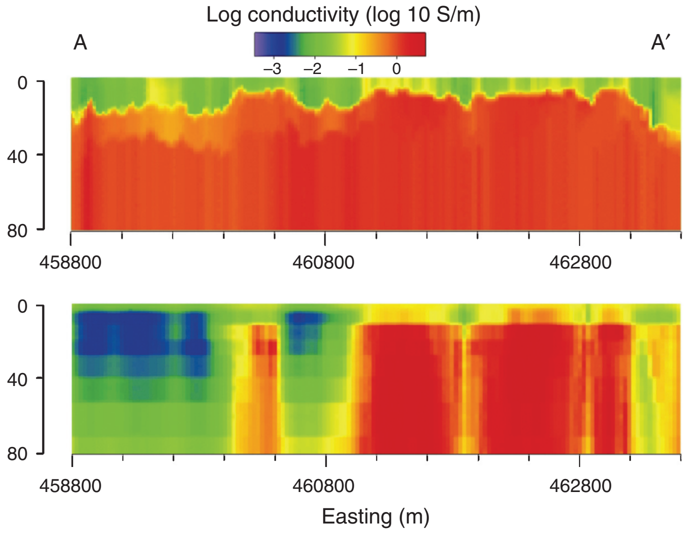

Fig. 8. *2D vertical cross-section of conductivity along profile A-A′ (shown in Figure 2) obtained from 3D inversion (lower panel) and interpolation of layered earth inversions (upper panel) of the high-moment SkyTEM data. A vertical exaggeration of 20 is applied to this image.*

The 3D inversion of the RESOLVE data required 9 hours on a Windows workstation with a 2.4 GHz serial processor and 8 GB RAM. The 3D inversion of the SkyTEM data required 10 hours on a Linux workstation with eight 2.4 GHz processors and 24 GB RAM. Figures 3 and 4 show a slice of the model at 4 m depth derived from the 3D inversion results for RESOLVE and SkyTEM, respectively. The Murray River, which has a lower conductivity than the floodplains, is clearly visible in both 3D inversion results. At depth, both 3D inversions create very coherent images of the losing and gaining sections of the Murray River. The relatively smaller footprint of the RESOLVE system appears to recover finer scale variations in the conductivity across the floodplain compared to the high moment configuration of the SkyTEM system.

For comparison of our 3D inversion results to those obtained from layered earth inversion, we inverted both the RESOLVE and SkyTEM data using *AirBeo* (Raiche et al., 2007). The initial model for each station was a four-layered half-space where the resistivity and thickness of each layer was allowed to vary. Figures 5 and 6 show a slice of the conductivity model at 4 m depth obtained from interpolation of the layered earth inversion results for RESOLVE and SkyTEM, respectively. Inversion of the 48 431 RESOLVE stations required 3 hours on a Windows workstation with a 2.4 GHz serial processor and 4 GB RAM. Inversion of the 5610 SkyTEM stations required 2 hours on the same computer. The results obtained from the layered earth inversions are generally consistent with the conductivity depth images and laterally constrained inversions described by Munday et al. (2007) and Viezzoli et al. (2009). That being said, several notable features were clearly defined in the 3D inversions which were not clear in the various 1D interpretations. The layered earth inversions somewhat smear the results, and in some areas, completely miss the fact that the Murray River is even present! This is not just a limitation of layered earth inversions alone, as even laterally constrained inversions of the same area presented by Viezzoli et al. (2009) also miss the Murray River's rather obvious presence. Figures 7 and 8 compare conductivity cross-sections along profile A-A′ as shown in Figure 2. Allowing for seasonal variation between surveys, the thickness of the upper resistive layer is very similar between the two images. This corresponds to the depth of the water table which varied in thickness from 2 m to 6 m in this area. At depth, the 3D inversions produce very coherent images of the losing and gaining sections of the River, while the layered earth inversions produce cross-sections which are more difficult to interpret. We note that there is a magnitude difference in the conductivity models recovered by both RESOLVE and SkyTEM, but these are consistent between the 3D and layered earth inversion results. These differences may be due to data calibration and/or processing between the frequency-domain and time-domain AEM systems.

Conclusions

Our research shows that 3D inversion of entire AEM surveys is now a practical consideration, with runtimes less than half a day for both frequency- and time-domain AEM systems. We have achieved this by exploiting the efficiencies of the 3D integral equation method and the fact that the area of an AEM system's footprint is much smaller than the area of an AEM survey. This property of an AEM system and survey is effectively used in our 3D inversion methodology. Our implementation naturally lends itself to large-scale parallelization, and we are currently in the process of distributing our software on massively parallelized architectures. This will allow for a further decrease in the runtime, and will make it possible to invert even larger AEM surveys.

It is often argued that 1D methods are the only practical approach to interpreting AEM data. As we have demonstrated with our case study using 3D inversion of both RESOLVE and SkyTEM data, that is not the case. We have shown that results of our 3D inversions more accurately reflect the known geology of the Bookpurnong area than the results obtained from a variety of 1D interpretations. Moreover, the difference in runtimes between our 3D and various 1D methods are insignificant relative to acquisition and processing times.

Acknowledgements

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Integrating offshore geophysics and geotechnical data to enhance engineering foundation design

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Introduction

In order to advance foundation design for an offshore platform, a tightly spaced site investigation using carefully selected geophysical and geotechnical methods is typically required. While the spacing of geophysical survey lines and offshore boreholes can often be tailored to suit the expected ground conditions and proposed foundation, caution should be exercised to avoid under-specifying the investigation. History shows that it is better to develop a comprehensive scope of field work that can be reduced as information is obtained and assessed, rather than having to source additional resources and offshore time when the soil conditions turn out to be more variable than first thought.

For a (typical) platform foundation study, a geophysical survey may comprise a line spacing of no more than 25 metres apart, combined with a geotechnical programme that incorporates sufficient field work both to 'calibrate' the geophysical data and provide engineering parameters for design. Ideally, geotechnical testing would be performed at the intersections of the of the geophysical line grid, which enables direct correlation with two or more lines of data.

Positioning accuracy and vertical resolution

Detailed geophysical data analysis requires a good understanding of the strengths and weaknesses of each tool and technique used, particularly the positioning accuracy for the sensor and the vertical resolution. Positioning accuracy will vary with water depth, equipment used, surface weather, underwater conditions and tides. Just because the surface positioning system is accurate to a few centimetres, it does not mean that position of features identified by the survey sensors is also accurate to a few centimetres. Vertical resolution of geophysical tools ranges from about 15 centimetres for a chirp profiler (High Frequency High Resolution Seismic Profiler) in ideal conditions, to as much as 2 or 3 metres for a 40 cubic inch airgun.

One of the fundamental characteristics of seismic profiling is the trade off between vertical resolution and depth of signal penetration. It is unrealistic to think you can get 15 centimetre resolution at 200 metres below the seabed, and selection of profiling tools needs to take this into account. A common solution is to run two profilers, which may be done simultaneously if their frequency ranges are not so close as to cause interference. An example is the use of a chirp profiler or conventional pinger in conjunction with a small air gun. Figure 1 is an example of reflection seismic data over varied geology. Figures 2 to 5 show a comparison of different seismic profiling tools run over the same point.

Impact of ground conditions

A good understanding of seabed (geotechnical) properties and how they might influence various types of seismic data is required. The best quality data is often obtained from finely layered silts and clays deposited under a low energy environment, such as a lake or estuary. At the other extreme, geophysical profilers will struggle to interpret conditions involving buried limestone or calcarenite reefs.

Determining the seabed intercept

When undertaking a detailed correlation between geophysical and geotechnical data, obtaining quality data at the seabed is paramount. For a lot of engineering applications such as pipeline embedment, gravity base structures and even anchor holding capacity, the first metre below seabed is crucial. This can be a zone where geophysical data is often less than optimal, especially for surface towed systems deployed in less than ideal weather. It is common practice to lower the streamer or hydrophone in marginal weather conditions, to reduce the sea surface noise. However doing this also reduces the high frequency content and thus the resolution of the data, and can introduce unwanted sea surface reflections as an artefact. While this practice may have commercial benefits in enabling the survey to progress at a faster pace, it does not help the quality of the data.

During processing, the seismic data may or may not have been converted to zero phase. It is important to know this as it affects the exact picking of the seabed. With data acquired using a 40 cubic inch airgun, this can cause an error of ±2 or 3 metres (see Figure 5).

Selection of seabed velocity

Precise correlation of the seismic data with geotechnical data requires an accurate time to depth conversion for the seismic, which requires a good knowledge of the seismic velocities through the seabed. In an offshore environment with unconsolidated sediments to significant depth, an assumed constant velocity is a good starting point. However, if the seabed geology comprises alternating layers of variably cemented calcarenite or limestone and uncemented sediments (see Figure 1) then the velocity regime will be complex. If there is multi-channel seismic data available, then the stacking velocities may help, however, the velocity analysis is typically too coarse, both vertically and horizontally, to be much real

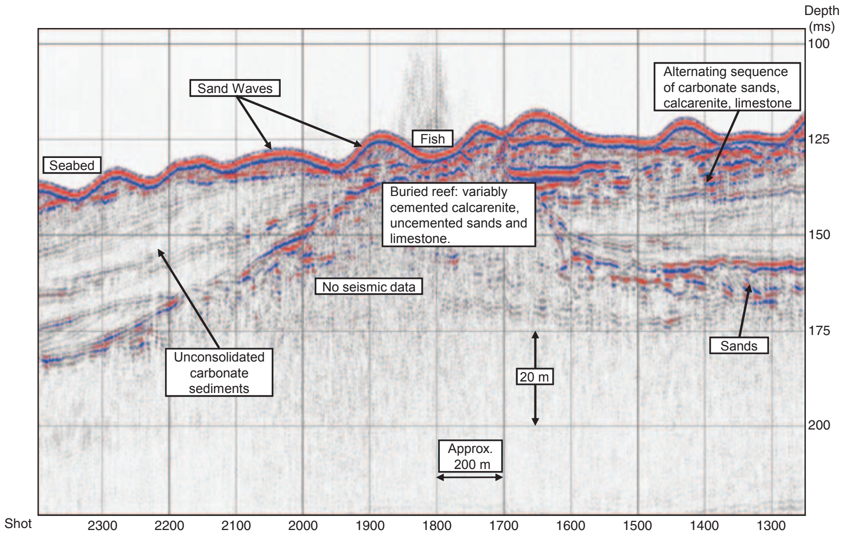

Fig. 1. *Reflection seismic data, variable geology.*

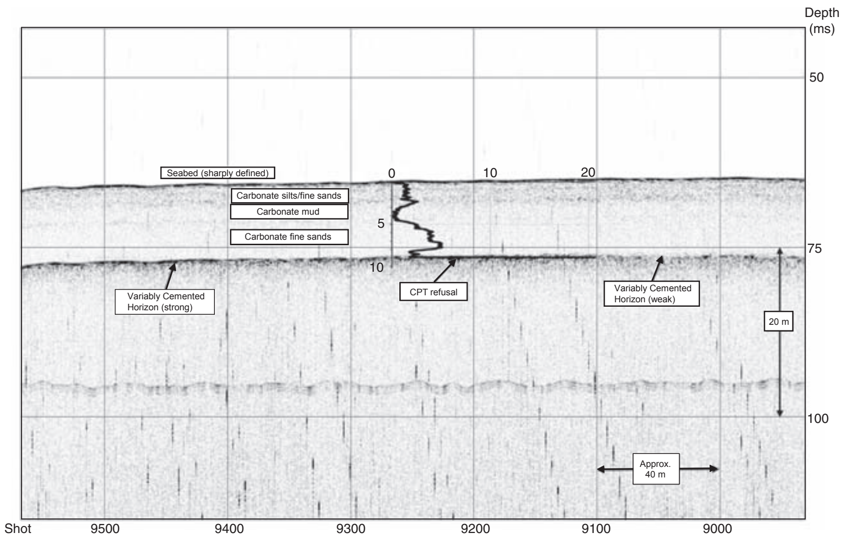

Fig. 2. *Chirp profiler.*

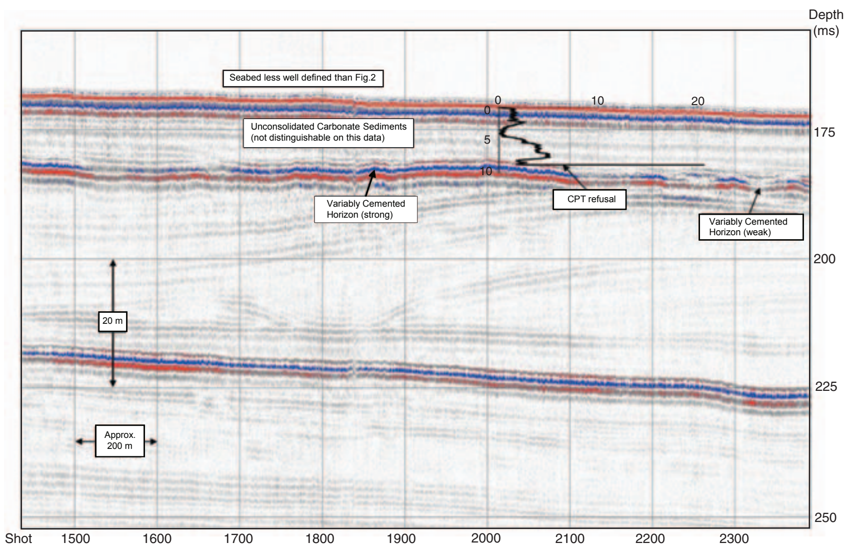

Fig. 3. *10 cubic inch air gun.*

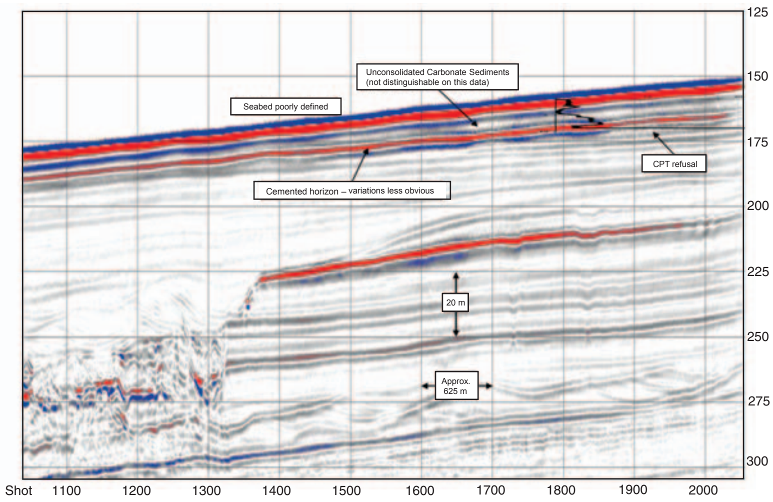

Fig. 4. *2D high resolution seismic, 40 cubic inch air gun.*

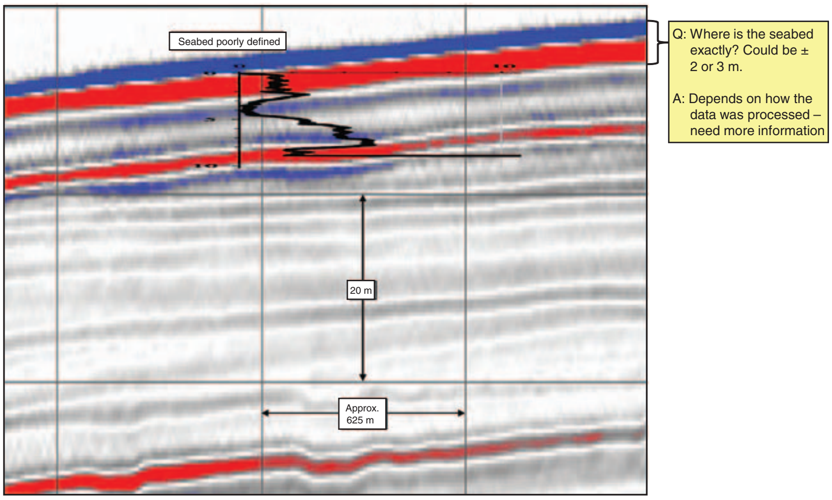

Fig. 5. *Close-up of Figure 4.*

use – time to depth conversion carried out this way may have an accuracy of ±10%. Where available, a better solution is to use geotechnical data (such as obtained from a seismic Cone Penetrometer Test) to calibrate the geophysical data.

Comparing geophysical and geotechnical information

Discrepancies between the seismic and geotechnical tools are common and arise because they are recording different parameters. The seismic data represents the acoustic properties of the seabed while the geotechnical tools record physical properties. Velocity contrasts in the sediments cause seismic reflections – and the bigger and more sudden the contrast, the stronger the reflection. Generally, increasing velocity is indicative of increasing 'hardness' of the material, although there are exceptions. For example, it is possible to have a gradational change in the sediments that is observed on the geotechnical tools, but which does not generate a reflection on the seismic. Also, it is possible to have a reflection on the seismic that does not seem to correlate with anything on the geotechnical data, although this generally only occurs with the minor reflectors.

Conclusion

In summary, interpretation of seismic data is based upon the characteristics of the reflections in conjunction with a holistic review of the available data to build a plausible geological model. This needs to take into account the environmental setting, and be integrated with other sources of information such as borehole logs and other sampling techniques to ground truth the interpretation.

Biography

Magnus has over 25 years experience in Marine Geophysics, mainly from Australia, South East Asia and the North Sea. He has progressed through several survey companies ending up in Fugro, before moving into consulting with RPS. After 5 years in Chevron working on the Gorgon and Wheatstone Projects, he joined Advanced Geomechanics in 2008. He is part of the new Integrated Geosciences team, developing a geophysics and geohazard interpretation capability to complement AG's established geotechnical competence. He has recently been selected to participate in the ISO Technical Panel for Marine Geophysical Site Investigations.

Enhanced coastal geotechnics with integrated marine seismic reflection and multi-source, extended array refraction

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Introduction

Strong world demand for energy, mineral resources and agricultural products is underpinning new construction and upgrades at many Australian ports, particularly in Western Australia (WA). These have required extensive near-shore marine geophysical investigations in shallow waters, typically less than 20 metres deep directed mainly at port entrance channels, pipeline routes and supporting facilities such as jetties and wharfs. The technologies have usually employed continuous seismic profiling (CSP) with surface-tow boomer sources and single-ended, continuous underwater seismic refraction (CUSR) with near-bottom towed equipment and air-gun sources (Whiteley and Stewart, 2008).

The near-shore marine environment of WA is challenging for both shallow reflection and refraction methods. This area is essentially a Pleistocene dune platform, sometimes overlain by Holocene sediments, that has been submerged and dissected (Bird, 2008). It contains re-worked calcareous marine and terrestrial sediments with 'hard' cap rocks, variably cemented 'hard' calcarenites, limestones, sandstones and conglomerates of variable thickness and lateral extent. These materials lie on an irregular surface of much older, but also highly variable, bedrock units. Generally these 'hard' layers, their seismic velocity, as indicative of their excavatability and strength are of most importance to dredging and piling contractors together with the depth to bedrock.

CSP example – Pilbara region

Figure 1 shows a sample of near-shore boomer CSP data from the Pilbara region, WA. This is about 1.4 km long and extends to about 16 m sub-bottom depth. Four simplified, geotechnical logs for boreholes about 400 m apart are also shown on this CSP section. Drilling within these conditions is also difficult with sometimes significant core losses so the location of the interfaces between the various geotechnical units can often be uncertain.

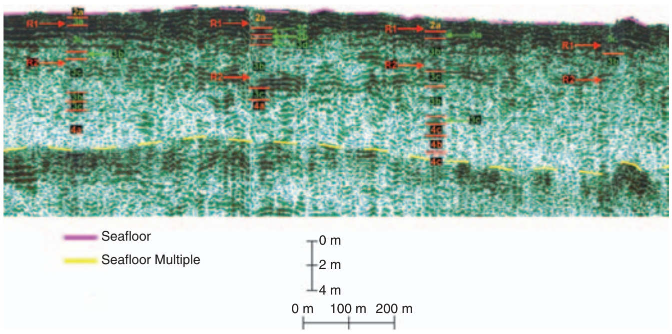

Fig. 1. *Sample of near-shore boomer CSP data and borehole logs from the Pilbara region, WA.*

From the sea floor, unit 2a represents the relatively thin Recent Marine sediments, mainly sands, gravels and silts. Units 3a to 3c represent the calcareous shallow marine sediments. The 'hard' cap rocks (3a) and the 'hard' siliceous calcarenite, calcareous sandstones and conglomerates (3c) were encountered at differing depths in the boreholes and there is no easy way to correlate these units between these boreholes. The underlying units (4a to 4c) represent the older terrestrial sediments, mainly calcareous clays, gravels (4a and b) and claystone (4c).

There is also no detailed correlation between the CSP record and these geotechnical units, however, there are general correlations, as is typical of this region. Two CSP reflectors (R1 and R2) are marked where they occur at the boreholes. R1 approximately represents the base of recent marine sediments near the sea floor but does not clearly distinguish the thin cap rock (3a) and calcarenite (3c). R2 occurs within the shallow marine sediments and shows some correlation with the deeper "hard" calcarenite (3c) unit in three of the boreholes. Laboratory testing of calcarenite samples from this area indicated seismic velocities in excess of 3000 m/s could be expected.

Taken together the CSP and borehole data suggest a seismic velocity reversal (or inversion) beneath the 'hard' layers that could pose some interpretation difficulties with interpretation of CUSR data from this region (Whiteley and Greenhalgh, 1979).

Multilayered synthetic model results

To date much of the near shore CUSR data in WA and elsewhere around Australia has been collected with relatively short hydrophone arrays (<50 m) and a single near-array source. This data is usually interpreted with intercept time methods assuming a horizontal, plane-layered earth model with a uniform velocity in each layer and velocities increasing with depth.

In order to investigate the performance of this system in more realistic situations a multilayered synthetic model was constructed using typical seismic velocities for the region with a relatively thin high velocity 'hard' layer of limited lateral extent as shown in Figure 2*a*. Single-ended, CUSR first arrival times were computed through this model to a 50 m source-receiver array with detectors at 2 m intervals and a 10 m source interval

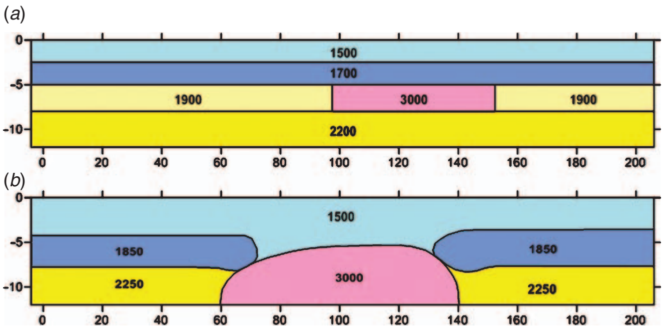

Fig. 2. *Synthetic seismic model and intercept time interpretation: (a) synthetic seismic model; (b) smoothed intercept time interpretation.*

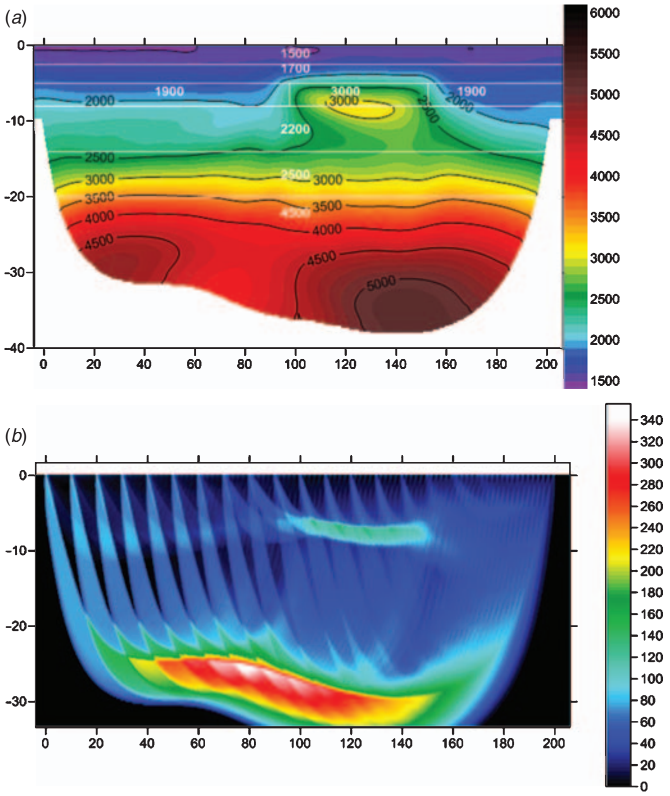

Fig. 3. *WET Interpretation and seismic wavepath density model: (a) WET interpretation; (b) seismic wavepath density.*

using Polvin and Lecomte's (1991) finite difference solutions to the 2D seismic eikonal equation.

This data was then interpreted using the intercept-time method and the smoothed intercept-time interpretation is shown in Figure 2*b*. This interpretation shows a more extensive high velocity region that has been migrated laterally in the source direction and is a considerable variance with the original model.

These limitations can be largely overcome and improved resolution in these conditions can be achieved employing a longer seismic array and multiple offset sources together with improved tomographic interpretation methods. Figure 3*a* shows the same synthetic model in Figure 2*a* that has been extended to include deeper higher velocity layers (2500 and 4500 m/s). First arrival travel-times were again computed through this model for a 100 m receiver array with sources at 0 m and 50 m offsets

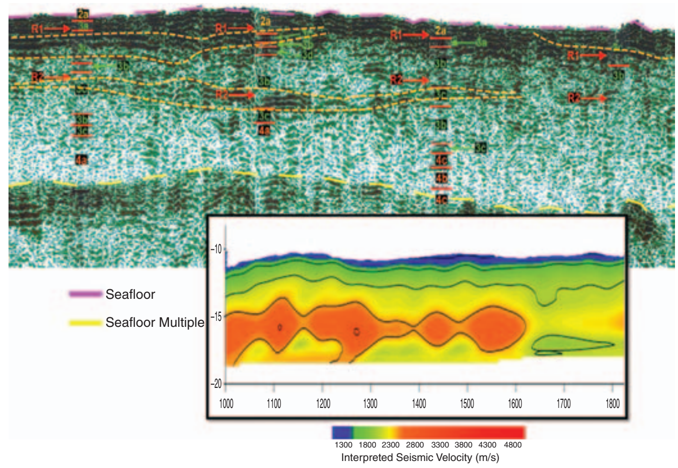

Fig. 4. *Interpreted CSP and CUSR sections.*

and inverted using Wavepath Eikonal Tomography (WET, Schuster and Quintus-Bosz, 1993) and RAYFRACT(R) Version 3.1 software (Intelligent Resources, 2010) from an initial velocity gradient model. This produces a seismic image that is continuous rather than discrete as assumed with the intercept time method and is increasingly used in near-surface seismic refraction on land (Whiteley and Eccleston, 2006).

The seismic image obtained is shown on Figure 3*a*. This bears a strong resemblance to the discrete model. Both the lateral extent and depth to the top of the high velocity lens are closely defined in this image. The base is less well defined in Figure 3*a* but is more clearly observed on the seismic wavepath density diagram in Figure 3*b* that is produced by the software. This shows the concentration of seismic waves in the high velocity lens and within the deepest 'hard' bedrock refractor.

Figure 4 shows the CSP section from Figure 1 on which the approximate extent of the cap and calcarenite layers have been marked using both the CSP and borehole information. The CUSR tomographic image along part of this line obtained with the improved system and approximately scaled to the CSP record is also shown. The cap and calcarenite layers near sea floor are not evident in this image suggesting that they are also less cemented but the higher velocity deeper calcarenite layer that is truncated laterally is clearly observed.

Conclusion

This study demonstrates that application of this improved CUSR system and its integration with CSP and offshore drilling offers enhanced geotechnical modelling and reduces engineering risks in near-shore deeper dredging and construction in complex near-shore regions such as those in Western Australia.

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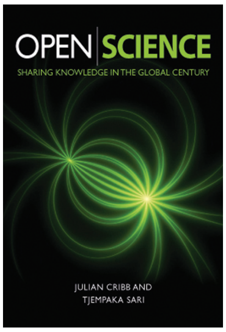
Open science: sharing knowledge in the global century



by Julian Cribb and Tjempaka Sari

Publisher: CSIRO Publishing, 2010, 232 pp. RRP: $39.95 (paperback), ISBN: 9780643097636

In the opening chapter of this book, the authors highlight some extraordinary facts about modern science. For example, 'scientific knowledge is now said to double about every 5 years'; 'it has been claimed that up to half the world's published scientific papers are never read by anyone other than their authors, editors and reviewers – and 90 per cent are never cited'; and perhaps most extraordinarily of all. 'In the morning of the 21st century, knowledge grows faster than anything humans now produce (with the possible exception of environmental degradation).'

The book then develops two major themes. First, it calls for excellence in science communication and a need for democratisation of science. The authors argue that sharing of knowledge is equal in importance to its discovery and that a move to 'open science' will be of benefit to everyone as we deal with the major challenges of the 21st century. Second, the book is a practical guide to excellence in science communication. It is the combination of these two themes that I found particularly interesting – big-picture thinking combined with some useful strategies to do something about it.

The book comprises twelve chapters; an appendix titled 'Declaration on science and the use of scientific knowledge', adopted from the 1999 World Conference on Science; and a useful set of Endnotes directing the reader to a range of further reading. As outlined above, Chapter 1 sets the scene as to why it is so important to look more closely at how well we are disseminating the vast amount of scientific knowledge being accumulated around the world.

Chapters 2 and 3 discuss the mechanics of good science writing and communication. In Chapter 2 the authors demonstrate that short sentences, active voice, article structure, and avoiding jargon are all key factors in good science writing. There are even a few examples of poor science writing that will be sure to put a smile on your face! Chapter 3 is about planning for open science and specifically about developing a communication plan. The latter is discussed in the context of an organisational communication plan; however the specific steps recommended are equally applicable to an individual project.

Understanding your audience is the subject of Chapter 4. The tools discussed include quantitative and qualitative research; media analysis; and business-orientated tools such as customer value analysis (CVA) and reputational analysis (RA). 'Reading the public mind' is a new variant of CVA. Using a statistical method, the technique aims to map what the public thinks about a given scientific or technological issue at any given time. This information can then be used to further develop specific aspects of the communication plan.

Chapters 5, 6 and 7 address key strategies for dealing with three major sectors associated with science communication – the media, government and industry; and the public. Again, these chapters are full of practical, hands-on recommendations. To summarise very briefly, the authors provide a list of strategies for building trust and communication between journalists and scientists because whilst science is about 'the creation of knowledge and exploring ideas', media is about 'sharing, debating and testing ideas in society's marketplace'. Government is a major supporter of science through either direct funding or incentives that encourage private sector research, whilst private industry provides an avenue for scientific advancements to be applied and developed. Whereas government interactions are dominated by considerations of politics, policy, and electoral implications, industry interactions need to take account of commercial realities. Public perception of science is equally important because public opinion will influence whether a new scientific method or technology is developed. In particular, the authors explore the 'crisis of trust' between the public and science. A range of communication strategies are suggested, largely aimed at engaging the public in dialogue about science and technology issues.

The role of the Internet and global media in science communication is covered in Chapter 8. 'By 2010, some two billion people around the planet were sharing thoughts, ideas and information at light speed.' As practising geophysicists, most of us do this every day – it has become second nature to use the Internet as a major communication tool in our industry. Of course, it is also a very potent tool for disseminating information about science globally. The trick is to make sure that science writing for the internet is made as clear, accessible and navigable as possible.

Chapter 9 takes a particular look at the problems associated with communicating a new technology to the world. It is perhaps natural for humanity to respond with caution when an innovation has the potential to make major changes to some part of our lives. However, the authors also note that a very large number of advances have been adopted in the last 100 years, thus implying that society is not averse to adopting new technologies.

Much of the book has a focus directed at science institutions and organisations. However, Chapter 10 discusses how individual scientists can work toward open science. The authors suggest that an open science unit should be mandatory for all undergraduate science courses. They outline why scientists should communicate and also why they don't; they give a comprehensive list of hints for dealing with media interviews; and they cover the need for excellent quality public reports, media releases, public speeches and presentations.

If a move to open science is going to be successful, there will need to be some basic rules. Chapter 11 suggests that scientific institutions should include in their charter not just a commitment to excellence in scientific research, but also a commitment to excellence in science communication. Of course, in some circumstances there are commercial considerations – the value in a piece of scientific research is the commercial advantage it gives to a particular company or organisation. This is especially true in the world of applied geophysics.

Finally, Chapter 12 delivers a set of guidelines for dealing with issues – organisational crises; natural disasters where science can help or inform; problems with poor perception of a scientific body or new technology; etc. In this context, ideas associated with brand name and image are also discussed.

In many different ways, this book proposes that excellence in scientific research needs to be matched with excellence in science communication. I found the authors' arguments persuasive, interesting and inspiring. If you have an interest in 'open science' and how you and your organisation can be more effective science communicators and advocates for your particular area of expertise, then read this book. I do not think you will be disappointed.

Copies can be ordered directly from CSIRO Publishing. Website: www.publish.csiro.au; email: publishing.sales@csiro.au.

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Date	Event	City	Country
July			**2010**
4–8 Jul	Australian Earth Sciences Convention 2010: Earth systems: change, sustainability, vulnerability http://www.aesc2010.gsa.org.au	Canberra	Australia
19–22 Jul	Bali 2010 International Geosciences Conference and Exposition http://bali2010.hagi.or.id	Nusa Dua	Bali, Indonesia
August			**2010**
8–13 Aug	2010 Meeting of the Americas http://www.agu.org/meetings	Iguassu Falls	Brazil
22–26 Aug	**ASEG – PESA: 21st Conference and Exhibition** **http://www.aseg.org.au/Events/Conference**	**Sydney**	**Australia**
29 Aug–4 Sep	Seismix 2010 – 14th International Symposium on Deep Seismic Profiling of the Continents and their Margins http://www.earthscrust.org/earthscrust/seismix2010.htm	Cairns	Australia
September			**2010**
5–10 Sep	11th IAEG Congress http://www.iaeg2010.com	Auckland	New Zealand
6–8 Sep	Near Surface 2010: 16th European Meeting of Environmental and Engineering Geophysics http://www.eage.org	Zurich	Switzerland
12–15 Sep	AAPG 2010 International Conference & Exhibition http://www.aapg.org/calgary	Calgary	Canada
29 Sep–1 Oct	Geo-Computing 2010: 'Uses and Abuses' http://www.aig.org.au/events	Brisbane	Australia
29 Sep–1 Oct	GeoSkill2010: The Challenges of Training and Developing E&P Professionals in the 21st Century http://www.eage.org	Pau	France
October			**2010**
17–22 Oct	SEG International Exposition and 80th Annual Meeting http://www.seg.org	Denver	USA
November			**2010**
15–17 Nov	KazGeo 2010: Where Geoscience Meets the Silk Road http://www.eage.org	Almaty	Kazakhstan
December			**2010**
8–10 Dec	GEO India 2010: 2nd South Asian Geosciences Conference and Exhibition http://www.aeminfo.com.bh/geoindia2010	Greater Noida	India
January			**2011**
16–19 Jan	Borehole Geophysics Workshop: Emphasis on 3D VSP http://www.eage.org	Istanbul	Turkey
February			**2011**
15–16 Feb	Egyptian Society of Applied Petrophysics (ESAP): 6th Conference on Geophysics	Cairo	Egypt

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