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PREVIEW

AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

NEWS AND COMMENTARY

FEATURE ARTICLES

PREVIEW

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FRONT COVER

HELITEM™ on the ground in Cobar, NSW, October 2010 (photo courtesy of Fugro Airborne Surveys) (see p. 16 of this issue).

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Editor
Ann-Marie Anderson-Mayes
Tel: (08) 9203 7231
Email: preview@mayes.com.au

Associate Editors
Book Reviews: Mike Middleton
Email: mike.middleton@dmp.wa.gov.au

Canberra Observed: David Denham
Email: denham@webone.com.au

Data Trends: Guy Holmes
Email: guy.holmes@spectrumdata.com.au

Minerals and Environment: Greg Street
Email: gstreet@intergeo.com.au

Petroleum: Mick Micenko
Email: micenko@bigpond.com

Web Waves: Andrew Long
Email: andrew.long@pgs.com

ASEG Head Office & Secretariat
Ron Adams
Centre for Association Management
Tel: (08) 9427 0838
Email: secretary@aseg.org.au
Website: http://www.aseg.org.au

Publisher
CSIRO PUBLISHING

Production Editor
Helen Pavlatos
Tel: (03) 9662 7639
helen.pavlatos@csiro.au

Advertising
Wendy Wild
Tel: (03) 9662 7606
Email: wendy.wild@csiro.au

Ann-Marie Anderson-Mayes

The last two months have seen me come across some issues related to education, which I thought I would share with you.

First, at the recent ASEG AGM an incidental conversation led to a discussion of the likely withdrawal of funding for the *Primary Connections* and *Science by Doing* programmes. These programmes were established by the Australian Academy of Science in response to concerns over the quality of science teaching of science in Australian schools. *Primary Connections* has developed materials which assist teachers (who are typically not trained in science) to integrate science material into their numeracy and literacy programs. The programme only requires a further small investment of $1.5 million to become self funding, and yet this funding was not forthcoming in the recent federal budget. *Science by Doing* enables high school teachers to present science in a fun, hands-on, and engaging manner. It has been successfully piloted in 28 schools across Australia, but again withdrawal of funding at this point potentially impacts on the future of this initiative.

Second, I had the pleasure of recently attending and addressing a group of senior earth science teachers at a professional development day run by Earth Science WA. My small contribution to the day was to give the teachers a brief overview of some of the free material available to them on the Internet related to earth science. In particular, I chose to show them online magazines and resources that were available from professional societies (like the ASEG) and geological surveys, both in Australia and overseas. At the beginning of my talk, I asked how many of the teachers present were members of either GSA or AIG. To my surprise only one teacher was a member of AIG. I found myself wondering why more of these teachers were not members of a professional society directly related to the subject they were teaching.

These two unrelated events have really left me thinking hard about science education. Why is this relevant to the ASEG? Because the future of our profession depends on inspiring young people to become interested in science now. And it seems to me that the very best way of inspiring students is to inspire and support teachers first. The teachers are our front line in education and if we give them the confidence and interest to teach science, this will naturally flow into improved student experiences in the classroom.

The ASEG already supports Teacher Earth Science Education Programme (TESEP) (see *Preview*, Issue 142, p. 25). But, it seems to me that as members of the wider earth science community, we should also be taking an interest in issues such as those highlighted above. Successful science education programs deserve continued funding, because a small investment now will make a real difference towards improving participation in science in schools. And perhaps there is some way in which we can encourage secondary school earth science teachers to join a professional science society relevant to their subject area. In this way teachers would have access to the latest earth science news and research, and professional societies will gain members who can give them clear ideas on how to promote their field of science, particularly to the young Australians who we need to be scientists in the future.

Initial Notification for Nominations for the 2012 ASEG Honours & Awards

Categories include:

- **Outstanding contributions to the geophysical profession**
- **Outstanding contributions and service to the ASEG**
- **Recognition of innovative technological developments**
- **Promotion of geophysics to the wider community**
- **Significant achievements by younger ASEG members**

To be announced and awarded at:
- **ASEG Brisbane Conference 26–29 February 2012**

Nomination guidelines:
- **ASEG website www.aseg.org.au/awards**
- **Further details in the next issue of *Preview***

For further information, or to notify an initial expression of interest for an award, please contact:
Andrew Mutton
Chairman, ASEG Honours and Awards Committee
Email: andrew.mutton@bigpond.com

The ASEG: current state and goals for the future

Greetings from Dennis Cooke, your incoming ASEG President– and in this month's President's Piece I'd like to discuss my thoughts about goals and focus areas for the ASEG. These goals are related to the state of geophysics in Australia and the state of the Australian economy, so I will touch on those topics too.

Right now the Australian economy is doing relatively well. The world is struggling to recover from the WFC and crash of 2009, but Australia's economy is doing better than most of the rest of the world. Our economy's strengths are based largely on mineral and hydrocarbon resources and the (hopefully) growing need for those resources in China and India. In this sense we truly are the lucky country – especially now when most other developed economies are saddled with much more debt and lacking our growth prospects. And Australian geoscientists are important enablers of this resource boom as well as beneficiaries of it.

The purpose of the ASEG is to further the cause of geophysics and support our members in their practice of geophysics. A quick 'snap-shot' of the ASEG shows that we are doing a good job with hosting/organizing conventions, workshops, training courses and technical meetings. We are also doing an excellent job with our publications; Preview and Exploration Geophysics. We have a healthy cash balance of about $1 million which largely comes from our conventions. In the future, I (and the other officers of the ASEG) want to spend/invest more of that cash balance on geophysics, geophysical education and our members.

Demographics, students and future geophysicists

The average age of geoscientists in the workforce and in the ASEG is increasing. One of the good things we can do with our healthy cash balance is to invest it in scholarships and field trips for students. I note that the SA/NT branch of the ASEG is currently doing both and I encourage other branches to make similar local investments in students.

Continuing education

Federally, the ASEG has started – and will continue – to spend more on continuing education for our membership. The best example of this is the Distinguished Instructor Short Course (DISC). The DISC program is organized by the SEG and EAGE – but due to cost constraints, they traditionally have restricted DISC courses to a single Australian session. The ASEG, however, has started and will continue to pay costs associated with bringing the DISC program to more Australian locations (limited only by the instructor's time constraints).

Mineral resources & potential fields technologies versus petroleum & seismic technologies

There are two major sub-groups within the exploration geophysics community: those using potential fields in the minerals industry and those using seismic methods in the hydrocarbon industry (and this over-simplified lumping ignores all those doing groundwater, environmental, engineering and academic geophysics). There is not a lot of technical and commercial overlap between these two communities and it is possible for our organization to favour one community at the expense of the other. Currently, Australia and the ASEG are the 'big dogs on the block' with respect to developing and deploying new potential fields technologies, while the US and the SEG dominate development of new seismic technologies. I'd like to see the ASEG increase its activity and membership amongst seismic geophysicists. This can only be done by offering more courses, workshops and technical talks that are relevant to seismic geophysicists.

Sister societies

The ASEG is doing a great job of engaging the Korean and Japanese geophysical societies and we currently publish a joint technical journal with them. Last year we signed an agreement of cooperation with the Chinese geophysical society. Relations between the ASEG and the SEG are good and both societies would like to strengthen them. One concept under discussion is to make the ASEG's digital database accessible via the web as part of the SEG's digital database. Another sister society I would like to strengthen ties with is PESA. We currently organize some conferences and technical talks with PESA and I would like expand as part of an effort to bring more seismic/petroleum geophysicists into the ASEG.

ASEG membership dues

I suspect that many members would like to see our cash balance used to reduce our membership dues. Our current membership dues are set to cover the cost of printing and posting our journals – Preview and Exploration Geophysics – to each of you. It would not be sustainable to set our dues at a level below the printing and distribution costs, but what we are considering instead is to offer lower dues to those who wish to receive digital copies of our journals instead of the printed version.

So above is a brief description of my thoughts and goals for the ASEG. I am very interested in how our members think we should focus our activities. We are currently planning a speaking tour where I would visit ASEG branches and present a technical talk. Those technical meetings would also provide an opportunity for each local ASEG community to share their thoughts on where we should be going as an organization. I look forward to meeting all of you and discussing ASEG goals!

Dennis Cooke
Email: dennis.a.cooke@gmail.com

ASEG Federal Executive 2010–11

President and International Affairs: Dennis Cooke
Tel: (08) 8338 7335
Email: dennis.a.cooke@gmail.com

President Elect: Kim Frankcombe
Tel: (08) 6201 7719
Email: kfrankcombe@iinet.net.au

Vice President Conferences: Andrea Rutley
Tel: 0438 599 644
Email: rutley@sylvanpark.com.au

Vice President Education: Koya Suto
Tel: (07) 3876 3848
Email: koya@terra-au.com

Immediate Past President and ASEG Research Foundation: Phil Harman
Tel: (03) 9909 7633
Email: phil.harman@bigpond.com

Past President: Michael Asten
Tel: 0412 348 682
Email: michael.asten@sci.monash.edu.au

Secretary: David Denham, AM
Tel: (02) 6295 3014
Email: denham@webone.com.au

Treasurer: David Cockshell
Tel: (08) 8463 3233
Email: david.cockshell@sa.gov.au

Membership: Cameron Hamilton
Tel: (07) 3839 3490
Email: cameron@energeo.com.au

Publications: Phil Schmidt
Tel: (02) 9490 8873
Email: phil.schmidt@csiro.au

State Branch Representative: Reece Foster
Tel: (08) 9378 8023
Email: reece.foster@groundprobe.com

Webmaster: Carina Kemp
Tel: 0412 514 075
Email: c.kemp@geomole.com

ASEG History Committee: Barry Long
Email: blong@jafss.com

Conference Advisory Committee: Michael Hatch
Email: michael.hatch@adelaide.edu.au

Honours and Awards Committee: Andrew Mutton
Email: andrew.mutton@bigpond.com

Technical Standards Committee: David Robson
Email: david.robson@industry.nsw.gov.au

ASEG BRANCHES

ACT

President: Ron Hackney
Tel: (02) 6249 5861
Email: ron.hackney@ga.gov.au

Secretary: Marina Costelloe
Tel: (02) 6249 9347
Email: marina.costelloe@ga.gov.au

New South Wales

President: Dr Mark Lackie
Tel: (02) 9850 8377
Email: mlackie@els.mq.edu.au

Secretary: Dr Bin Guo
Tel: (02) 9024 8805
Email: bguo@srk.com.au

Queensland

President: Fiona Duncan
Tel: (07) 3024 7502
Email: fiona.duncan@bg-group.com

Secretary: Kate Godber
Tel: (07) 3010 8951
Email: kate.godber@groundprobe.com

South Australia & Northern Territory

President: Philip Heath
Tel: (08) 8463 3087
Email: philip.heath@sa.gov.au

Secretary: Michael Hatch
Tel: 0417 306 382
Email: michael.hatch@adelaide.edu.au

NT Representative: Jon Sumner
Tel: (08) 8999 3606
Email: jon.sumner@nt.gov.au

Tasmania

President: Michael Roach
Tel: (03) 6226 2474
Email: michael.roach@utas.edu.au

Victoria

President: Asbjorn Christensen
Tel: (03) 9593 1077
Email: asbjorn@intrepid-geophysics.com

Secretary: John Theodoridis
Tel: 0412 570 549
Email: jthe1402@bigpond.net.au

Western Australia

President: Riaan Mouton
Tel: 0488 500 859
Email: geosoft@orcon.net.nz

Secretary: CASM
Tel: (08) 9427 0838
Email: asegwa@casm.com.au

The ASEG Secretariat

Centre for Association Management (CASM)
36 Brisbane St, Perth, WA 6000
Tel: Ron Adams (08) 9427 0800
Fax: (08) 9427 0801
Email: aseg@casm.com.au

eLearning from SEG

We have received a message from SEG that they have a growing number of eLearning resources available on their website that ASEG members should take advantage of. This is a great resource for continuing education and training available from the convenience of a home or work computer. It includes Kurt Marfurt's seismic attributes course, several past Distinguished Instructor Short Courses, and over 30 IHRDC courses on a variety of topics. There are also other eLearning products and resources like the 2010 Technical Program DVD-ROM, past annual meeting recordings, and of course the popular Distinguished and Honorary Lecture recordings. All of these are listed at http://seg.org/eLearning.

Some of the items are available for a fee, others are free to SEG members, and others are free to anyone. Questions can be directed to eLearning@seg.org or +1 918 497 5526.

Koya Suto
Chairman, Education Committee

Australian Capital Territory

On 13 April, the ACT Branch hosted SEG Pacific South Honorary lecturer Richard Lane. The talk was held at the Research School of Earth Sciences at ANU, where members mingled over a light lunch before around 25 people heard about the philosophy underpinning the use of potential-field data to build 3D geological knowledge. Richard demonstrated new 3D modelling workflows using the Capel/Faust basins off eastern Australia as an example. He highlighted the need for streamlining of the interface between users, data and modelling tools and highlighted the immense opportunities arising in 3D potential-field modelling from increasing computational capability.

About a month later, on 11 May, the ACT Branch hosted Prof. John Bancroft (University of Calgary) for an ASEG Distinguished Lecture. John's presentation, held at Geoscience Australia, reminded everyone of the importance of getting the basics right when processing seismic data, stressed the independence of stacking and RMS velocities and demonstrated the problems induced by anisotropy. For the seismic processors in the room, the talk provided a useful reminder of the care required in processing, while the non-seismic people were given a useful reminder of the potential pitfalls in preparing high-resolution seismic data for interpretation.

The ACT branch commends the Federal Executive for instigating and supporting the ASEG Distinguished Lecturer concept – the opportunity to hear from eminent geophysicists who are visiting Australia, that otherwise may not travel widely across this vast continent, is certainly appreciated by members!

Ron Hackney

New South Wales

In March, Richard Lane, the SEG Pacific South Honorary Lecturer, gave a talk about building on 3D geological knowledge through gravity and magnetic modelling workflows at the regional through to the local scale. Richard discussed many aspects of potential field modelling and invoked much discussion and as a consequence many questions were asked. The discussion went long into the evening.

In April, Simon Williams from University of Sydney gave a talk on imaging sedimentary basins and reconstructing their tectonic history using geophysical data. Simon spoke about how gravity and magnetic data are fundamental tools for mapping the extent and depth of sedimentary basins. Simon discussed the Tilt-Depth method and how it is utilized to estimate regional variations in basin depth. Simon then discussed how potential field data provide important constraints on the crustal structure at continental margins, allowing us to generate more robust models of the rifting between continents.

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.

The speaker for June will be Clive Foss from the CSIRO on 'Down-hole tensor magnetic gradiometry'.

Mark Lackie

Queensland

May will be a busy month for the Queensland Branch. We were lucky to have Professor John Bancroft visit Brisbane as a distinguished lecturer and present 'Concepts of High Resolution Seismic Imaging and Inversion'. Another meeting is also planned with Nick Sheard and John Donohue presenting an update on their NSW Iron Ore project.

The Queensland Branch is currently on the lookout for some presenters to fill the 2011 program. If you can help or have any suggestions, please contact Fiona Duncan (fiona.duncan@bg-group.com).

Fiona Duncan

South Australia/Northern Territory

The South Australian & Northern Territory branch has held several successful events over the last few months. On the 31st of March we held a barbecue at the University of Adelaide, encouraging students interested in studying Geology and Geophysics to meet ASEG members, and learn a little of what we do. Around 30 students signed up for the ASEG.

Shortly after – on 5 April – Dennis Cooke presented 'A short summary of the North American shale gas industry'. The talk was very well received, and with the venue packed to capacity, it was standing room only.

On 5 May we welcomed Ian Roach and David Hutchinson from Geoscience Australia. They presented a talk entitled 'Acquisition, processing and interpretation of the Frome AEM survey'. Many university students attended the talk as well as consultants, university, government and industry geophysicists.

At the same event we announced the recipients of the inaugural SA/NT scholarships. This scholarship is awarded to two Honours geophysics students and is valued at $2000 each. The photograph below shows the two recipients, Robert Lampe and Alison Langsford. They have agreed to present their Honours work at a technical night later this year.

The SA branch holds technical meetings monthly, usually on a Tuesday or Thursday night at the Coopers Alehouse 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. If you're an ASEG member and are not receiving emails please ensure your contact details are up to date by contacting aseg@casm.com.au.

Philip Heath

Victoria

On Wednesday 30 March the ASEG Victorian Branch hosted the Annual Student Night at the Kelvin Club. A select group of members enjoyed the presentations by graduate-level students from Monash University and University of Melbourne. Zara Dennis from the School of Geosciences, Monash University, presented 'Mapping the TEM Smoke-Ring in Anisotropic Ground'. Brenton Crawford from the School of Geosciences, Monash University, presented 'Modes of Deformation and Reactivation along a Major Proterozoic Shear Zone: Insights from Aeromagnetic Data'. This work is being partially funded by the ASEG Research Foundation. Ben Harrison from the School of Earth Science, University of Melbourne, presented 'Heat Flow Data in the Gippsland Basin'. In a very strong field of contenders the Annual Student Night prize for best presentation eventually went to Teagan Blaikie from the School of Geosciences, Monash University, for the presentation 'A Geophysical

ASEG News

From L to R: Michael Hatch (SA/NT secretary), Robert Lampe, Tania Dhu (SA/NT treasurer), Alison Langsford & Philip Heath (SA/NT President). Robert and Alison are receiving the inaugural SA/NT scholarships.

Investigation into the Subsurface Structure and Morphology of Maar Volcanoes within the Cainozoic Newer Volcanics Province of South Eastern Australia'. Well done, Teagan, and a big thank-you to all the presenters for some really interesting and varied presentations.

On Tuesday 24 May at the Kelvin Club (at 6:00 pm for 6:30 pm start), the ASEG Victorian Branch will be hosting the technical presentation 'Potential Field Searchlights' by Mark Dransfield, Chief Geophysicist & AGG Manager, Fugro Airborne Surveys.

On Wednesday 22 June, at the Kelvin Club (at 6:00 pm for 6:30 pm start), Tim Rawling will present 'Development of Complex Basin Management Systems from 3D Geology and Geophysics'.

We are looking forward to seeing many ASEG Victorian branch members at the technical meetings this autumn.

Asbjorn Christensen

Treasurer's Annual Report for 2011 AGM

Audited financial Statements for the year ended 31 December 2010 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 2010 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;
- 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 $149 466. The end of year balance shows a Total Equity of $1 110 727 as of 31 December 2010, compared to $961 260 to the end of 2009. The result is a vast improvement over the budgeted surplus of $37 200, largely due to the record success of the 2010 Conference and Exhibition.

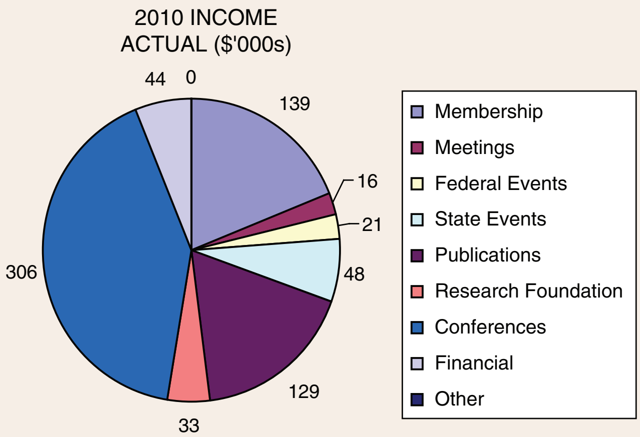
The Society's revenue source continues to be derived from:

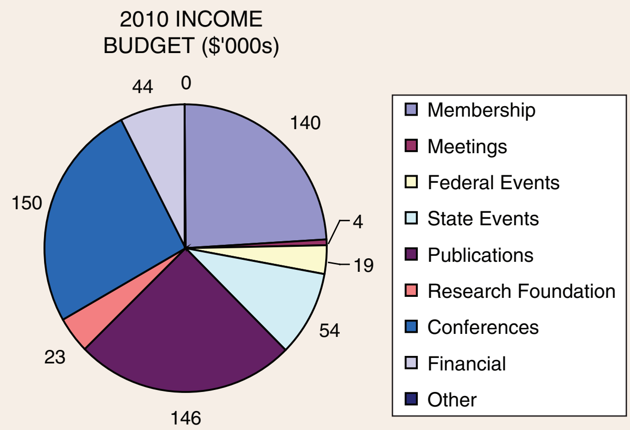
- conferences – $306 000 (204% of budget);
- membership subscriptions – $139 000 (100% of budget);
- publications advertising – $129 000 (88% of budget);
- events and sponsorship – $85 000 (111% of budget);
- interest from accumulated investments – $44 000 (100% of budget); and
- donations to the Research Foundation – $33 000 (144% of budget).

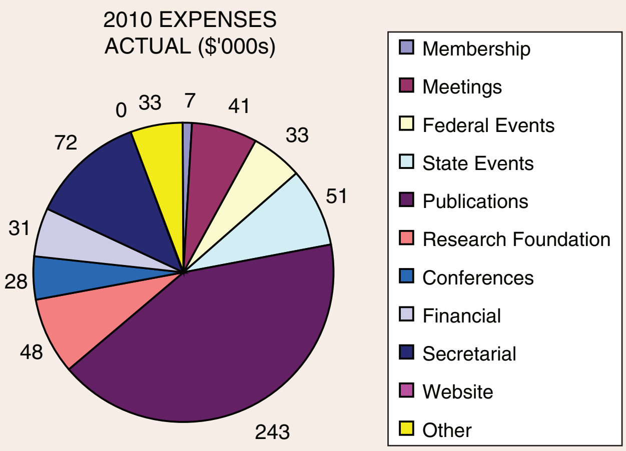
Overall the actual income for the year was 127% of the budget figure. The increase in membership is also very pleasing along with the much improved contributions to the Research Foundation. Income from publishing advertising was lower than budgeted. Approximately 50% of cash on hand was transferred to a term deposit during the year to take advantage of higher interest rates. However, the best rate required a term of 12 months which means that the account will mature in May 2011. Even so, this interest has been accrued into the 2010 books.

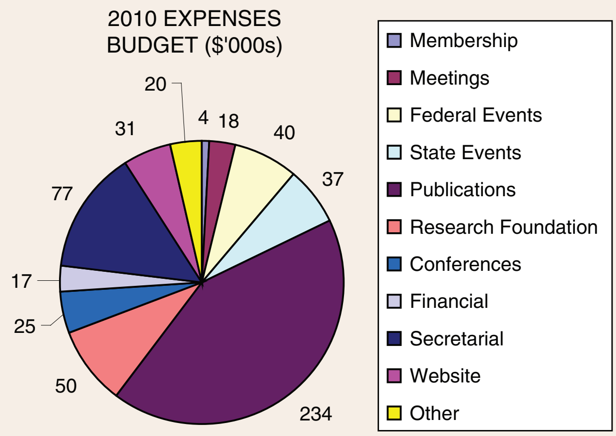
The major expenses for the Society include:

- publications – $243 000 (104% of budget);
- secretariat fees – $72 000 (94% of budget);
- events – $157 000 (137% of budget);
- financial – $31 000 (184% of budget); and
- conferences – $28 000 (112% of budget).









The overall expenditure was 106% of the budgeted figure. State branch meeting and event costs were higher than budgeted but most other budget lines were generally close to budget. There was a contingency of $31 000 in the 2010 budget for web costs. However, these funds were not called upon, all web functions being undertaken by our webmaster on a voluntary basis.

The restructure of the 2009 budget, Chart of Accounts and cashflow was followed again in 2010 which facilitated a better reconciliation of portfolio allocation and reporting on a monthly basis.

Modelling the financial position of the society for the next four years, considering potential future conferences indicated that another ASEG conference in early 2012 would be prudent financially, at least. There would be no conference in 2011 and the next major conference being the International Geological Congress in late 2012 where the ASEG could not expect revenue to the same level as would be expected from ASEG Conferences.

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

A major change to the timing and amount of payments to the Research Foundation has been implemented in 2010 to provide more clarity and certainty to the management of the Foundation.

The Society is in a very sound financial position going into 2011. The equity held will cover the uncertainty of income from future conferences, particularly in 2011 where there is no conference to provide a revenue stream to the society.

C. David Cockshell
Honorary Treasurer
12 April 2011

Outgoing President's Report to the AGM: 12 April 2011

Some of Phil Harman's report to the AGM effectively appeared in his President's Piece in the last issue of Preview (Issue 151, pp. 4–5). So the following is an edited version of his report to the AGM to avoid duplication.

Against a buoyant resources sector, the past year has been a good one for the ASEG. For me it seems to have flown past and I feel privileged to have had the opportunity, even if it did involve dealing with many of my crusty old mates.

Key events during my term as President were the very successful Sydney conference and an agreement with the Society of Exploration Geophysicists of Japan, and the Korean Geophysical Society, to jointly publish our main technical journal, Exploration Geophysics. This year Fedex agreed to fund the publishing of a book on the interpretation of aeromagnetics by Dave Isles and Leigh Rankin. Dave and Leigh have been conducting training courses on the subject now for many years and we believe that this will be a seminal publication. I am also pleased to say that the SEG has agreed to co-brand and market the book with the ASEG.

Along with Mike Asten, I continued to represent the ASEG on the Australian Geological Council (AGC). Their principal current activity is as the legal entity behind the forthcoming International Geological Congress to be held in Brisbane in late 2012. The ASEG is a co-sponsor and contributor to the IGC, however we shelved plans to try to run an ASEG conference at the same time as we felt that there would be little real technical overlap for the majority of our members. To this end we decided to hold a separate ASEG conference in Brisbane in February 2012. Our conferences are critical to the well being of the Society and we felt that we would earn very little for the effort needed to be a full part of the IGC. Nevertheless, we plan to help organise sessions and symposia to cover geophysical topics of interest to the broader geological community.

In March 2011 the ASEG co-sponsored the first Western Australian Geothermal Exploration Symposium. It is hoped that this will be the first of a regular event. I attended and gave an address at the opening session. I came away with the impression that there are lots of small gains to be made in a domestic sense, in a similar way to the photovoltaic collectors on rooves, but baseline power generation has a long way and lots of money to go.

The Fedex was very capably represented at the SEG meeting in October 2010 by Koya Suto and by Dennis Cooke. There have been many ructions in the SEG over the past year or so in relation to the legality of their constitution and what to do about it. I guess we have all looked on, incredulous at how resistant some of the SEG membership is to the winds of change.

One issue that cropped up this year has been the operational safety of ground IP and EM crews. This was raised by the NSW Mines Inspectorate. Dave Robson and Steve Collins agreed to coordinate follow-up which will hopefully lead to acceptable guidelines and a code of practice. Last I heard some slow progress was being made.

This is a good time to raise the topic of CASM. I know that several years ago there was a suggestion that we should have a fulltime CEO. In principle there is nothing wrong with this idea however as yet, we really aren't big enough to justify the cost including office space and secretarial help etc. Having said that, CASM is an excellent alternative solution and good value for money. This year I have made a small attempt to give them more administrative work which is why we asked them to design and spec out the new website. This is the front door of the ASEG and needs a fulltime keeper. It is also a vital tool for the administration of our society.

A recurring theme of my ramblings this year has been about the 'geo' in geophysics. More and more as we look under cover a 'target' is not enough…

there's too many of them. If we are to be successful they need to be in a geological context. This has been the key component of all of the 'undercover' discovery case histories that I am aware of. This is also the area of real creative challenge. The importance of this to the industry is demonstrated by the research issues being addressed by the latest exploration CRC, 'Deep Exploration Technology'. It is not only targeting the development of better and more efficient drilling technology, but also the more efficient imaging and interpretation of geology under cover.

I would like to pass on my personal thanks to everyone who has assisted me, in particular the members of the Federal Executive along with branch and other specialist committees and in particular Ron Adams and his team at CASM.

I would like to acknowledge the enthusiastic contributions of the younger members of the Fedex, including Cameron Hamilton, Reece Foster and Andrea Rutley. Their enthusiasm has been inspiring to me and they give the Fedex a different perspective. I also acknowledge their employers who allow them to make valuable time available for the ASEG.

Finally, I wish the incoming president Dennis Cooke and President Elect, Kim Frankcombe, all the best for the coming year and look forward to working with them on the next Fedex.

Phil Harman
Immediate Past President
phil.harman@bigpond.com

Outgoing President, Phil Harman (right), hands over the ceremonial gavel to new ASEG President, Dennis Cooke (photo courtesy of David Denham).

President Elect, Kim Frankcombe (left), gets the good oil on all matters financial from Treasurer, Dave Cockshell (photo courtesy of Koya Suto).

New President-Elect – Kim Frankcombe

I joined the ASEG in 1978 while still a student at the University of Tasmania. As was common at the time, I graduated with a double major in geology and geophysics which lead to a job as a geologist with DeBeers working mostly in WA. After a couple of years, the 'boys own' adventure started to wear off and I decided to get a job using both sides of my brain, looking for uranium with Mobil. Unfortunately, or maybe in hindsight not so unfortunately, in the mid-80s Mobil, along with the other oil companies decided to pull out of mineral exploration. A$US10/lb uranium price helped their decision. This led to a 6-year stint consulting which included almost all geophysical techniques and a wide range of clients. These ranged from pushing electrodes down toilets in order to find cracks in sewer pipes under houses in Adelaide using a misse-a-la-masse variant I had developed, through conventional mineral exploration to collecting and processing up hole refraction statics for oil exploration. There wasn't a lot of money around for software and the internet was still a toy for US academics and the military so I taught myself to program and coded up processing and modelling routines for all the methods I used. As well as meaning that any job was processable, this had the added benefit that in order to know what to write I was forced to have a reasonable understanding of the physics behind each method. Each office move required a bigger truck to accommodate the ever expanding library.

In 1989 I moved to Perth to join Pat Cunneen's vehicle for total world domination, World Geoscience, to manage their ground division and later, the Australian airborne EM arm. Later, when Normandy were building their geophysics division in the early 90s, I jumped ship to work for an exploration company again. The next 6 years were spent working on some magnificent deposits and gold fields including The Golden Mile, Scuddles and the Tennant Creek Goldfield as well as working with the exploration teams and the new

Continued on p. 40

ASEG News

New members

The ASEG extends a warm welcome to 38 new members to the Society (see table). These memberships were approved at the Federal Executive meetings held on 31 March and 5 May 2011.

Name	Organisation	State	Member grade
Mark James Armstrong	Teck Australia	WA	Active
Lauren Nicole Burraston	The Australian National University	ACT	Student
Natasha Bysterveld	University of Adelaide	SA	Student
Marco Daniel Criado	University of Adelaide	SA	Student
Bryony Beatrice Plaxy Crowe	University of Adelaide	SA	Student
James Matthew Deeks	University of Western Australia	WA	Student
Matthew Richard Fargher	University of Adelaide	SA	Student
Holly Marie Feltus	University of Adelaide	SA	Student
Rommy Angela Fisher	University of Adelaide	SA	Student
Krestabelle Futalan	University of Adelaide	SA	Student
Lisa Jade Gavin	University of Western Australia	WA	Student
Scott Gerbhardt	University of Adelaide	SA	Student
Matthew Kenneth Goldman	University of Adelaide	SA	Student
Eun-Jung Holden	University of Western Australia	WA	Active
Isaac John Kell-Duivestein	University of Adelaide	SA	Student
Joel Kirk	University of Adelaide	SA	Student
Nicholas James Lambos	University of Adelaide	SA	Student
Jacob Kiat Beng Low	University of Adelaide	SA	Associate
Anna Maddocks	University of Adelaide	SA	Student
Hamish Robert McKay	University of Sydney	NSW	Student
Todd Michael Mojesky	CGGVeritas	WA	Active
Megan Jennifer Nightingale	Arrow Energy Pty Ltd	QLD	Active
Bronwyn Cherie O'Keefe	QGC	QLD	Associate
Tony Parks	Macquarie University	NSW	Student
Nathaneal Pittaway	University of Adelaide	SA	Student
Sean Michael Plunkett	Nautilus Minerals	QLD	Active
Anya Marie Reading	University of Tasmania	TAS	Active
Ian Charles Roach	Geoscience Australia	ACT	Active
Claire Robertson	Water Corporation	WA	Active
Seda Rouxel	CGGVeritas	VIC	Associate
Jeremy Ryan Schulz	University of Adelaide	SA	Student
Katherine Lee Silversides	University of Sydney	NSW	Student
Frank Fotios Stamoulis	University of Adelaide	SA	Student
Bai Chun Sun	Curtin University of Technology	WA	Student
Jasmine Tearle	University of Adelaide	SA	Student
Matthew Wheeler-Carver	Fugro	WA	Active
Sam White	University of Adelaide	SA	Student
Zhe Zhou	Santos	SA	Active

We would also like to welcome *Instrumentation GDD Inc.* as a new corporate member of the ASEG. Since 1976, Instrumentation GDD Inc. has manufactured, sold, rented and developed a range of innovative instruments for geophysics and mining. In 2009, the GDD team developed a new, portable, innovative tool to measure the electrical properties (IP) of core samples called SCIP Tester (Sample Core IP Tester). For induced polarization or resistivity surveys, there is a new 32 channel IP Receiver with the proven 1800W-3600W-5000W/2400V IP Transmitter. Two 5000W IP Transmitters can be linked together and transmit up to 10 000W/4800V. GDD's handheld MPP probe logs DDH cores instantaneously and records the conductivity and the magnetic susceptibility. Airborne and ground EM conductors can be sampled using the Beep Mat with GPS to detect and localize sulphides, gossans or floats down to three metres below the surface. To increase grades in a mine, the SSW-EM-Probe can be used to log blast holes to outline the limits of ore before selectively loading explosives.

Contact details are:
Instrumentation GDD Inc.
860 Boul. de la Chaudière, Suite 200
Québec, QC, Canada
G1X 4B7
Ph.: +1 418-877-4249
Fax: +1 418-877-4054
Email: gdd@gddinstrumentation.com
Website: www.gddinstrumentation.com

Coffey Geotechnics joins ASEG Student Sponsorship program

The ASEG extends a warm welcome to Coffey Geotechnics as they join Rio Tinto and Origin Energy as corporate sponsors of the ASEG Student Sponsorship Program.

This program aims to secure the future of our profession by offering subsidised ASEG memberships to students while they study. Currently the program caters for career interests in Minerals or Oil & Gas geophysics (subsidised by Rio Tinto and Origin Energy respectively). With the addition of Coffey Geotechnics, we can now include the category of Engineering/Environmental geophysics.

Cameron Hamilton
Membership Committee Chairman

James Duncan Crone: 7 August 1929 – 4 March 2011

James Duncan Crone, pioneering Canadian mining geophysicist, explorationist and entrepreneur, passed away on Friday 4 March 2011, in Mississauga at the age of 81. Duncan, known and recognized in the mining and exploration community around the globe, was a very innovative, practical-minded geophysicist who made numerous important contributions to the advancement of mining geophysics and to mineral exploration discoveries during his long career.

In 1962, Duncan founded Crone Geophysics Ltd. where the Shootback EM method was further improved and put into production. Duncan's innovation and inventiveness led him to produce numerous practical and portable instruments such as the CEM (Shootback), the VEM (Vertical Loop), the RADEM (VLF receiver), I.P. Receivers, and backpackable I.P. transmitters. These were sold to a worldwide market.

Realizing that there was a growing need to look deeper into the earth, Duncan began to develop borehole and surface time-domain EM equipment, which he named Pulse EM. The original Crone surface Pulse EM system, developed in 1973, was first used in the Sultanate of Oman where, serendipitously, the first field test outlined three massive sulphide ore bodies. This was the first commercially available surface time-domain EM system, and it was an immediate success. He followed this in 1978 with the first commercial Borehole Pulse EM system. Today, borehole Pulse EM is an integral part of many mineral exploration programs, and has led to the discovery of many deep massive sulphide orebodies.

Duncan presented many papers and wrote numerous case histories in his very readable, straightforward style.

The easy-to-operate and highly reliable geophysical instruments for practical geophysical surveys developed by Duncan and his dedicated collaborators provided a great service to the exploration industry and are his legacy. He will be remembered by many colleagues, associates and friends who were inspired by his ideas, benefited from his innovations and encouragement, and enjoyed his humour, his down-to-earth nature and his generosity of spirit.

Duncan is survived by his devoted wife, step-daughter, five children from two prior marriages, fifteen grandchildren and sixteen great-grandchildren.

A detailed obituary and profile can be found at www.cronegeophysics.com/Home/JDuncanCroneObituary.pdf.

Len Collett: 19 September 1922 – 9 March 2011

Leonard Stanier Collett spent his pre-university years on a farm near Burford, Ontario, graduated from McMaster University with a degree in Physics and Chemistry, then completed his masters in Geophysics at the University of Toronto. After four years with Newmont Mining in Arizona, he joined the Geological Survey of Canada for a full and valued career in Ottawa.

The following is extracted from an article in *The Phoenix* in June 1995.

> *…His career [at the GSC], spanning more than 30 years, was many-faceted. The early days included research into near surface seismic sounding with George Hobson; in the early 1960s the electrical methods section was set up to research rock properties (Collett was one of the five original researchers measuring electrical properties of lunar rocks); radar sounding came in the '70s and finally, his role of 'scientific watchdog' through the 1980s with IRAP (Industrial Research Assistance Program) and the Unsolicited Proposal Program.*

Collett retired in 1987 at age 65 and then stayed on part-time for two and a half years as an IRAP representative. His greatest joy outside of his professional life was creating a haven of self-taught cabinet making on their farm near Hopetown, including the propagation of nut trees surrounded by a thriving grove of black walnut. As a humanitarian, Len was active in community affairs, supported the arts and cultural life of Ottawa, and was a strong advocate of scholarships for students of geo-sciences.

Len passed away peacefully at the Ottawa Civic Hospital on Wednesday, March 9, 2011 after a brief struggle with mesothelioma. He was predeceased by their son Ronald in 1973 and is survived by his devoted and loving wife, Genice (nee Mauney).

ASEG 2012 22nd ASEG International Conference and Exhibition News Update (05)

Our key focus at this time is the appointment of sponsors. So far the following companies have agreed to be sponsors at the conference: Anglo American Exploration (Australia) and Origin at the Gold level; Beach Energy, CGGVeritas, Carpentaria Exploration, Geosoft, Pitney Bowes Business Insight, Talisman Energy and Velseis at the Silver level; and Planetary Geophysics Pty Ltd at the Bronze level. Congratulations to them and we welcome them. There is still time in this financial year to get on board.

If you have not done so already, please visit our website (www.aseg2012.com.au) to register your expression of interest in presenting a paper. The closing date is 30 June 2011. Twelve keynote speakers have been invited to date and we are confident that most if not all of these will accept the invitation. Keep visiting the website for further updates.

Please contact Michelle Ianna at mianna@arinex.com.au for a poster for your office. Your assistance will help us to promote this event.

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

Anyone able to help (we still urgently need people to help with papers) should contact Binzhong. You don't need to be in Brisbane.

Our conference theme of 'Unearthing new layers' recognises that change within our industry remains achievable, and as such we invite contributions from all geophysical and related disciplines, highlighting the application of geophysics in diverse industries from resource exploitation to environmental and engineering applications.

Henk van Paridon

A lacklustre Budget for Science and Innovation in 2011

Funding declines in real terms

The 2011/12 Federal Budget, tabled in May this year, was a rather boring steady as she goes document. There were no major surprises and no significant new initiatives.

Even the prime media release of Senator Kim Carr, the Minister for Innovation, Industry, Science and Research, which reported that the government will support CSIRO to the tune of '*a record $3 billion, through a new Quadrennial Funding Agreement to operate over four years from 2011'* did not effectively change the allocation for CSIRO.

A closer look at the numbers reveals that government funding for CSIRO in 2010/11 of $720 million will only rise, in the forward estimates, to $768 million by 2014/15 (see Table 1) – in other words an increase of about 1.7% per year. This is unlikely to keep pace with inflation. All that seems to have happened is that CSIRO have been locked in for four years to government funding that will decline in value over the four years covered by the agreement.

At the same time the cash received from external goods and services is budgeted to rise from $458 million to $548 million. This amounts to an increase of about 20% or 5% per year – so we may be back to the bad old days of cost recovery driving scientific programs. By 2014/15 the ratio of external earnings to government appropriation will have risen from 64 to 71% - quite a hike.

It was therefore rather strange for the Australian Academy of Science to *'welcome the Government's decision to protect science research funding in the 2011 Federal Budget but said it was disappointed there will be no increase in the research budget'*. The Academy release had a headline: *Steady science budget shows lack of inspiration* – for once the headline tells a better story than the text.

The '*Take home message'* from the Federation of Australian Scientific and Technological Societies (FASTS') media release hit all the nails on the heads.

> *The Federal Budget is quite unremarkable and takes a business as usual approach. The budget offers no vision to the science sector, nor does it recognise science and technology as drivers of economic growth and productivity. Australia continues to lag behind the OECD average on research expenditure (less than 2 per cent of GDP) leaving Australia ranked 13th amongst OECD countries.*

Table 1 shows the fate of the main government science and research agencies. As can be seen, the larger agencies such as CSIRO, the Australian Research Council, and the National Health and Medical Research Council are scheduled to obtain small increases, but the smaller agencies, such as The Australian Institute of Marine Science (AIMS), Geoscience Australia, The Australian National Nuclear Research and Development Organisation (ANSTO and the CRC Program do not fare well in the forward estimates.

Notice how the total funding for all the agencies only increases by 1.7% per year in the period 2010/11 to 2014/15 – hardly sustainable.

Table 1. Appropriation from Government for key science agencies

Agency	Appropriation from Australian Government in $ million								
Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
CSIRO	610	664	668	691	720	725	742	756	768
ARC (Value of grants)	575	577	603	676	718	817	886	898	899
NH & MRC	466	541	632	722	766	791	818	831	835
DSTO	341	365	352	390	447	434	441	424	448
CRC Program	189	212	183	197	173	166	155	146	136
BoM	214	235	245	254	252	261	266	266	269
ANSTO	142	153	164	153	166	158	160	158	158
Geoscience Australia	125	145	139	129	123	111	112	98	97
Antarctica	102	107	105	110	103	103	88	88	88
AIMS	24	27	28	28	31	31	32	32	33
Totals	2788	3026	3119	3350	3499	3597	3700	3697	3731

Government review of Geoscience Australia recognises the value of GA

However, a government review of Geoscience Australia released with the budget papers confirmed the value of the agency's work to the ongoing exploration of Australia's natural resources. The media release stated:

> *Geoscience Australia is Australia's national geological surveyor, offering valuable pre-competitive data for explorers. Its products and services inform the government on a wide range of policy challenges in managing Australia's natural environment.*
>
> *The Department of Finance and Deregulation looked at the future direction of Geoscience Australia.*
>
> *The Review recognised the significant value of Geoscience Australia to the nation's economy. This includes vital functions relating to Earth monitoring, remote satellite sensing, spatial data, ground water and natural disaster warnings and assessments.*
>
> *Major resources companies operate globally – capital is highly mobile and the work undertaken by Geoscience Australia helps attract that investment to Australia's shores, boosting jobs and exports.*
>
> *Geoscience Australia is a world leader in its field. The Review found that much of its work amounts to a national prospectus for some of Australia's most lucrative natural resources.*
>
> *The Review is an important mechanism to ensure that, as with all government funding, value for our public money is achieved.*

News

The Review found Geoscience Australia's activities complement those of other government agencies. It called for more structured policy oversight of some activities, in particular the spatial data functions.

Recent calculations show that Geoscience Australia's work under the Offshore Energy Security Program for the period June 2006 to June 2011 delivered a return on the Government's investment of $75 million of $625 million in committed frontier exploration expenditure in acreage awarded to date, with an additional $1 billion for secondary work programs.

And the agency is encouraged to advance a case to government to address the fall in funding indicated by the forward estimates in Table 1. The full report of the Review of Geoscience Australia is available at http://finance.gov.au/publications/strategic-reviews/geoscience.html.

Big picture indicates stable (stagnant?) situation

Table 2 (taken from numbers in the budget papers) and Figure 1 show the changes in government investment as a percentage of government expenditure and also as a percentage of GDP, during this century. As can be seen these percentages have remained relatively unchanged during this century.

As expected the government's investment in Science and Innovation has kept pace with the GDP, but according to FASTS, we should be aiming higher.

Eristicus

Table 2. Australian Government Investment in Science and Innovation

Financial year	Government investment $ billion	% of Gov. expenditure	% GDP	GDP $ billion
99/00	4.025	2.57	0.624	645
00/01	4.206	2.34	0.614	689
01/02	4.793	2.49	0.622	736
02/03	4.967	2.42	0.608	782
03/04	5.674	2.60	0.638	841
04/05	5.251	2.27	0.548	898
05/06	6.043	2.42	0.574	967
06/07	6.557	2.46	0.575	1047
07/08	6.548	2.34	0.541	1146
08/09	7.268	2.26	0.528	1206
09/10	8.372	2.75	0.651	1286
10/11	9.077	2.56	0.654	1388
11/12	9.384	2.56	0.635	1478

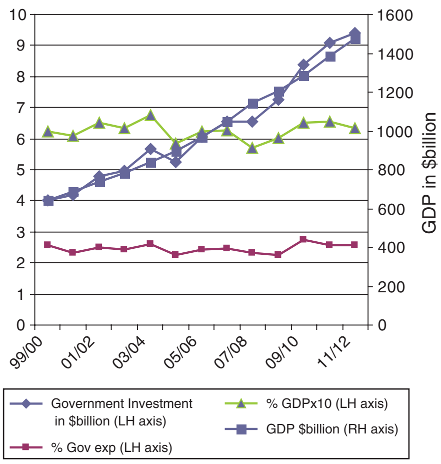


Fig. 1. *Changes in the Australian Government's investment in Science and Innovation this century. The left hand axis shows investment in $billion (blue): as a percentage of GDP x 10 (green); and as a percentage of government expenditure (red). The right hand axis shows the Australian GDP in $billion (purple).*

Professor Ian Chubb, Australia's new Chief Scientist

Prime Minister Julia Gillard and Minister for Innovation Senator Kim Carr have appointed Professor Ian Chubb AC as Australia's new Chief Scientist. Professor Chubb commenced his new role on 23 May 2011.

Professor Chubb has had a distinguished career in higher education and research and recently retired after a decade as vice-chancellor of the Australian National University. He is a neuroscientist by training, has co-authored some 70 full papers and co-edited one book all related to his research. He later took on leadership roles in university administration and sector advocacy bodies.

Professor Chubb has a Masters in Science, a DPhil from the University of Oxford and is an honorary doctor of science from Flinders University. He was made an Officer in the general division of the Order of Australia in the Queen's Birthday Honours in 1999, and was made a Companion of the Order in 2006 for service to higher education. He was made the ACT's Australian of the Year in 2011 for his contribution to higher education.

Professor Chubb's appointment has been largely welcomed by the Australian science community. Australian Academy of Science President Professor Suzanne Cory said, 'He is well known for his ability to put a powerfully reasoned case for research. We hope as Chief Scientist he will speak strongly for the entire Australian science community'. Similarly, FASTS President Dr. Cathy Foley said, 'Professor Chubb has a long track record of being a strong advocate for science and FASTS looks forward to his continued advocacy'.

Last year Professor Ian Chubb said, 'The world can't do without science, and if we denigrate it and belittle it and besmirch it by inappropriate behaviour we're in trouble'. We wish him well in selling this message to our politicians.

Professor Ian Chubb accepting his new appointment as Chief Scientist for Australia.

HELITEM™ flying in Australia

The Australian introduction of Fugro Airborne Surveys HELITEM™, the world's highest powered helicopter TEM system, is proving very successful with the system rapidly gaining acceptance by explorers.

A HELITEM system has been operating in Australia since October 2010. Surveys completed to date, totalling over 18 000 line km, have been located in WA, NT, QLD and NSW. Mineralisation types targeted include VMS, Cobar-style base metals, IOCG, Cu-Au, and Poly-metallic.

In response to high demand, a second system started operations in June 2011. This will improve system availability for explorers across Australia.

Worldwide, Fugro Airborne Surveys currently have eight HELITEM systems operating, with major surveys in Canada, India, Mexico, Brazil, Africa and elsewhere.

HELITEM is the product of R&D by Fugro Airborne Surveys over a number of years, and is produced in Toronto by Fugro. HELITEM was designed for mineral exploration applications with particular emphasis on deep conductor detection in conductive as well as resistive regimes, with increased conductor definition and interpretability.

To achieve these design goals, key features include:

- The transmitter features a moment of 2 million A.m², the highest powered helicopter TEM system available, a 25 Hz base frequency and a long off-time, providing deep conductor detection in conductive as well as resistive terrains;
- The receiver features three component X, Y and Z coils, for maximum interpretability of anomalies, in an unique Stable Suspension Receiver Cone mounting for low noise levels and increased sensitivity; and
- Complete on-time and off-time measurements at full sensitivity providing high sensitivity to both strong and weak conductors, and allowing the calculation of high quality B-field data.

In Australia, demonstration surveys have been flown at Forrestania and Nepean in Western Australia, with evaluation datasets available on request. For more information, please contact Craig Annison (CAnnison@fugroairborne.com.au).

HELITEM™ in the air, Forrestania, WA, February 2011 (photo courtesy of Fugro Airborne Surveys).

Geophysics in The Centre for Exploration Targeting, The University of Western Australia

Mike Dentith

Winthrop Professor, CET, UWA
Email: michael.dentith@uwa.edu.au

The Centre for Exploration Targeting (CET; www.cet.uwa.edu.au) was established in 2005 and is the latest in a series of successful mining-industry oriented research and teaching centres within the School of Earth and Environment (previously Department of Geology & Geophysics) at The University of Western Australia (UWA). Growth has been rapid since the inception of the CET with turnover in 2011 projected to exceed $5 000 000 with 30 research staff working in the centre.

The CET's goal is to work with industry to develop more efficient exploration methods and to share research with the community to encourage and cultivate future economic growth. One of the CET's key performance indicators is the commercialisation of its research outputs. The work of the CET is dominantly, but not exclusively, in applied science. However, in 2009, CET also produced a third of UWA publications in the top international journals *Nature* and *Science,* all from industry co-funded projects, demonstrating that astute research project design can satisfy both academic and industry priorities.

The current Director of the CET is Professor T. Campbell McCuaig. The CET has a Board (Chair Dr Jon Hronsky), which is responsible for the Centre's mission, objectives and strategic directions, including technical and financial performance and risk management. There is also an External Advisory Group (EAG), with overall responsibility for reviewing the Centre's research strategy, comprising personnel from the mineral exploration sector, CSIRO and the Geological Survey of WA. The current geophysical representatives are Lisa Vella of Teck Australia and Howard Golden of Kinross Gold. Barry Bourne (Barrick Gold) is a past geophysical representative.

As with all geophysics at UWA, the geophysical teaching and research in CET is fully integrated with the geology programmes and continues the successful practice of working closely with scientists with expertise in fields other than geophysics. As shown in Figure 1, the CET has five main 'themes': three are specific commodity oriented and two are cross-disciplinary. The 'Geophysics and Image Analysis' theme is jointly led by Professor Mike Dentith and Associate Professor Eun-Jung Holden. They lead a team of six researchers, which includes geophysicists, geologists and computer scientists.

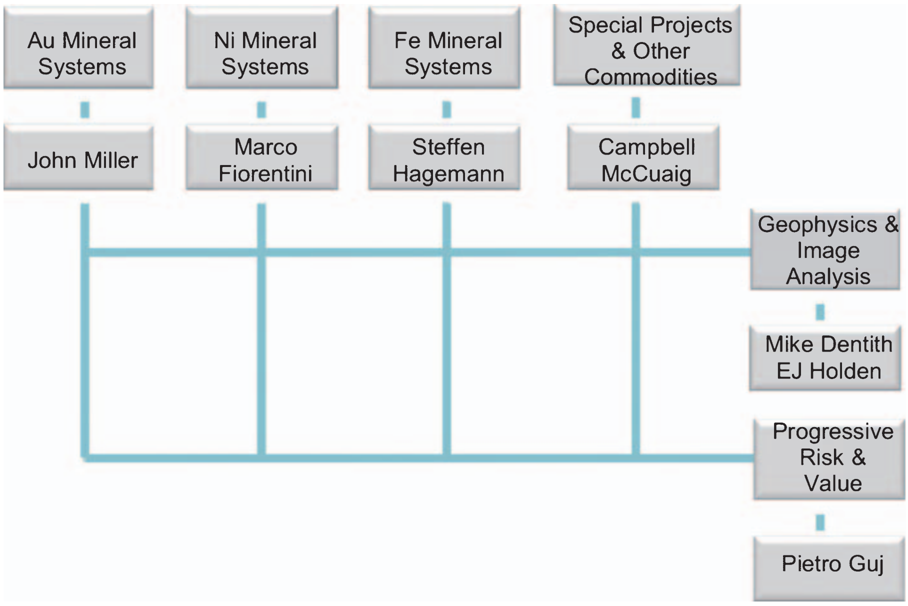


Fig. 1. *Organisation of research within the Centre for Exploration Targeting.*

- Professor Mike Dentith: applied geophysics
- Associate Professor Eun-Jung Holden: image analysis
- Dr Luis Gallardo: inverse modeling, near-surface geophysics
- Dr Alan Aitken: interpretation and modelling of potential field data, structural and tectonic analysis
- Dr Aurore Joly: geological interpretation of geophysical data, geoscientific model building
- Professor Peter Kovesi: image analysis
- Dr Daniel Wedge: image analysis, pattern recognition
- Dr Jason Wong: visualisation, game development.

Individuals in this research team have significantly different expertise but together, and incorporating other CET staff, represent cross-disciplinary capabilities and interrelated research interests allowing for a variety of research directions. Combined with the computational and seismic geophysics expertise concentrated in other research centres in UWA this represents a significant pool of geophysical expertise. The overall theme of the research in the CET is the geophysical characterisation of mineralised environments from drillhole to terrain scale (http://www.cet.uwa.edu.au/research/geophysics-image-analysis). Some current research areas are briefly described below.

Geophysical characteristics of deposit and camp-scale environments (Aitkin, Dentith, Holden, Kovesi, Wedge, Wong)

Research on the geophysical responses of individual deposits is a long standing activity at UWA (e.g. Guo and Dentith, 1997; Dentith, 2003). Current student research projects in this area include constrained inverse modelling of the Wallaby gold deposit, an investigation of the optimal application of downhole IP surveys at the Centenary gold deposit (both sponsored by Barrick Gold) and a study of controls on the electrical responses of massive sulphide deposits (with Teck Australia). Following some early attempts to apply computer vision derived methods to geophysical datasets (Dentith, 1995), image analysis applied to geophysical data became a major area of research with the appointment of

Dr Eun-Jung Holden, a computer scientist by training. Current research projects are focusing on characterizing camp-scale environments as a means of better utilising regional geophysical datasets (e.g. Holden et al., 2008).

A major area of recent research is the development of automated image analysis methods to identify potentially prospective areas in gridded geophysical datasets. Working with Archean lode-gold deposits, the initial emphasis was on mapping structures via lineaments in the data with particular use made of phase congruency and textural mapping. In April 2010, these algorithms were commercialised as the CET Grid Analysis Extension for the Oasis Montaj package which is marketed by Geosoft Inc. This product contains a suite of algorithms for texture analysis, and ridge/edge detection and their vectorisation.

Subsequent work concentrated on the analysis of the spatial distribution of lineaments (Figure 2). Given the lineament features that are automatically identified from the existing algorithms, 'heat maps' are generated which characterise the structural complexity in local neighbourhoods based on such parameters as lineament crossings and range of orientations. These tools are designed to highlight the areas of structural complexity where lode gold deposits are known to occur. These structural heat maps can be used either to aid manual prospectivity analysis or as an additional layer of information for GIS-based quantitative prospectivity analysis that combines multiple geoscientific datasets.

Another fruitful line of research has been on the automatic detection of anomalies with characteristics consistent with particular mineralized environments. A set of tools has been developed to aid in identifying the magnetic response of an idealised copper-gold porphyry system within magnetic datasets. Porphyry-style mineralisation is associated with comparatively widespread hydrothermal alteration with approximately concentric alteration zones surrounding a central intrusion. In some zones, magnetite is destroyed and in others, it may be created. The result is annular magnetic responses which may be positive or negative with respect to the surrounding areas. These algorithms allow the detection of circular anomalies that are associated with the central intrusion of the porphyry system and the boundaries of the features based on their magnetic contrast relative to the surrounding. This work was funded by Barrick Gold of Australia.

Interest is currently being assessed in the development an 'interpreters tool box' for gridded geophysical data, equivalent to those available to seismic interpreters. The intention is to allow semi-automated and simultaneous interpretations of mineral geophysical datasets to assist stratigraphic and structural analysis for exploration purposes.

Terrain-scale prospectivity analysis using geophysical datasets (Aitkin, Dentith, Gallardo, Joly, McCuaig)

A major ongoing project, in association with the Geological Survey of Western Australia (GSWA) and funded by the Western Australian Government's Exploration Incentives Scheme, involves assessing the mineral prospectivity of selected terrains in Western Australia.

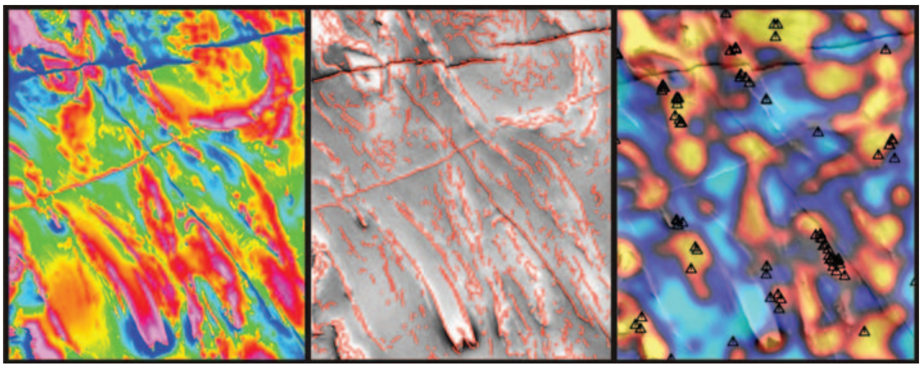


Fig. 2. *(Left) An RTP TMI aeromagnetic image from the Yilgarn Craton of Western Australia, the property of Fugro Airborne Surveys Pty Ltd (Group A – Menzies to Norseman 1986–1987 Non-exclusive Database); (Middle) Automated lineament detection result in red overlaid over the grayscale image of the RTP-TMI; (Right) The orientation entropy heat map, which uses the cold-hot colour map where blue indicates low and yellow indicates high values, overlaid on the grayscale RTP-TMI data. Locations of gold deposits greater than 1 t are shown by the black triangles.*

The intention is to achieve a step change in the exploration relevance of GSWA datasets; it has been recognized that a series of targeting products will help junior to mid-size exploration companies translate the GSWA's geoscientific datasets into actual ground acquisition and drill target decisions.

This project will consider eight terrains: with work in the Western Arunta Orogen and southern Yilgarn Craton largely complete, current emphasis is on the Musgraves Orogen. A typical work flow involves compilation of available data, regional scale interpretation of geological and geophysical data to create a 3D geological model and develop a 4D understanding of the study area. The resulting geological map and 4D history are used as a basis for GIS-based prospectivity analysis for delineating and ranking exploration targets. A mineral system approach is used to identify the critical processes involved in the deposit formation, as well as their respective exploration criteria and spatial proxies (or predictor maps). One of the key objectives is to develop a method for best-practice in terrane- to camp-scale exploration targeting that can be applied to different terranes and deposit types.

To complement the prospectivity studies, and in particular to provide 3D information, the acquisition and interpretation of magnetotelluric data has become a significant area of activity in CET. Working with personnel from Moombarriga Geoscience and the Universities of Adelaide and Manitoba, four surveys have been undertaken to date: Fraser mobile Belt (Balladonia-Kambalda); southern Yilgarn Craton (Hyden-Norseman), Musgraves Complex and eastern Capricorn (Sylvania to Marymia inliers).

Geophysical interpreter-data interaction (Dentith, Holden, McCuaig)

Geophysical data interpretation is a highly subjective task and interpreters use various data visualisation methods for enhancement and display in this process. The ultimate goals of this research theme are twofold: one is to understand how current visualisation practices evolved and how they may affect an interpretation; and the second is ultimately to design and implement more effective visualisation and interpretation methods. As a first step toward these goals, work has concentrated on

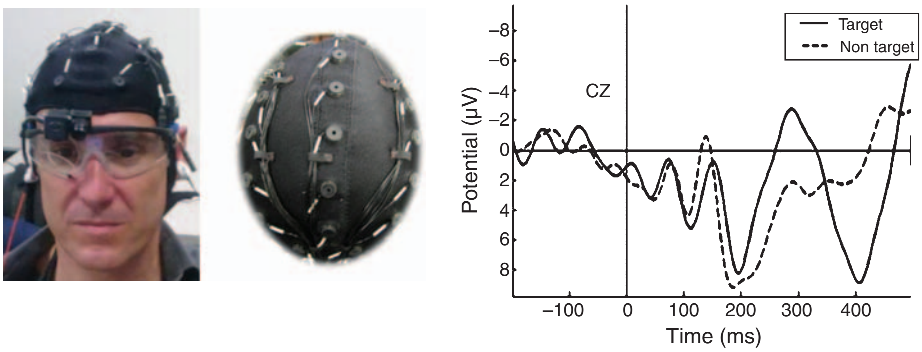


Fig. 3. *(Left) An interpreter wearing an eye tracker goggle and an EEG cap; (Middle) The top-down view of the EEG cap; (Right) Brain responses when viewing a target (a feature of interest) and a non-target. The positive deflection between 300 and 600 ms is the 'P300' response elicited by task relevant stimuli.*

understanding how interpreters interact with the data when conducting specific tasks during interpretation, and analysis of how these interactions differ when different visualisation methods are used. This is a collaborative project by a team of multidisciplinary researchers (electrical engineering, psychiatry, and computer science) at UWA and Curtin University.

The neurological and physiological responses of interpreters are monitored using an eye tracker system (ETS) that pursues their vision during data observation and an electroencephalograph (EEG) that captures brain responses of the interpreter as the interpretation proceeds (see Figure 3). Since 2010, a PhD study by Yathnanthan Sivarajah has been focusing on the detection of brain waves that are associated with the mental fitting of a geoscientific model to the patterns of variation within data being interpreted. On-going study combines this mental fitting process with the data observation patterns identified by the eye tracker, which will help us understand the variations in the mental fitting process associated with specific data patterns that are being observed.

Numerical geophysics (Gallardo)

Mathematical geophysics has a long history at UWA with early research guided by Dr Ron List from the Department of Mathematics. Research undertaken in the 1990s included some of the first applications of genetic algorithms to geophysical inverse problems (e.g. Boschetti et al., 1996) and wavelets in geophysical data processing (e.g. Ridsdil-Smith and Dentith, 1999).

More recently, mathematical geophysics has again become an active area of research following the appointment of Dr Luis Gallardo as Goodeve Lecturer in Geophysics. This position is funded by the UWA Geoscience Foundation and the Goodeve Foundation, a foundation created in memory of the ex-government and industry geophysicist Peter Goodeve. Dr Gallardo's particular speciality is developing methods for the simultaneous inversion of multiple datasets (Gallardo and Meju, 2011). Originally developed for shallow geophysical surveys (Gallardo and Meju, 2003; Gallardo, 2007), the methods are currently being used as part of collaborative projects with geologists working in mineralised granitoid-greenstone and Proterozoic orogenic terrains in Australia, Africa and South America. Work is also underway to extend the methods to 3D and to simultaneously model potential field and magnetotelluric data.

Figure 4 shows an example of inversion results from a granitoid-greenstone terrain near Leonora, in central Western Australia. Nineteen cross-cutting sections have been created showing subsurface variations in density and magnetisation. The physical property variations in the sections are found to:

(i) correlate with the different suites of granites and greenstone sequences exposed on the surface,

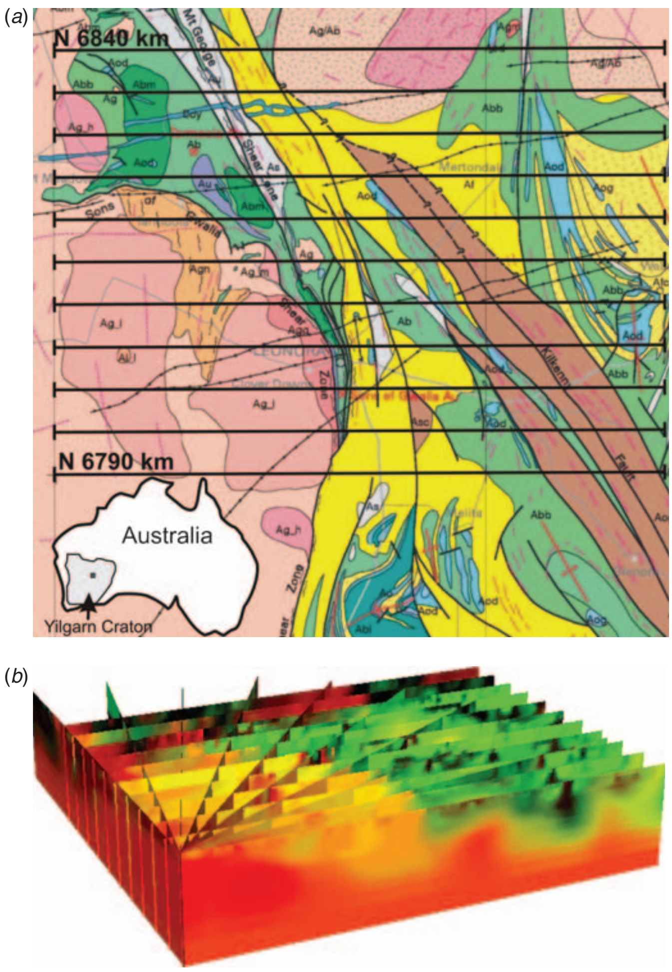


Fig. 4. *(a) Location map of Leonora district showing the location of East–West profiles for joint gravity and magnetic inversion. (b) Density-magnetisation images of the profiles in the studied area. Colours are associated with characteristic density-magnetism combinations and are directly correlated with different lithologies exposed at the surface and features on the NY1 seismic section.*

- (ii) match the structures imaged by the NY1 seismic reflection data, and
- (iii) coincide with the major tectonic structures mapped in the area.

The methodology has demonstrated its suitability for improved use of gravity and magnetic exploration in structurally complex cratonic areas.

Conclusion

The Centre for Exploration Targeting has assembled a group of geophysical researchers whose expertise ranges from numerical modeling and analysis through to geologically oriented data interpretation. Within UWA there is also significant geophysical expertise in sister research centres (Centre for Petroleum Geoscience and CO_2 Sequestration, Western Australia Geothermal Centre of Excellence). A close working relationship with these centres, a track record of delivering fundamental and applied research valued by industry, and close collaboration with personnel from other fields of geosciences and many other disciplines has allowed significant growth in geophysical research in CET and the host School. It is anticipated that geophysics will continue to develop in CET. One field where it is hoped to increase activity is in petrophysics: both database creation and understanding of the processes that affect rock physical properties.

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WesternGeco and Schlumberger support Curtin University students

As part of WesternGeco and Schlumberger's commitment to helping educate the next generation of geoscientists, two students from Curtin University, Jason Valuri and Sean Herbert, along with their Curtin University supervisor, Dr Christian Dupuis, and WesternGeco co-supervisor, Dr Tim Dean, recently travelled to the United Arab Emirates to acquire data for their honours projects. Their work, which involves the evaluation of seismoelectric methods using vibratory sources in arid environments, was conducted as part of a larger study showcasing the use of WesternGeco's state-of-the-art acquisition technology for near-surface hydrogeological studies.

The Shwaib test site is located on the western edge of the northern Oman mountains about 60 km north of Al Ain (Figure 1) and was originally developed as a prototype aquifer storage and recovery project by the Environment Agency-Abu Dhabi and Schlumberger Water Services (Black et al., 2008). In order to develop a better understanding of the aquifer, its recharge and storage capacity, Schlumberger Waters Services had previously acquired a number of geophysical surveys such as gravity, surface NMR, time-domain electromagnetics and well logging. The reprocessing of heritage 2D seismic data in the region highlighted the benefits that could be obtained using high-resolution seismic over the area. The availability of all the additional geophysical data also made it an excellent site to further the on-going seismoelectric research at Curtin University.

Fig. 3. *Members of the project team dwarfed by a tracked 80 000 lb Desert Explorer vibrator. From left: Sean Herbert (Curtin University), Rolf Herrmann (Schlumberger Water Services – Abu Dhabi), Tristan Hollande (WesternGeco – Oslo Technology Centre), Christian Dupuis (Curtin University), Jason Valuri (Curtin University), Tim Dean (WesternGeco – Perth GeoSolutions Development Centre) and Peter Nyhuus (WesternGeco – Oslo Technology Centre).*

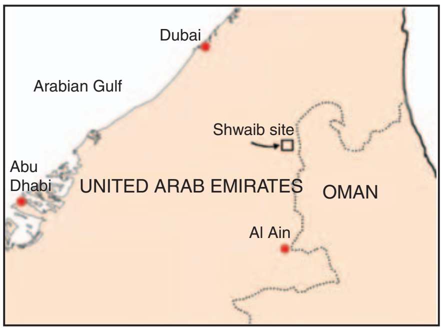

Fig. 1. *Location of the study area (adapted from Bradley et al., 2007).*

Fig. 2. *Burying the UniQ geophone accelerometers.*

The test involved all of the latest proprietary WesternGeco technology including the UniQ integrated point receiver land acquisition system (Figure 2) and the 80 000 lb tracked Desert Explorer DX80 vibrator (Figure 3) employing a low-frequency enhancing maximum-displacement sweep. Dr Dupuis stated that: 'This collaboration with WesternGeco and Schlumberger is an exceptional opportunity for the students to have access to industry-leading technology and resources that are generally unattainable by Universities.'

WesternGeco and Schlumberger have also sponsored a third student, Hayan Nasreddin. His project involves the evaluation of the trade-off between productivity and quality for a range of recently introduced high-productivity Vibroseis techniques. Along with scholarships for the students and practical assistance Schlumberger and WesternGeco have also donated Petrel and Omega seismic data processing system licences in order to assist students in their research. The results of the studies should be available by the end of 2011.

For further information please contact Christian Dupuis (C.Dupuis@curtin.edu.au) or Timothy Dean (tdean2@slb.com).

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News

Update on Geophysical Survey Progress from the Geological Surveys of Queensland, Western Australia, New South Wales, Tasmania, and Geoscience Australia (Information current at 13 May 2011)

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

This issue reports one new airborne electromagnetic survey over the Central Australian Palaeovalley (see Figure 1) for Geoscience Australia.

Final infill survey data from the Pine Creek AEM survey were released by

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
South Officer 1 (Jubilee)	GSWA	Thomson	1 Jun 10	180 000	200 m 50 m N–S	32 380	64.1% complete @ 3 Apr 11	TBA	148 – Oct 10 p23	TBA
South Officer 2 (Waigen – Mason)	GSWA	Thomson	28 Jun 10	113 000	400 m 60 m N–S	39 890	100% complete @ 5 Jan 11	TBA	148 – Oct 10 p24	QA/QC of final data in progress
East Canning 3 (Stansmore)	GSWA	Thomson	14 Jul 10	114 000	200 m (east) 400 m (west) 50 m N–S	25 934	100% complete @ 2 Nov 10	TBA	148 – Oct 10 p24	Data in preparation for release before the end of June
Eucla Basin 2 (Loongana)	GSWA	Fugro	20 Jun 10	113 000	200 m 50 m N–S	20 320	100% complete @ 3 Dec 10	TBA	148 – Oct 10 p24	Data in preparation for release before the end of June
Eucla Basin 4 (Madura)	GSWA	Fugro	1 Jul 10	102 000	200 m 50 m N–S	18 220	100% complete @ 22 Nov 10	TBA	148 – Oct 10 p24	Data in preparation for release before the end of June
Eucla Basin 5N (Forrest)	GSWA	Fugro	16 Jun 10	75 000	200 m 50 m N–S	13 040	100% complete @ 12 Sep 10	TBA	148 – Oct 10 p25	Data released via GADDS 14 April 2011
Eucla Basin 5S (Eucla)	GSWA	Fugro	6 Jul 10	87 500	200 m (onshore) 400 m (offshore) 50 m (onshore) 100 m (offshore) N–S	16 100	100% complete @ 5 Nov 10	TBA	148 – Oct 10 p25	Data released via GADDS 14 April 2011
South Canning 1 (Madley – Herbert)	GSWA	Aeroquest	19 Jul 10	95 000	400 m 60 m N–S	33 520	100% complete @ 12 Nov 10	TBA	148 – Oct 10 p25	Data released via GADDS 14 April 2011
South Canning 2 (Morris – Herbert)	GSWA	Aeroquest	1 Jul 10	125 000	400 m 60 m N–S	45 850	100% complete @ 11 Jan 11	TBA	148 – Oct 10 p25	Data in preparation for release before the end of June
North Canning 4 (Lagrange – Munro)	GSWA	Aeroquest	20 Sep 10	103 000	400 m 60 m N–S	36 680	71% complete @ 9 May 11	TBA	148 – Oct 10 p26	Survey re-mobilised 4 May 2011
Southeast Lachlan	GSNSW	Fugro	1 Mar 10	107 533	250 m (NSW) 500 m (ACT) E–W	24 660	100% on 9 Sep 10	TBA	144 – Feb 10 p15	QA/QC of final data in process
Grafton – Tenterfield	GSNSW	GPX	TBA	100 000	250 m 60 m E–W	23 000	TBA	TBA	151 – Apr 11 p16	TBA

Table 1. *Continued*

Survey name	Client	Contractor	Start flying	Line (km)	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
West Kimberley	GSWA	Aeroquest	TBA	134 000	800 m 60 m N–S Charnley: 200 m 50 m N–S	42 000	TBA	TBA	150 – Feb 11 p20	Expected to commence June 2011
Perth Basin North (Perth Basin 1)	GSWA	Fugro	TBA	96 000	400 m 60 m E–W	30 000	TBA	TBA	150 – Feb 11 p20	Expected to commence May 2011
Perth Basin South (Perth Basin 2)	GSWA	Fugro	22 Mar 2011	88 000	400 m 60 m E–W	27 500	28.2% on 8 May 2011	TBA	150 – Feb 11 p20	TBA
Murgoo (Murchison 1)	GSWA	Thomson	28 Feb 11	128 000	200 m 50 m E–W	21 250	5.6% complete @ 7 Mar 11	TBA	150 – Feb 11 p20	Survey resumes at the completion of the South Officer 1 survey
Perenjori (Murchison 2)	GSWA	GPX	TBA	120 000	200 m 50 m E–W	20 000	TBA	TBA	150 – Feb 11 p21	Expected to commence September 2011
South Pilbara	GSWA	GPX	TBA	136 000	400 m 60 m N–S	42 500	TBA	TBA	150 – Feb 11 p21	Expected to commence May 2011
Carnarvon Basin North (Carnarvon Basin 1)	GSWA	GPX	TBA	104 000	400 m 60 m E–W	32 500	TBA	TBA	150 – Feb 11 p21	Expected to commence May 2011
Carnarvon Basin South (Carnarvon Basin 2)	GSWA	GPX	TBA	128 000	400 m 60 m E–W	40 000	TBA	TBA	150 – Feb 11 p21	Expected to commence February 2012
Moora (South West 1)	GSWA	Aeroquest	TBA	128 000	200 m 50 m E–W	21 250	TBA	TBA	150 – Feb 11 p22	Expected to commence June 2011
Corrigin (South West 2)	GSWA	GPX	TBA	120 000	200 m 50 m E–W	20 000	TBA	TBA	150 – Feb 11 p22	Expected to commence September 2011
Cape Leeuwin – Collie (South West 3)	GSWA	Fugro	25 Mar 2011	105 000	200/400 m 50/60 m E–W	25 000	32.2% complete @ 8 May 11	TBA	150 – Feb 11 p22	TBA
Mt Barker (South West 4)	GSWA	GPX	24 Apr 2011	120 000	200 m 50 m N–S	20 000	3.7% complete @ 8 May 11	TBA	150 – Feb 11 p22	TBA
Offshore East Coast Tasmania	MRT	Fugro	28 Feb 11	30 895	800 m 90 m E–W	19 570	100% complete @ 21 Apr 11	TBA	150 – Feb 11 p23	TBA
Galilee	GSQ	TBA	TBA	125 959	400 m 80 m E–W	44 530	TBA	TBA	151 – Apr 11 p15	Anticipated start date mid May 2011
Thomson West	GSQ	TBA	TBA	146 000	400 m 80 m E–W	52 170	TBA	TBA	151 – Apr 11 p15	Anticipated start date mid May 2011
Thomson East	GSQ	TBA	TBA	131 100	400 m 80 m E–W	46 730	TBA	TBA	151 – Apr 11 p16	Anticipated start date mid May 2011
Thomson Extension	GSQ	TBA	TBA	47 777	400 m 80 m E–W	16 400	TBA	TBA	151 – Apr 11 p16	Anticipated start date mid October 2011

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Albany – Fraser North	GSWA	Atlas	21 Oct 2010	9200	2.5 km regular	50 980	100% on 30 Jan 2011	TBA	146 – Jun 10 p17	Data released via GADDS 14 April 2011
Sandstone	GSWA	IMT	Early Oct 2010	6300	2.5 km regular	35 640	100% on 17 Dec 2010	TBA	146 – Jun 10 p17	Data released via GADDS 5 May 2011
South Gascoyne	GSWA	IMT	9 Aug 2010	9700	2.5 km regular	55 760	100% on 27 Oct 2010	TBA	146 – Jun 10 p17	Data released via GADDS 12 May 2011
Galilee	GSQ	IMT	3 May 2011	6400	2.5 km regular	TBA	9% complete @ 8 May 11	TBA	151 – Apr 11 p15	TBA
Thomson	GSQ	Daishsat	1 Apr 2011	7670	2.5 km regular	TBA	44% complete @ 8 May 11	TBA	151 – Apr 11 p15	TBA

TBA, to be advised.

Table 3. Airborne electromagnetic surveys

Survey Name	Client	Contractor	Start survey	Line (km)	Spacing AGL dir	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Frome	GA	Fugro	22 May 10	34 986	5000 and 2500 100 m E–W	95 450	100% on 31 Oct 2010	TBA	146 – Jun 10 p18	Final data released by GA on 31 March 2011
Central Australian Palaeovalley	GA	Aeroquest	Late May 2011	5000	1000 m and tie lines at 30 km	4113	TBA	TBA	This issue (Figure 1)	TBA

TBA, to be advised.

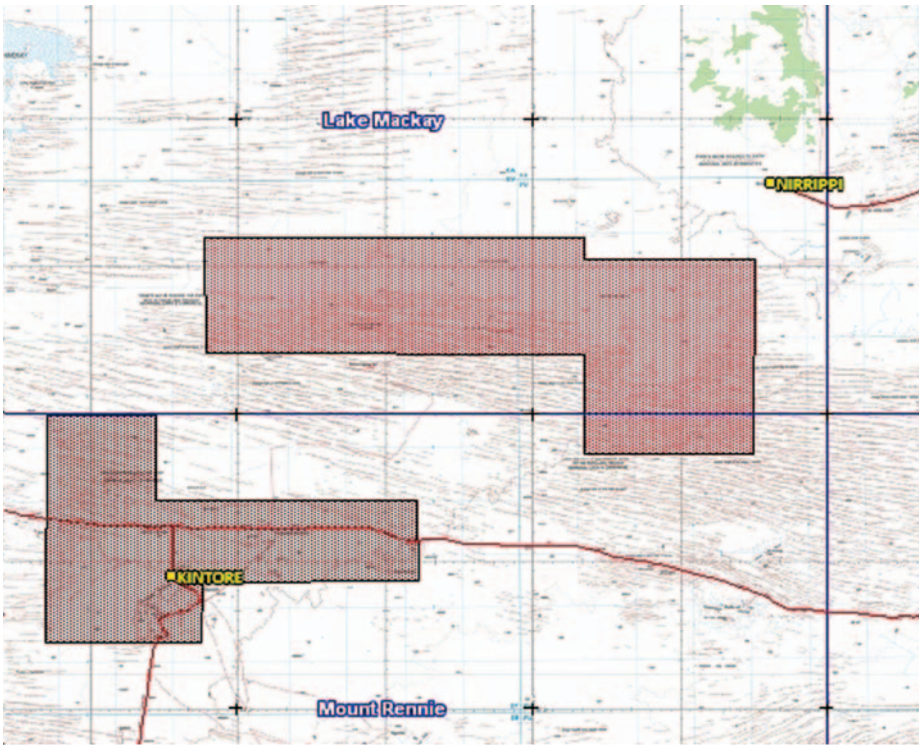

Fig. 1. *Survey boundary for Central Australian Palaeovalley AEM survey in the Northern Territory.*

Geoscience Australia on 4 April 2011. This data release consists of 23 blocks of infill flying funded by private exploration companies. The company infill data are being released 12 months after the official release of the data funded by Geoscience Australia. The release contains point located electromagnetic, magnetic and elevation data and EmFlow™ conductivity estimates and derived conductivity depth slices. Also included are gridded conductivity, magnetics and digital elevation data. For further information on this release please visit the Geoscience Australia web site at: http://www.ga.gov.au/minerals/projects/current-projects/airborne-electromagnetics.html.

To order the data please visit the Geoscience Australia web site at http://www.ga.gov.au/oracle/agsocat/textonly.jsp and search for product number 71641.

Queensland Greenfields 2020 geophysical survey progress

Daishsat commenced data collection on the Thomson gravity survey in the Cunnamulla area on 1 April. Production has been steady and over 35% of the field work was completed by 1 May 2011. Estimated finish date for the data collection is mid June. Preliminary data indicate that the 4 km station spacing is providing excellent results.

Integrated Mapping Technologies commenced data collection on the Galilee gravity survey around Alpha on 3 May. Wet weather and helicopter availability delayed the initial start. Estimated finish date for the data collection is early July.

The start of both the Thomson and Galilee airborne magnetic and radiometric surveys has been delayed by wet weather. These surveys are now expected to start in late May/early June.

Information on these surveys can be obtained from Bernie Stockill, Geological Survey of Queensland, (Ph: 07 3035 5272).

News

The release of the 2011 gravity grid of South Australia

Philip Heath, Gary Reed, Tania Dhu, Tim Keeping, Laz Katona, George Gouthas, Mark Asendorf

Primary Industries and Resources, South Australia
Email: Philip.heath@sa.gov.au

The previous gravity grid of South Australia was constructed from 382 206 stations of gravity data. It was created using the Intrepid Geophysics gridding tool, using a Variable Density gridding algorithm, interpolated to 100 m pixel size and was first uploaded to SARIG in November 2009. While this was an excellent grid, several problems were identified that required resolving.

The primary issue related to point anomalies: points in the grid that occur at each gravity station. These points are particularly prominent when viewing the first vertical derivative of the grid. Various strategies were put forward to remove these points. A successful technique has been to split all of the gravity station data in South Australia into several layers, gridding each layer separately to an appropriate resolution, and then merging the grids together, effectively undertaking a manual variable density gridding process.

Gravity information in South Australia was split into numerous layers. Each layer is a collation of gravity surveys from a specific era that can be gridded smoothly to a particular grid size. For example, the base (lowest) layer consisted of all regional data collected in the 1960s and 1970s. It was gridded using a minimum curvature algorithm to 2000 m. The top layer consisted of the Northern Olympic Domain and Curnamona surveys, gridded to 200 m and resampled to 100 m. In between these are 12 other layers, all gridded to approximately ¼ of the station spacing, and ranked by data quality.

Data prior to 1960 have not been included in the production of this grid, and 2455 duplicate points have been removed. A total of 417 173 points were used in the production of the new grid which includes 34 967 new additional stations. Various commercially available gridding packages were trialled as part of the compilation of the grid. Ultimately, all gridding was undertaken using Encom Profile Analyst (Pitney Bowes Software Pty Ltd) and grid merging undertaken using Intrepid Geophysics software (Desmond Fitzgerald & Associates Pty Ltd).

The point anomalies in the new grid are far less prominent than they were in the previous grids, and the Intrepid feathering and grid merging process has produced a grid where boundaries between surveys are less visible. Figure 2 shows an example around the Northern Olympic Domain Gravity Survey.

All gravity ASCII data (including the data not used in the state grid) are still available for download through SARIG and SA_GEODATA. A project is currently underway to incorporate a ranking of gravity surveys described above for the purpose of statewide gridding into SA_GEODATA. This will involve extra fields available for download that will illustrate which grids have been used in our state grid. By doing this, no gravity data will be withheld from users.

The new gravity grid is available from SARIG 2020 through the Databases & Geophysical Data tab (powered by Intrepid's Jetstream technology), and is available as a sunshaded and colour-draped geoTIFF image directly from SARIG. At the time of writing SARIG 2020 is in beta version (https://sarigbeta.pir.sa.gov.au/Map) and is best viewed in Google Chrome, Safari & Firefox. It is also accessible in Internet Explorer.

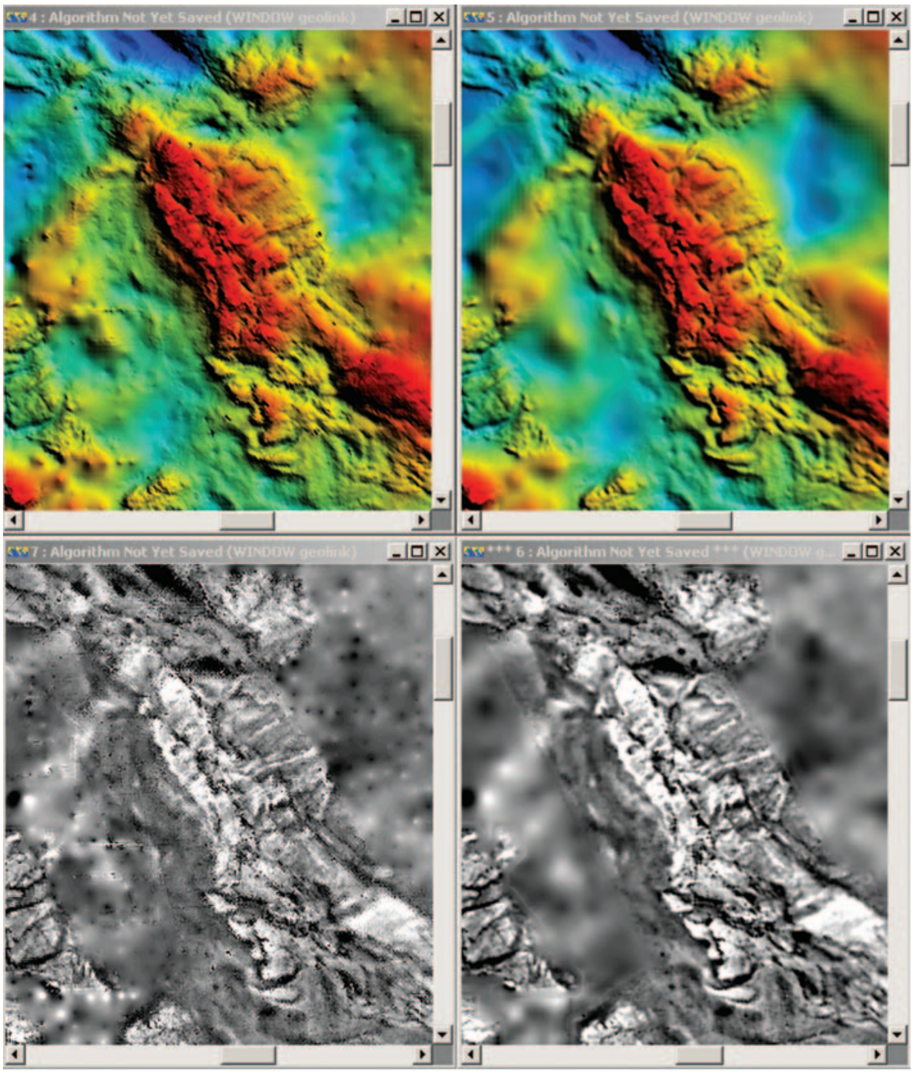

Fig. 2. *Top left: a portion of the previous gravity grid, around the 2007 Northern Olympic Domain survey. Top right: the same area of the new grid. Lower left: the first vertical derivative of the previous gravity grid. Lower right: the first vertical derivative of the new gravity grid.*

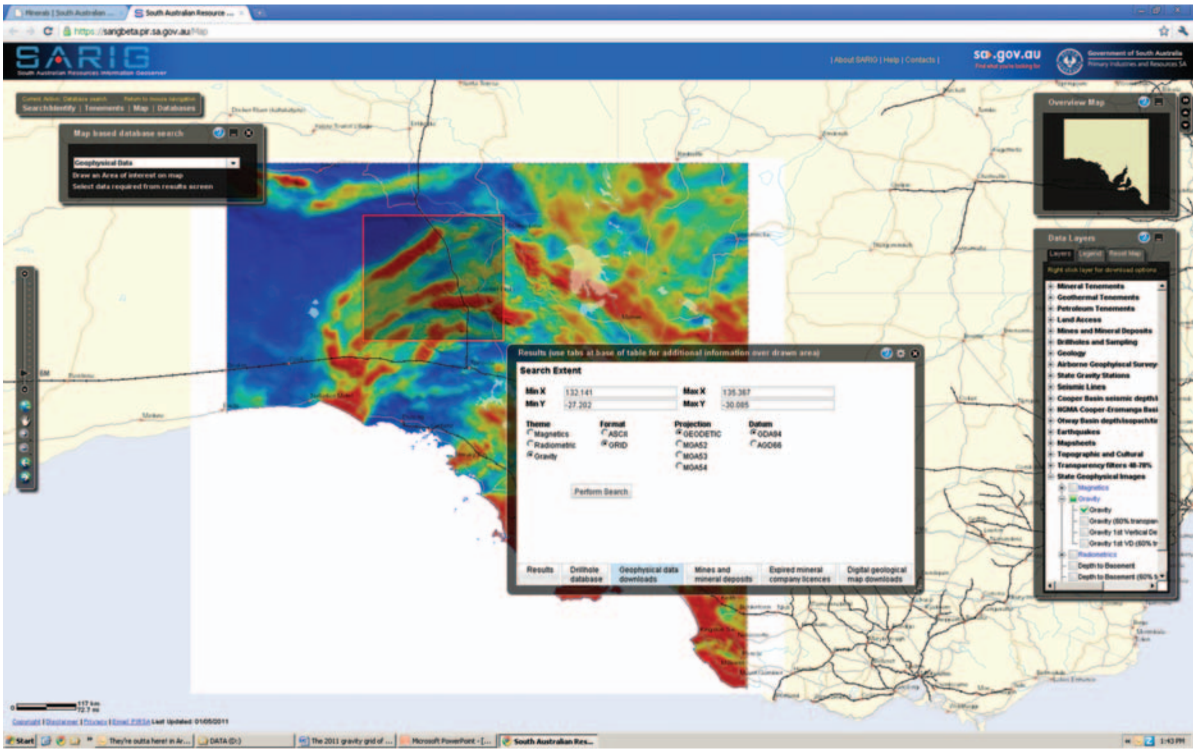

Fig. 3. *Visualising the new gravity grid in SARIG 2020 is simply a case of ticking the Gravity box on the right hand side of the screen under 'State Geophysical Images'. By right clicking on the word 'Gravity' in the submenu you have the option to download the entire state as a GeoTIFF. To download the ASCII data or .ers, use the 'Geophysical Data' option under 'Databases' (top left hand side of the screen) and draw a box over your area of interest and follow the on-screen prompts.*

Figure 3 shows a screengrab of SARIG 2020 with the gravity grid overlying the state. To download a GeoTIFF of the entire state, find 'State Geophysical imagery' on the list on the right hand side of the screen. The submenu contains four gravity options: the Bouguer Anomaly and 1VD, as well as two partially transparent layers. Right click on the word 'Gravity' to download the image.

To download a specific area of gravity as ASCII or .ers files, go to the 'Databases' tab on the top left hand side of the screen and select 'Geophysical Data'. Select your area of interest and follow the onscreen prompts. The new grid is named 'SA_GRAV'. For help using SARIG 2020 please contact PIRSA customer services on +61 8 8463 3000 or via email PIRSA.CustomerServices@sa.gov.au.

Massively parallel 3D inversion of gravity and gravity gradiometry data

Glenn Wilson

Glenn Wilson[1,4], Martin Čuma[1,2], and Michael S. Zhdanov[1,3]

[1]TechnoImaging, Salt Lake City, Utah, USA.
[2]Center for High Performance Computing, The University of Utah, Salt Lake City, Utah, USA.
[3]Department of Geology and Geophysics, The University of Utah, Salt Lake City, Utah, USA.
[4]Corresponding author. Email: glenn@technoimaging.com

Reliance on desktop computers limits the scale of 3D inversion of gravity and gravity gradiometry surveys, making it impractical to achieve an appropriate level of resolution and detail for geological interpretation. To begin with, airborne surveys are characterised by very large data volumes. They typically contain hundreds to thousands of line kilometres of data with measurement locations every few metres. Often, surveys cover thousands of square kilometres in area with tens of thousands of line kilometres of data. Regional surveys may be even larger and denser as the result of merging multiple and/or historic surveys. Secondly, 3D modelling of large-scale surveys exceeds the capacity of desktop computing resources. And finally, gravity data are finite and noisy, and their inversion is ill posed. Regularisation must be introduced in order to recover the most geologically plausible solutions from the infinite number of mathematically equivalent solutions. Various strategies for 3D inversion have been previously proposed but few lend themselves to truly large-scale 3D inversion. In this paper, we describe how gravity and gravity gradiometry surveys can be inverted to 3D earth models of unprecedented scale (i.e., hundreds of millions of cells) within hours using cluster computers.

Introduction

Structural interpretations of gravity and gravity gradiometry data are often based on some form of Euler deconvolution, wavelet analysis, or analytic signal method. While such methods may provide information about the sources, it is not immediately obvious how this information can be quantified in terms of the density distribution within a 3D earth model. For this reason, inversion of gravity data to a 3D density distribution is an important step in quantitative interpretation. Generalised inversion methods first discretise the 3D earth models into cells of constant density. Then, regularisation is introduced. Regardless of the inversion methodology used, all geological constraints manifest themselves as regularisation that can be quantified through a choice of data weights, model upper and lower bounds, model weights, an a priori model, and the type of stabilising functional used. The stabilising functional incorporates information about the class of models from which a unique solution is sought, and its choice should be based on the user's geological knowledge and prejudice.

It has been common (if not ubiquitous) practice to use smooth stabilising functionals, which minimise the deviation from an a priori model and/or the gradients of the 3D density distribution (Li and Oldenburg, 1998; Li, 2001). However, smooth density distributions are rare in real geology. Economic geology is typically characterised by sharp boundaries of contrasting density, for example, between an ore deposit and host rock, or across a discontinuity. It follows that the various smooth stabilisers can produce results that bear little relevance to real geology. To overcome this problem, Portniaguine and Zhdanov (1999) introduced focusing regularisation that makes it possible to recover 3D density models with sharp boundaries and contrasts. Below, we use this technique. We refer the reader to Zhdanov (2002, 2009) and Zhdanov *et al.* (2004) for further details on focusing regularisation.

For gravity, computational complexity increases linearly with the size of the problem. There are two major obstacles in large-scale 3D inversion. The first one being that storing the kernels of the forward modelling operators requires a large amount of computer memory. Even a small-sized 3D inversion of thousands of data to 3D earth models with hundreds of thousands of cells can exceed memory available on a desktop computer. The second obstacle is the amount of CPU time required to apply the dense matrix of the forward modelling operator to the data and model vectors. The translational invariance of the kernels has been used to reduce the matrices to Toeplitz block structure and use FFTs for matrix-vector multiplication (Pilkington 1997; Zhdanov *et al.*, 2004). This strategy, and others like it, dramatically reduces memory requirements and CPU time. However, these methods presume that the data lies on a regular grid of a flat surface above the topography. This means FFT-base modelling is applicable only if the data have been upward continued to a flat surface or in other special cases (e.g. marine gravity).

Another strategy for 3D inversion is compression (Portniaguine and Zhdanov, 2002; Li and Oldenburg, 2003). However, for the large-scale 3D inversion of tens of thousands of data to models with millions of cells, the compressed linear operators can still be too large to store and manipulate on a desktop computer. As a result, large surveys are often divided into subsets and each subset is inverted separately. The resulting 3D earth models are stitched together post-inversion (Phillips *et al.*, 2010). Depending on the functionality of the software environment, such work flows can become complicated and time consuming. Our goal is to use massively parallel 3D inversion so as to eliminate the need for stitching and to deliver results within hours. Our inversion methodology is similar to those of Zhdanov *et al.* (2004) in that we use the re-weighted regularised conjugate gradient method for minimising the objective functional. Additionally, we have incorporated a wide variety of regularisation options.

Inversion methodology

The gravity potential, $U(\mathbf{r}')$, is linear with respect to the 3D density distributions, $\rho(\mathbf{r})$:

$$U(\mathbf{r}') = \int \psi(\mathbf{r}', \mathbf{r})\ \rho(\mathbf{r}) d^3\mathbf{r}$$

where the kernel functiony $\psi(\mathbf{r}', \mathbf{r})$ is the Green's function for the gravity potential. All components and gradients of the gravity field can be derived from spatial differentiation of $\psi(\mathbf{r}', \mathbf{r})$. Closed-form solutions for the volume integrals over right rectangular prisms of constant density have been previously derived (Okabe, 1979). While exact, these analytic solutions are inefficient to implement; for example, the gravity response requires evaluation of 16 logarithms and 8 arctangents (Li and Chouteau, 1998, p. 344). However, the volume integrals can be evaluated numerically. Zhdanov (2009) showed how for gravity gradiometry, single-point Gaussian integration with pulse basis functions was as accurate as the analytic solution, provided the depth to the centre of the cell exceeded twice the dimension of the cell. This implies that for an airborne gravity gradiometry survey with 80 m ground clearance, the 3D earth model can be discretised to 40 m cubic cells. The advantage of numerical integration is that it significantly decreases the run time when compared to the corresponding analytic solutions.

The above kernels also represent the sensitivity of the data to the variations of the density due to the linearity of gravity fields. Dransfield (2010a) used the same kernels to investigate instrument sensitivity. He demonstrated that at a limited distance, which we call the footprint, the receiver is no longer sensitive to the 3D earth model. The size of the footprint is often less than the size of an airborne survey. Cox *et al.* (2010) previously introduced the concept of a moving footprint for 3D inversion of airborne electromagnetic (AEM) data. They showed that for a single transmitter–receiver pair, there was no need to calculate the responses or sensitivities beyond the AEM's footprint. The sensitivity matrix for the entire 3D earth model could be constructed as the superposition of footprints from all transmitter–receiver pairs. The framework of this approach can be described as follows: for a given receiver, compute and store the sensitivities for those inversion cells within the footprint. The radius of the footprint is based on the rate of sensitivity attenuation. As an analogue of this 3D AEM inversion strategy, we introduce a moving footprint for 3D potential field inversion.

For example, we can consider an instrument 60 m above a homogeneous earth model. Figure 1 presents the integrated sensitivities for each of the gravity fields and gravity gradients. The figure shows that the gravity gradients have approximately 95% of the sensitivity within a 15 km footprint. It also shows the integrated sensitivity for the total magnetic intensity (TMI). The sensitivity of the TMI with respect to the footprint radius behaves similarly to the gravity gradients with about 95% of the sensitivity being within the 15 km footprint. This behaviour is fully expected since the kernels have similar spatial dependencies. Past a 15 km radius, the sensitivity decays very slowly. Increasing the footprint radius beyond 15 km is not practical. Therefore, we conclude that 15 km is an optimal footprint radius for gravity gradiometry.

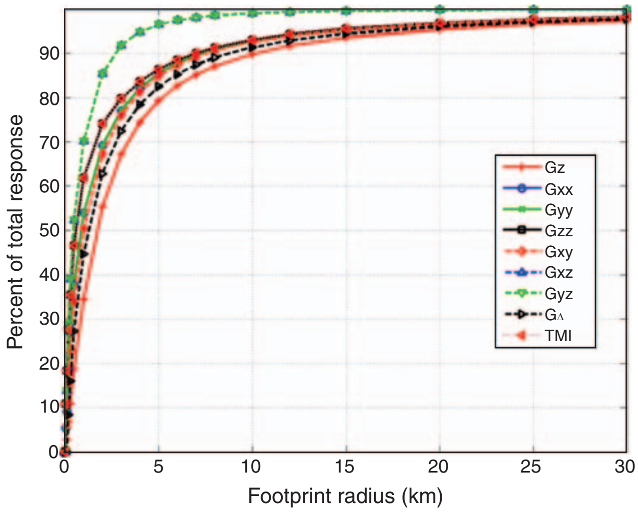

Fig. 1. *Percentage of total response of the integrated sensitivity for the vertical gravity component, various gravity gradients and total magnetic intensity as a function of footprint radius. Note that as the footprint is symmetrical in x and y directions, some gravity gradients overlap.*

Parallel performance

Our 3D inversion algorithm has been implemented as a multilevel parallel application. The 3D inversion domain is divided in a distributed fashion over Message Passing Interface (MPI). On a fine-grained level, loops over the data points and a few other auxiliary loops within each MPI process are further parallelised with a shared memory OpenMP standard. This two-level approach has multiple advantages. It reduces the number of MPI communicating processes, minimising communication stress on the network. It also saves memory, since there are data structures needing to be replicated by each process and most of the data is shared by the OpenMP threads. Finally, it allows for better locality of the processes/threads on the node's boards and sockets, which improves data transfers to/from the main memory. The data locality is critical on modern non-uniform memory architecture (NUMA) computers with a growing number of CPU cores.

In a typical cluster configuration, we run one or two MPI processes per cluster node. Each of these processes launches a number of OpenMP threads – one thread per processor core. The current generation of clusters ship with two hexa-core CPUs (i.e., 12 cores) per node. We have found that it is optimal to run one MPI process per socket (i.e., two per node), with six OpenMP threads per MPI process. The advantage of this is the ability to pin the process to the CPU socket, so that it does not move from one socket to another, which improves the memory performance. We have found that without pinning, the performance can degrade by up to 20%.

Our 3D inversion is relatively light in MPI communication, largely thanks to the linearity of the forward modelling operators. Most MPI communication consists of accumulation of the sensitivities and the regularisation as reduction operations. As a result, the program exhibits excellent parallel scaling. Parallel scaling is usually evaluated with two different metrics. The first one is called *strong scaling*. It measures the performance of a fixed problem size with an increasing number of processors. Another parallel scaling evaluation metric is *weak scaling*. It relates the time to complete one unit of work on one

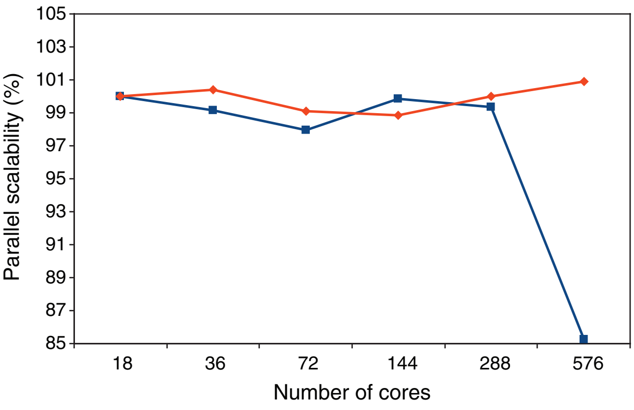

Fig. 2. *Parallel scaling efficiency for 3D inversion of the Vredefort FALCON® data. Strong scaling is shown in blue, and weak scaling is shown in red.*

processing element to the time to perform *N* units of work on *N* processing elements. In both cases, ideal (linear) scaling is 100%. Any scaling below 100% is sublinear, and any scaling above 100% is superlinear. As a side note, it is possible to achieve superlinear scaling due to hardware architectural features that multiprocessor programs can exploit.

We have evaluated the parallel efficiency of our software. All results presented in this paper were run on the University of Utah Center for High Performance Computing's Ember cluster which has 260 nodes, each equipped with two hexa-core (i.e., 12) Intel Xeon CPUs running at 2.8 GHz with 24 GB of RAM and QDR InfiniBand interconnect. Figure 2 shows the parallel scaling efficiency of the subsequent Vredefort case study. In the case of strong scaling, as depicted by the blue line in Figure 2, we chose a 3D model with about 11 million cells and 600 000 data. The scaling efficiency is excellent from 18 to 288 cores. We see a drop at 576 cores. This is due to running 12 rather than 6 cores per process. The memory load is much more uneven for the single MPI process sharing threads on both CPU sockets in the node, which decreases the efficiency by 15%. The weak scaling, depicted by the red line in Figure 2, varied the number of inversion cells from about 11 million cells on 18 cores to about 350 million cells on 576 cores. Again, the scaling is nearly linear with a 1 to 2% difference, which can be attributed to system noise. We draw two conclusions from our scaling analysis. First, our 3D inversion software shows linear scaling and is expected to scale well to thousands of cores. Second, we have identified that process and thread locality is critical in achieving optimal performance, and that one MPI processes should be bound to each socket.

Case study – Vredefort, South Africa

We have applied our massively parallel 3D inversion with a moving footprint to a FALCON® airborne gravity gradiometry (AGG) survey acquired over the Vredefort dome in the Republic of South Africa, approximately 120 km southwest of Johannesburg within the Witwatersrand Basin of the Kaapvaal craton. The Vredefort dome is known as the largest and oldest impact structure on Earth, with a diameter of 250 to 300 km, it is larger than the 200 km Sudbury Basin impact structure in Canada and the 170 km Chicxulub impact structure in Mexico. The impact structure has since been deformed via erosion and tectonic processes, though the centre remains largely unaltered. The centre of the dome is approximately 40 km in diameter and contains an uplifted Archaen basement surrounded by upturned, sub-vertical sediments of the Witswatersrand Supergroup and volcanics of the Ventersdorp Supergroup.

In February 2007, Fugro Airborne Surveys flew a FALCON® AGG survey of 4800 line km over the Vredefort dome area (Dransfield, 2010b). The survey was comprised of two blocks. This study uses 2460 line km of data from the eastern block. The eastern block was flown north-south with a line spacing of 1 km and with 2 east-west tie-lines spaced at 40 km, over an area

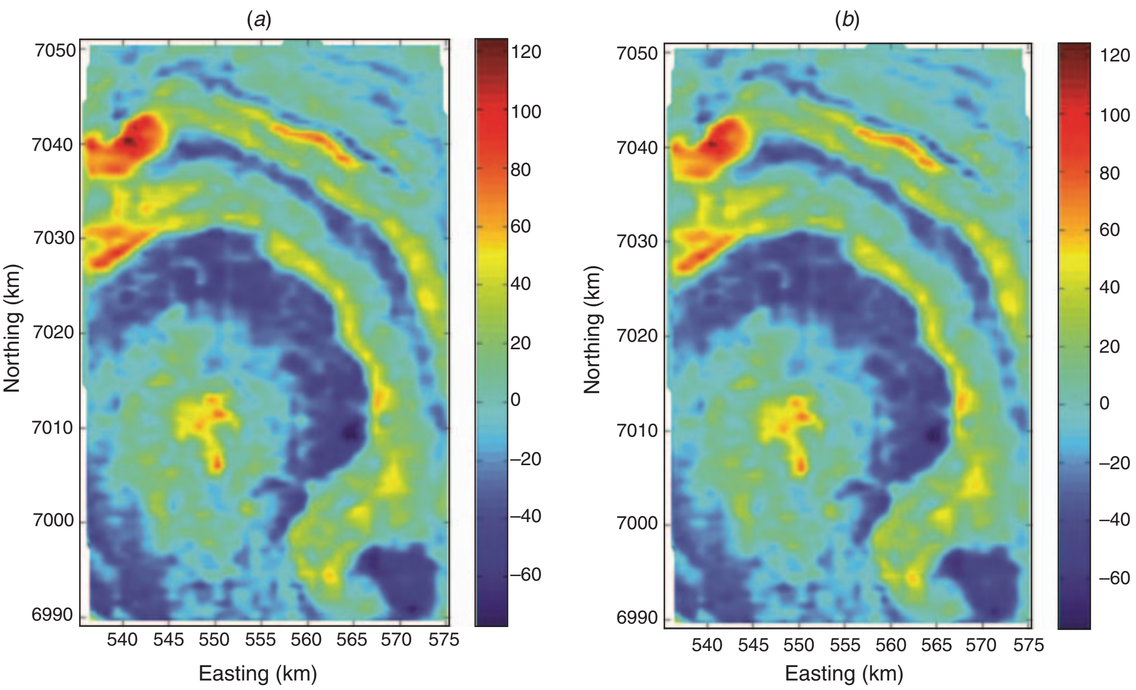

Fig. 3. *(a) Observed and (b) predicted terrain corrected g_{zz} data from joint inversion of all gravity gradient components.*

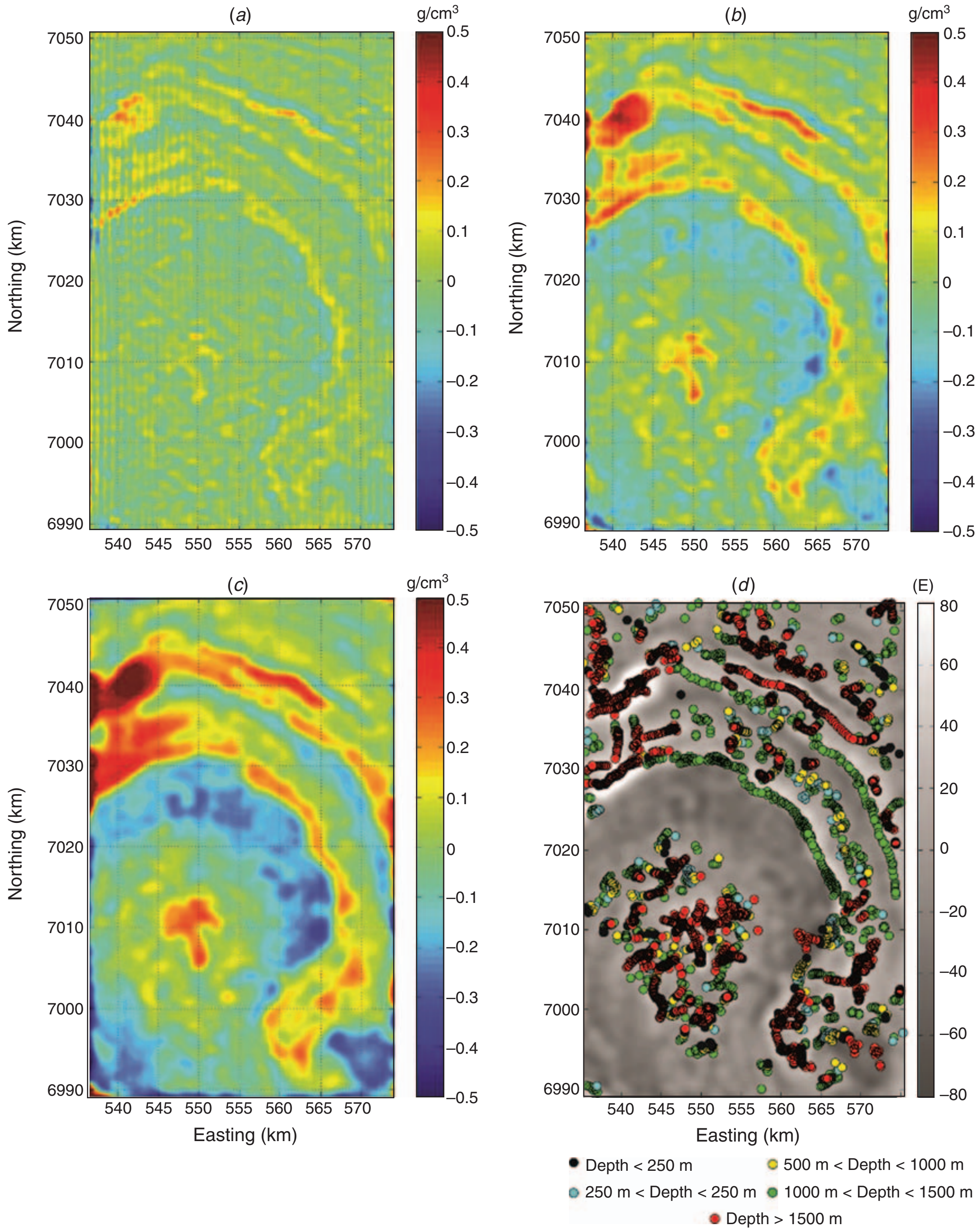

Fig. 4. *Comparison of horizontal cross sections through the 3D density model obtained from joint inversion of all FALCON® gravity gradiometry data at (a) 1137 m ASL, i.e., 500 m depth from topographic peak; (b) 637 m ASL, i.e., 1000 m depth from topographic peak; and (c) 137 m ASL, i.e., 1500 m depth from topographic peak. Panel (d) shows the estimated location of causative bodies based on their depths to the centre of mass from eigenvector analysis (from Beiki and Pedersen, 2010).*

60 km north-south by 40 km east-west, covering most of the Vredefort dome structure. The ground clearance was nominally 80 m flown in a drape over the terrain, corresponding to ellipsoidal heights of between 1430 m and 1740 m. Summer conditions meant moderate to high turbulence at this survey height. The measured gradients were processed by the usual multistep FALCON® processing procedures. After the initial reduction of error due to the residual effects of aircraft motion, the data were demodulated and low-pass filtered with a sixth order Butterworth low-pass filter at a cut-off frequency of 0.18 Hz. The demodulated data were corrected for the self-gradient effects of the aircraft and the tie-lines were levelled. The resulting differential curvature gravity gradient data were further processed to produce terrain-corrected data using a density of 2.67 g/cm^3, and hence the full gravity gradient tensor. In the processing, a low-pass filter with cut-off wavelength of 1000 m was applied to the data.

The 37.8 km × 61.9 km × 2.4 km inversion domain was discretised to over 358 million cubic cells of 25 m dimension. The inversion

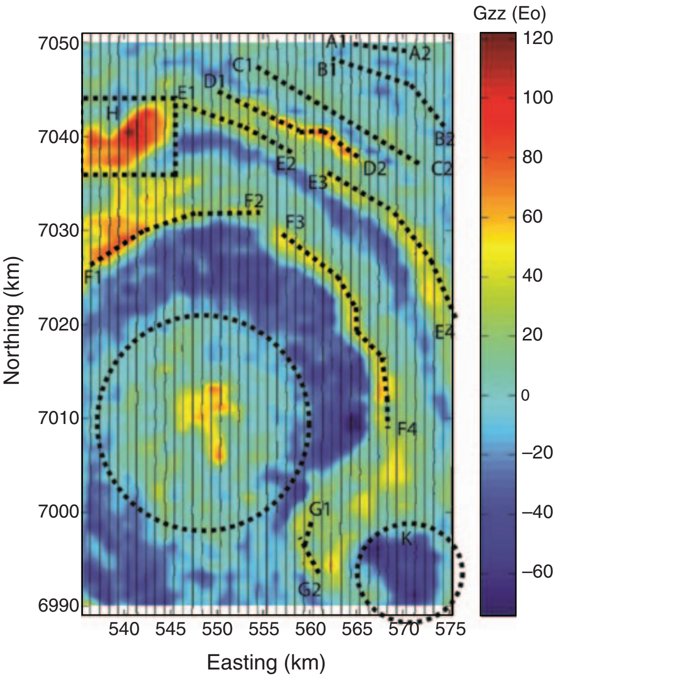

Fig. 5. *Regional geological structure of the Vredefort dome (after Beiki and Pedersen, 2010) superimposed on terrain corrected g_{zz} data from the Vredefort dome FALCON® survey.*

domain conformed to topography and contained no a priori density model. Our previous experience with moving footprint inversion (Cox *et al.*, 2010) has indicated that inversion of redundant data does not aid model recovery. As such, the survey data were decimated by a factor of four, resulting in a data density of one point every 25 m along line. Inversion was run for 85 970 stations, each containing all seven gravity gradients, giving a total of 601 790 data. An example of the observed and predicted data for the g_{zz} component is shown in Figure 3.

Figure 4 shows horizontal cross-sections through the 3D density model at depths of 500 m, 1000 m, and 1500 m below the peak topography, respectively. As we compare our results to the known geological structures (Figure 5), we are able to distinguish the ring structures E and F from the deeper ring structures C and D. The density high in the central part of the dome (J) is related to the deeper structures. Borehole drilling has confirmed that the underlying rock is peridotite, the source of which is open to debate. For example, it is not clear whether these rocks are related to the Bushveld igneous event approximately 2060 Ma (Henkel and Reimold, 1998) or represent mantle material which was uplifted to the surface as a result of the Vredefort impact approximately 2020 Ma (Tredoux *et al.*, 1999). Figure 4 shows a very good agreement between our 3D inversion results and the estimated depths to mass centres obtained from eigenvector analysis by Beiki and Pedersen (2010).

Conclusions

We have developed massively parallel software for the practical large-scale 3D regularised inversion of gravity and gravity gradiometry data to models of unprecedented size. We have also implemented kernels and positivity constraints for 3D magnetic inversion, but that discussion is beyond the scope of this paper.

We have achieved linear strong and weak scaling with our parallelisation. Our software can be confidently installed on massively parallel computing architectures. We have introduced a moving footprint, which allows us to represent large, dense linear operators using sparse matrices. The moving footprint approach reduces memory requirements and operation counts for matrix-vector multiplications significantly. Computing the linear operators as needed allows us to handle problems of unlimited size. The effectiveness of our approach has been demonstrated with a case study for 3D inversion of 2460 line km of FALCON® data from Vredefort, South Africa, which included the joint inversion of over 600 000 gravity gradient data to a 3D earth model with over 350 million cells. The computational time for the above inversion totalled about 24 hours using a cluster with 576 CPUs. The results of our inversion agree well with the known geology and independent analyses of the same data.

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Author Profiles

Glenn Wilson is Chief Geophysicist of TechnoImaging. He holds degrees in physics from Central Queensland and Griffith universities. He previously held positions with OHM Rock Solid Images, BP Exploration and Production, CSIRO Exploration and Mining, and The University of Utah.

Martin Čuma is a Computer Scientist with TechnoImaging and the University of Utah's Center for High Performance Computing. He holds degrees in metallurgy and physical chemistry from the Technical University of Ostrava and Southern University of Illinois at Carbondale.

Michael S. Zhdanov is a Professor in the Department of Geology and Geophysics at The University of Utah, Director of the Consortium for Electromagnetic Modeling and Inversion, and Chief Executive Officer of TechnoImaging. He holds degrees in geophysics, physics and mathematics from the Gubkin State University of Oil and Gas, and Moscow State University. He was previously Director of the Geoelectromagnetic Research Institute of the Russian Academy of Sciences, and Deputy Director of the Institute of Terrestrial and Ionospheric Radio Wave Propagation of the Russian Academy of Sciences. He is an Honorary Gauss Professor of the Göttingen Academy of Sciences, Fellow of the Russian Academy of Natural Sciences, Fellow of the Electromagnetic Academy, and Honorary Professor of the China National Centre for Geological Exploration Technology.

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Multichannel analysis of surface waves: evaluating the effects of acquisition parameters in distinguishing shallow subsurface structure

Jaime Lovell
Email: mark.lackie@mq.ed.au

This article reports on Jaime Lovell's Honours project which was sponsored by the ASEG Research Foundation and supervised by Mark Lackie at Macquarie University.

Project summary

S-wave velocity is an important parameter in many engineering geophysics investigations such as site characterisation, and ripability determinations. Multichannel Analysis of Surface Waves (MASW) is an alternate seismic method to refraction for gaining shear wave velocity profiles of the shallow subsurface.

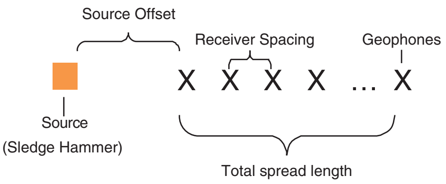

Fig. 1. *Diagram depicting the field parameters investigated.*

MASW utilizes the dispersive nature of Rayleigh waves to gain Shear wave velocity information in either one dimensional or two dimensional formats in a time efficient and cost effective manner.

This project aims to assess the effects of acquisition parameters in MASW on the dispersion curve analysis and the accuracy of the resultant S-wave velocity models across three different soil profiles around Sydney: weathered shale on sandstone at Macquarie University; quartz sand near the Middle Macdonald River, St Albans; and clay derived from a dolerite intrusion at Prospect Hill.

MASW relies on accurate dispersion curve analysis in order to determine the Shear wave velocity (Vs) profile, and thus the field parameters are chosen to enhance the surface wave signal responsible for the dispersion curve. There is a significant range between the upper and lower limits of the recommended field parameter guidelines put forward by researchers. A series of controlled field tests were conducted at each site whereby the field parameters source offset, receiver spacing (and receiver spread length), and the frequency of geophones were varied (see Figure 1). The results of the tests were compared to establish the optimum field parameters for each site based on the dispersion curve analysis and resultant S-wave profiles, and to

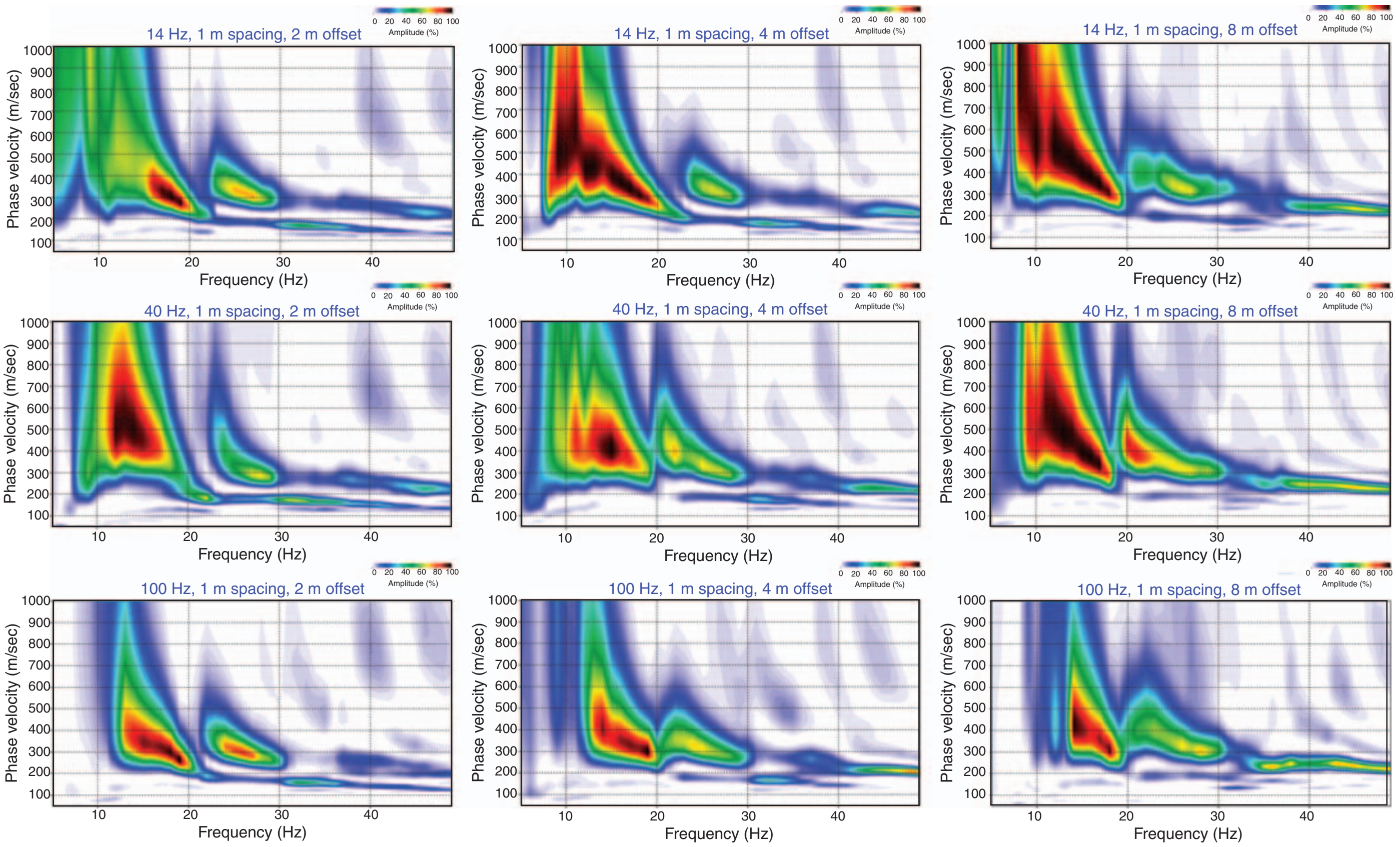

Fig. 2. *Example of the dispersion curve comparisons at Prospect Hill. The first row shows results for 14 Hz phones, while the second is for 40 Hz and the third for 100 Hz. The first column shows data with a 1 m geophone spacing and a 2 m shot offset. The second column shows a 1 m spacing and a 4 m offset, while the third column shows a 1 m spacing with an 8 m offset.*

ascertain the usefulness of MASW to distinguish near surface structure in the different soil types.

The MASW method is most suited to use on soils and was found to be beneficial for use in sites where gradual velocity changes occur and therefore is generally well suited to Australian environments due to the highly weathered and variable nature of many locations. It was effective at Macquarie and Prospect Hill in providing accurate results, at which gradual velocity changes exist. Shorter offsets gave better results than the far ones, as the longer offsets tended to increase the depths determined to layer boundaries. For the shorter offsets the different frequency geophones (14, 40 and 100 Hz) were comparable to the standard 4.5 Hz geophones. The higher frequency phones also allowed for easier identification of higher modes. The receiver spacing had the greatest impact on the resultant dispersion curves and V-s profiles, where the longest receiver spacing gave a significantly deeper depth estimate to layer boundaries. See Figure 2 for examples of dispersion curves for different parameters for tests done at Prospect Hill.

The MASW method was an unsatisfactory method for delineating subsurface structure of a sharp acoustic contrast at the uniform sand site of St Albans. Although ground roll was identifiable on the record, the results showed the inability of the method to model the high contrast between the unconsolidated sand and consolidated sand and therefore only penetrated a few metres allowing only the top uniform layer of sand to be profiled.

The results of this study have shown that altering the receiver spacing and total spread length has a large impact on the resultant dispersion curves and inverted profiles. The results also demonstrated the advantages of using a shorter source offset. The geophone frequency was not found to have as significant effect as the receiver spacing and spread length, potentially making the method more available to those that have access to standard seismic recording equipment without needing to purchase low frequency receivers. MASW was found to be a quick and easy method to determine S-wave velocities of subsurface layers where gradual velocity boundaries occur.

Project outcomes

The principal outcomes of the project were:

1. MASW is a fast and effective method for accurately deducing S-wave velocity profiles where gradual velocity changes occur.
2. The field parameter receiver spacing had the largest impact on the analysis of results, while the different geophone frequencies were comparable at shorter offsets and even allowed for higher mode identification more clearly.

Scientific Writing = Thinking in Words

by David Lindsay
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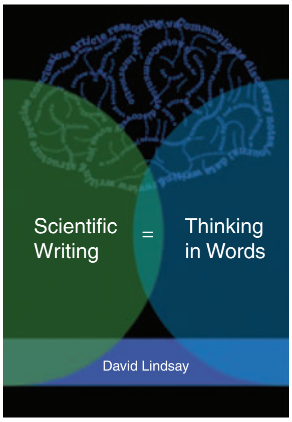

This book is an affordable paperback that all scientists who write about their work should read. It is 122 pages in length, although with small print. The author presents techniques to help scientists present their material more effectively in written form. Dr Lindsay is an 'animal biology' teacher and researcher of many years experience. I do not know this author personally, but some of my colleagues in the environmental geosciences sphere do, and speak highly of him. They have some anecdotal stories of him, not to be related here.

While Dr Lindsay expresses his ideas for new writers who are seeking excellence in scientific writing in terms of his direct experience, it is also of great value to scientific writers at all stages of their careers. He draws extensively from his personal sphere of scientific learning. It may initially be disconcerting to deal with titles like 'The influence of season of calving on the performance of Holstein cows'. However, the geophysical reader should readily be able to adapt from 'bio-words' into 'geo-words', as the concepts presented apply in a cross-disciplinary sense.

The book covers many important aspects of scientific writing, such as the structure of a scientific article, an oral presentation, the scientific review, writing for non-scientific people, and writing a thesis. Dr Lindsay's overarching hypothesis is described by his 'three immutable characteristics of good scientific writing that distinguishes it from other literature': it must always be

- Precise,
- Clear,
- Brief.

I particularly liked the material on thesis writing. If only I knew this when I started my own thesis, way back then. Eventually, some very generous English-literate supervisors sorted me out. The section on readability is very useful. I particularly liked the author's proposed seven verbal stumbling blocks. Actually, eight when he discusses sentences that are too long. He even talks about grammar (i.e. nouns, verbs, adjectives and subordinate clauses), a thing that is scarcely heard of nowadays.

The book is divided into three chapters: thinking about your writing, writing about your thinking, and thinking and writing beyond the scientific article. The first chapter, thinking about your writing, introduces the reader to the subject of scientific writing. Dr Lindsay engages the reader by trying to rationalise the need to think about the process of writing the scientific article, and then 'slipping his subject matter into the reader's comfort zone' with sub-titles like 'Getting into the mood for writing' and 'Getting started', both of which many writers, including myself, often struggle with.

Chapter 2 deals with writing about your thinking. In this chapter, the book deals with the anatomy of a scientific article. It treats in detail (1) the Title, and how to attract other researchers to read your paper, (2) the Introduction and the elements it should contain, (3) the Materials and Methods (often given by more specific titles in the geophysical literature), (4) the Results with a special emphasis on separating results from discussion, (5) the Discussion, and (6) the Summary and Abstract. I found the discussion about presenting results in a meaningful and 'user-friendly' way, especially in tables and figures, one of the more insightful aspects of this chapter.

Thinking and writing beyond the scientific article comprises the rather challenging content of the final chapter. In this chapter, Dr Lindsay deals with text to support an oral presentation, design and preparation of posters, the review article, and the preparation and content of a thesis. All oral and poster presenters should spend some time with this chapter; I shall.

I thoroughly recommend this work to all geophysicists regardless of their field of employment. We are always needing to write or talk about our work, and this book will make the process a lot easier for us. The book is available through CSIRO Publishing, www.publish.csiro.au/sales or email publishing.sales@csiro.au.

Reviewed by Mike Middleton
Book Reviews Editor
Email: mike.middleton@dmp.wa.gov.au

Australia's Meteorite Craters

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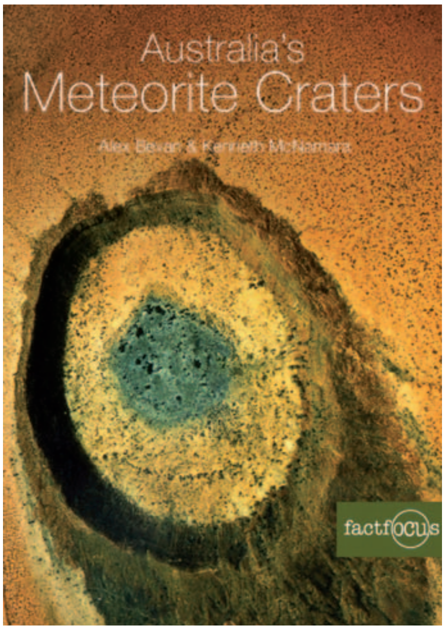


Now that Google Earth and satellite photography are available to reveal new impact craters with surface expression, exploration geophysics is not only helping to confirm that they are not volcanic by their characteristic magnetic high and coincident gravity low but is also, with increasing frequency, revealing the buried craters with no surface expression. In Western Australia recently, Woodleigh impact structure measuring 120 km across, the fourth largest in the world to date, was discovered by geophysics alone, as was Yallalie, north of Perth (*Preview*, Issue 94, 2001). At least four other buried structures in other states owe their discovery to geophysics.

Australia's Meteorite Craters is the only compilation of Australia's meteorites in book form that I am aware of, and being an enthusiast for the subject I just had to get it. It is however, a small paperback measuring 13 × 18 cm and of its 96 pages, only 54 pages have text, sometimes only on half the page or less. It is therefore easily read in one hour or less. Correspondingly, the book is not overpriced and well worth buying. Of course, it is not meant to be a highly technical publication (lacking references or footnotes) but is clearly designed more to intrigue the general public, authored as it is by a Curator of the Western Australian Museum (Bevan) and a former Curator (McNamara). The remaining 42 pages are taken up mainly by photos and while this would normally be applauded, it is as if some are used simply to fill the remaining pages. A two page spread is of the planetary alignment as the sun sets over Wolfe Creek crater rim. One page is of time lapse star trails over Wolfe Creek (!). There are also 12 photos of Wolfe Creek crater itself including as the front and back cover photos, one of which is duplicated inside over 2 pages.

The reason for this emphasis on Wolfe Creek is, as stated in the Introduction, that it is used as a classic example of the topics to be discussed. Granted, while it is only 880 m in diameter, it is able to be visited easily and a locality map for it is on page 15. There is a good three page Foreword by Robert Hough of the CSIRO, Perth; a 2 page Preface; and nine Chapters. Topics covered include the formation of craters, the distinguishing features of impact structures, the Earth as a target and the frequency of occurrence of impacts. The C/T boundary story is well done.

While there are no references in the text, there are 7 pages of 'Sources and Selected Further Reading', listing 72 general texts and specific references to individual craters. Of the 32 references to specific Australia craters, once again, 7 are of Wolfe Creek. One has to search all the references if looking for something more on a topic in the text. A Glossary includes many terms that are not very unusual ('mineral' and 'bed' for example).

Nine pages have one third of the page devoted to 'Fact Focus', headlining some specific fact such as the velocity of an incoming meteorite as more than 11.2 km/s (very precise!) which would travel Perth to Sydney in 6 min. One figure (actually originating from NASA) plots the estimated frequency of occurrence of impacts (from annually to 500 million years) versus diameter of asteroid which is also equated to impact energy in megatons of TNT equivalent. For example, the asteroid assumed to have caused the Wolfe Creek crater would have been 100 m in diameter and asteroids of this size have a predicted frequency of once every 25 000 years. This is not to say that an impact couldn't happen in historical times. At least one impact of this size has occurred in the last 1000 years, namely Tunguska in Siberia.

Given the background of the authors, not much might be expected in the book on the use of geophysics. However, geophysics is mentioned in four places in the text including reproducing the magnetic image of Yallalie (after Phil Hawke) and in a good table of 37 impact structures, five have geophysics listed as the only evidence for them, since they are buried. This table gives the state of location, diameter, age and evidence but not the coordinates in latitude and longitude which are available for them all elsewhere. Two website references are supplied but oddly, one is for the Vredefort Dome in South Africa which is not specifically mentioned anywhere in the book. The other site's URL is not correct but its initial part directs to the Earth Impact Database of the University of New Brunswick where a list of (only) 26 of Australia's impact structures is available (with latitudes and longitudes).

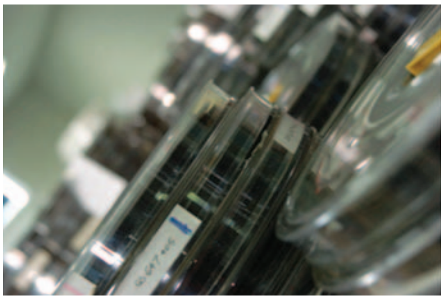
A half-page map of Australia shows the location of the 37 structures now recognised together with twelve others that are still lacking conclusive proof. This is quite up-to-date. The map also shows how very few occurrences there are in the eastern one-third of Australia which is due in part to greater deformation and burial by sediments there. There is only one for NSW, the Lorne Basin, yet to be confirmed, and Victoria has none. Some of my own suspects that could fill these spaces are Jervis Bay in NSW which juts anomalously beyond the general line of the coastline and has a magnetic high fitting neatly in its circular shape. As for Victoria, is it more than coincidence that Westernport, a circular bay with an island that could be a central uplift, has the Cranbourne meteorites on its western shore? More geophysics is needed for verification!

Reviewed by Roger Henderson
Email: rogah@tpg.com.au

The more things change – the more they stay the same…

Guy Holmes
Guy.Holmes@spectrumdata.com.au

Welcome to a new regular column in Preview. *Guy Holmes, Founder & Director of Ovation SpectrumData, has offered to contribute this regular column to discuss issues related to all things 'data'. Guy has over 10 years experience within the data management, information technology, data recovery and data preservation arena with specialisation in the data centre and oil and gas areas. His expertise can be applied to any industry that incorporates data storage technology as an essential element within its organisation. My warmest thanks go to Guy for joining the* Preview *team. – Ed.*



'Hey Peter – do we have that seismic data from our old prospect in Queensland?' I hear yelled across the office. Invariably – the answer is, 'Yes – I think so… but I am not sure where it is'.

Data seems to flow in and out of our offices, lives, and minds much like the hot water tap in our showers at home flows down the drain. We turn it on, wait for the right stuff to come along before we use it, and then we usually mix it with other stuff to get the desired result. And of course once we are done with it, most of it goes down the drain, and although we see it go down, and are mesmerised by the concentric circles as it whirlpools, no one seems to realise what is really happening.

Data in the workplace comes in so many forms and on so many media types these days that it is pretty difficult to keep track. In fact – so difficult most people don't even try. Larger companies have teams that tackle the issue, smaller ones ignore it or have a champion that recognises the importance of it and tries to plug the shower drain – usually only to be mesmerised by the whirlpool.

One would have thought that widely published statements like 'geophysicists spend 60% of their time looking for data, and only 20% of their time using it' would make someone stand up and take action. While I understand why they don't, I do wonder what geophysicists do with the other 20% of their time not stated above?

For the most part it is the data loss we don't know about that is most worrying (the data you didn't even know existed in the first place – as who would miss that?). Petroleum companies have large seismic data archives, in many cases overflowing with data recorded on what is now inaccessible media types. Without forethought, proper management and restoration, these data are now feeling the whirlpool tugging at their edges trying to drag them down the drain.

There are many factors that lead to data being poised for certain death, or in fact already lost, and these include:

- Hardware technology changes (that new tape drive you just bought);
- Software technology changes (that new application you purchased);
- Poor handling, transportation and storage (that box under your desk); and,
- Deterioration (a common but little known factor in data loss).

To explain more…

How could getting a new tape drive be a death knell?

Firstly, most people don't buy a new tape drive so they can carry out an archive project – they get one so they can store more on less tape, faster. This in turn leads to data created on your old storage media not being compatible with your new drive. And with that – voila – data falling off the radar and into the void.

Software = data loss?

Yes – it is true. Can't load that Novastor backup tape with your aeromagnetic grids on it? Why… Probably because you no longer use Novastor, and neither does anyone else. One major obstacle like incompatible media or data format is usually enough for most users to hit the wall and look elsewhere for joy – those tapes might as well be blank!

Poor storage? That box under your desk…

No need to explain this to most Geo's. Even an evangelist like me about preservation has a box with 'stuff' in it. Stuff so important that it could never be tossed… but not important enough for me to do anything about it. That might cost money – and the 'stuff' in there is of course also 'mine'. I don't want anyone else touching it…

Deterioration of media?

Yep – tiny little parasites, slowly chewing their way through the mylar substrate of your tapes. If you listen very carefully you can hear them chewing. Well not quite that nasty – but none the less serious and rampant in the industry – especially on pre-1996 data sets recorded on magnetic media (my back just suddenly got very itchy). I used to say pre-1988 data sets, but hey… the more things change the more they stay the same. Nowadays I just add eight to everything – and the best part is that I am usually right (or only off by eight or so).

So what to do? Never buy new technology? Keep a can of pesticide near your desk? Work without a desk so that your box has nowhere to hide?

None of the above… Start to future proof yourself from the issues is my advice. Take the time and energy now to get on top of the issues and form a plan to keep on top of them. No pain – no gain.

Future proof your data – tips to keep the bytes alive

1. Purchase a good media brand to prevent degradation.
2. Keep a register of what type of data you have on tape.
3. Keep a register of what type of tape you have data on (know the technology and hardware).
4. Include in your register the software and the formats used to backup the data including different versions.
5. Understand the lifespan of the media technology – know where the industry is headed and what the trends are.
6. Perform regular technology and media audits – keep testing! Ensure that this is a regular (preferably quarterly) part of your data management program.
7. Assign responsibility and make someone accountable.
8. Network – talk to peers, consultants and others within the industry.
9. Look at your tape storage facilities (personally – not just the brochure – everyone has had one of those holidays where the room does not quite match the picture in the advert).

Lastly, plan and budget for future data migration and preservation. Or if not, take the easy road and just plan for data loss.

Continued from p. 9

equipment built by Graham Boyd and his group in Adelaide. Ultimately however the positives of life in a big company were outweighed by the negatives and I went back to consulting and joined what was then the relatively small group at Southern Geoscience Consultants (SGC). Over the next 13 years I helped shape SGC into one of the largest mineral geophysics consultancies in the world which just goes to show that I didn't learn the lesson the first time, as SGC has become a big company with all its positives and negatives. Armed with a solemn promise not to grow big again, I left SGC in 2010 to establish ExploreGeo. I have bought an office about 10 min from home and moved in to it in May. ExploreGeo currently has two consultants, myself and Riaan Mouton who is also the ASEG WA president so there is plenty of ASEG discussion around the kitchen.

I'm pleased to see some new and younger faces taking up committee positions in the society and hope that this trend will continue. Having served on several of these committees and occasionally felt that the Federal Executive were not always effectively tapping a resource they had I'd like to hope that over the next 3 years I could energise some of the sleeping committees and use them to help the Federal Executive make better decisions on behalf of the members.

If you've got an idea which might help the society or a gripe about it, drop me a line at kim@exploregeo.com.au. If you're in Perth feel free to drop by the office – Riaan might even sign you up for the WA branch committee!

Kim Frankcombe

Cloud computing

My superficial impression of cloud computing (CC) was that it would simply be a mechanism for software companies to better manage software licensing and maintenance, a solution to reduce infrastructure and IT costs, or a vehicle to access files and data 'on the road' without having local file storage; all you need is an internet connection. But, there had to be more to it, so I decided to investigate. Alas, my worst fears about encountering endless jargon were quickly realized (see for example, http://en.wikipedia.org/wiki/Cloud_computing). Maybe the following few paragraphs will make your efforts easier, or maybe they will not.

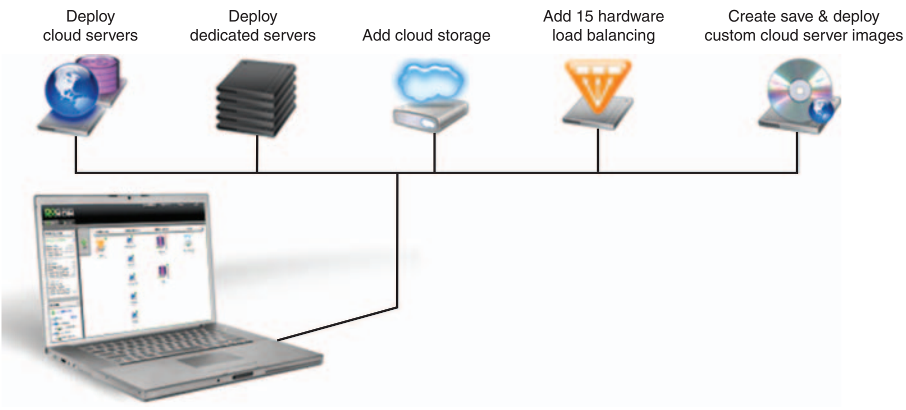


Fig. 2. *Example of cloud infrastructure management (from http://www.gogrid.com/).*

A lot of publicity regarding cloud services is driven by the providers, vendors and consultants. In a nutshell, any mention of CC to your friendly IT representative will probably evoke a pessimistic response regarding data security and the bottleneck challenges transferring large files of geophysical data to and from any CC server. If we can temporarily suspend such doubts and focus on opportunities instead, there may be CC opportunities for the geophysical community, including high performance computing (HPC) applications and shared development; notably inclusive to those without access to high-end computational resources. The caveat will remain, however, that a stable and reasonably high bandwidth (a subjective phrase) internet connection is available.

On the mainstream front, notable drivers are Microsoft (Windows Azure, http://www.microsoft.com/en-us/cloud/developer/default.aspx?fbid=omv3OTfykKB, a platform for collaborative development) and Amazon (Amazon Web Services, http://aws.amazon.com/). The Amazon online resources provide a useful overview, progressing from a cloud-based web service for content delivery (http://aws.amazon.com/cloudfront/), storage (http://aws.amazon.com/s3/), resizable compute capacity (http://aws.amazon.com/ec2/), and integration with HPC (http://aws.amazon.com/about-aws/whats-new/2011/04/07/announcing-amazon-ec2-spot-integration-with-hpc-instances/ and http://aws.amazon.com/about-aws/build-a-cluster-in-under-10/?utm_source=hpccloud&utm_medium=banner&utm_campaign=BA_hpccloud_hpctrial&trk=BA_hpccloud_hpctrial5). In the latter theme, the cluster resource manager vendors are looking into integrating their products with cloud services (http://www.platform.com/private-cloud-computing/clouds#cloudbursting) and large research programs also have started investigating cloud as an alternative to large scale data processing (http://www.taverna.org.uk/introduction/taverna-in-use/genome-and-gene-expression/next-generation-sequencing/).

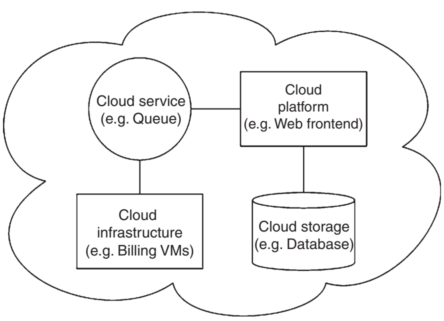


Fig. 1. *Example of cloud computing architecture (from http://en.wikipedia.org/wiki/Cloud_computing).*

I just focus on possible HPC applications for geophysics here. A few obvious areas of possible interest are as follows:

- Using HPC cloud for development and testing (new algorithms) where there is limited access to cluster infrastructure internally,
- Using HPC cloud in locations where investing in in-house infrastructure is not viable,
- Supplementing production with added capacity when needed, data transfer issues aside, and
- Data storage.

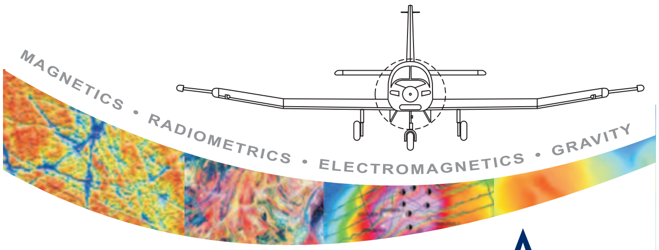
One can also ponder whether scientists in less privileged countries can overcome local infrastructure limitations by accessing cloud services too.

As an industry, we will each need to consider several aspects of applying cloud services, including the difference in cost between cloud and in-house, what level of service can be provided by the cloud business (including security and performance/capacity), and impacts upon existing company application architecture. It is clear that various services are already becoming available to manage infrastructure (e.g. http://www.gogrid.com/) and provide HPC 'on demand' (e.g. http://www.penguincomputing.com/POD). None of the links given here represent any kind of endorsement (!), but the white paper at http://www.penguincomputing.com/files/whitepapers/PODWhitePaper.pdf is probably a reasonable introduction to HPC via cloud services.

Overall, cloud computing is a messy affair to wade into right now, but you can be sure it will rapidly become a larger part of our life. From the replacement of DVDs to online video streaming to cloud HPC services, change is guaranteed.

Andrew Long
andrew.long@pgs.com

advanced airborne geophysics



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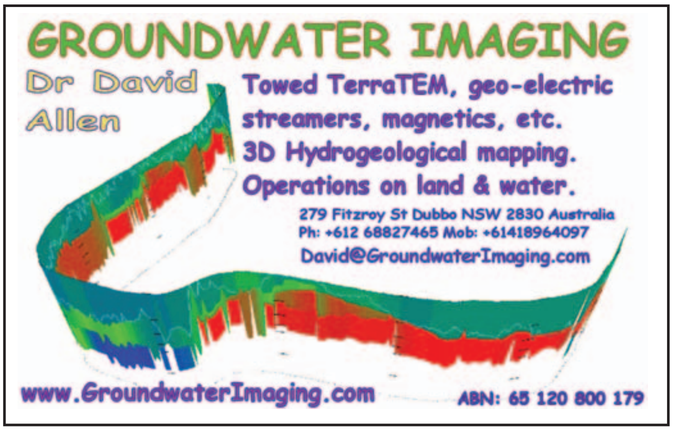

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Calendar of Events 2011–12

July			**2011**
31 Jul–5 Aug	SEG D&P 2011: Opportunities and Challenges in Unconventional Resources http://www.seg.org/events/upcoming-seg-meetings/dp2011-changping	Beijing	China
August			**2011**
22–24 Aug	Eighth International Mining Geology Conference http://www.ausimm.com.au/imgc2011/home.asp	Queenstown	New Zealand
28 Aug–2 Sep	Geosynthesis 2011: Integrating the Earth Sciences Conference & Exhibition http://www.sbs.co.za/geosynthesis2011	Cape Town	South Africa
September			**2011**
12–14 Sep	Near Surface 2011 http://www.eage.org	Leicester	UK
18–23 Sep	SEG International Exposition and 81st Annual Meeting http://www.seg.org	San Antonio	USA
October			**2011**
10–13 Oct	GEM Beijing 2011: International Workshop on Gravity, Electrical and Magnetic Methods and Their Applications http://geophysics.mines.edu/cgem/gem2011.html	Beijing	China
24–26 Oct	IGCP 5th International Symposium: Submarine Mass Movements and Their Consequences http://landslide.jp	Kyoto	Japan
30 Oct–2 Nov	Society of Petroleum Engineers ATCE 2011 http://www.spe.org/atce/2011	Denver	USA
November			**2011**
8–11 Nov	Sustainable Earth Sciences 2011: Technologies for Sustainable Use of the Deep Sub-surface http://www.eage.org	Valencia	Spain
15–17 Nov	2011 International Petroleum Technology Conference http://iptcnet.org/2011	Bangkok	Thailand
December			**2011**
5–9 Dec	AGU 2011 Fall Meeting http://www.agu.org/meetings	San Francisco	USA
11–14 Dec	First International Conference on Engineering Geophysics http://www.eage.org	Al Ain	United Arab Emirates
January			**2012**
22–24 Jan	4th International Professional Geology Conference: Earth Science – Global Practice http://www.4ipgc.ca	Vancouver	Canada
February			**2012**
26–29 Feb	22nd ASEG Conference and Exhibition 2012: Unearthing New Layers http://www/aseg2012.com.au	Brisbane	Australia
April			**2012**
2–5 Apr	Saint Petersburg International Conference & Exhibition 2012 http://www.eage.org	Saint Petersburg	Russia
June			**2012**
4–7 June	Copenhagen 2012: 74th EAGE Conference & Exhibition Incorporating SPE EUROPEC 2012 http://www.eage.org	Copenhagen	Denmark
August			**2012**
5–10 Aug	34th International Geological Congress http://www.34igc.org	Brisbane	Australia

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