Australian Society of
Exploration Geophysicists

JUNE 2015 • ISSUE 176
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PREVIEW

NEWS AND COMMENTARY

FEATURES

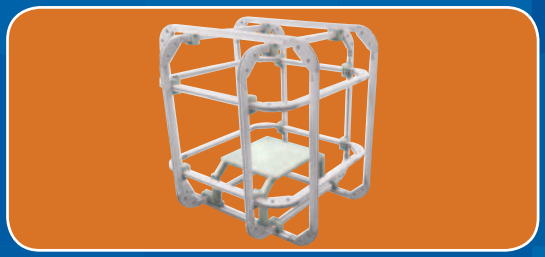
Magnetic Field Instrumentation

Three-Axis Magnetic Field Sensors

- Measuring ranges from ±60μT to ±1000μT
- Noise levels down to <5pTrms/√Hz at 1Hz
- Bandwidth to 3kHz; wide bandwidth version to 12kHz
- Range of data acquisition units

Helmholtz Coil Systems

- 500mm and 1m diameter coils
- Field generated up to 500μT (at DC) and up to 5kHz (at 100μT) for 500mm coil system
- Power Amplifier and Control Unit available



MS2/MS3 Magnetic Susceptibility Equipment

- Wide range of sensors for field and laboratory use
- Noise levels down to $2x10^{-6}$ SI
- Susceptibility/Temperature system

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PREVIEW

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Geotech Ltd
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FRONT COVER

New ASEG President Dr Phil Schmidt flying his drone in the Flinders Ranges, SA.
Photo: Greg Baker.

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Lisa Worrall

In this issue of *Preview* we welcome the new President of the ASEG, Dr Phil Schmidt. Phil is featured on the front cover, flying his drone in the Flinders Ranges, South Australia. Phil is planning to add fluxgate sensors to this drone and is refusing to be distracted by flies – which in the photo are almost as big as his drone and certainly more numerous! This same cheeky spirt of innovation characterised Alex Copeland who, I am sorry to report, died in Adelaide in April this year. Some of Alex's many friends and colleagues have collaborated on his obituary, which is published in this issue of *Preview*. I am also sorry to report on the death of Dave Hutchins. A giant of geophysics in southern Africa, Dave's legacy can be found in magnificent regional geophysical survey datasets and in the young geophysicists who are continuing his work in Botswana and Namibia.

A certain cheekiness also characterises one of the feature papers in this issue. I suspect that the authors of 'The application of geophysics to the sport of cricket' have found the perfect way to combine work and pleasure! On a more serious note, Phil Schmidt draws our attention to the call for a new unit to measure magnetisation in his preface to our second feature paper 'A new basis for the SI system of units: occasion to reconsider the presentation and teaching of magnetism'. Debate about what magnetic units are valid and whether H or B are fundamental has been bubbling away for years. A fresh approach has been signalled in this feature paper, which first appeared in a newsletter published by the Institute of Rock Magnetism (University of Minnesota, Minneapolis USA). The authors are well known in the field (Frank Stacey, Bruce Moskowitz, Mike Jackson, David Dunlop, Özden Özdemir and Subir Banerjee) and for those interested in rock magnetism, remanence, self-demagnetisation and magnetic anomalies their IRM paper is a very interesting read. Only a few ASEG Members subscribe to the *IRM Quarterly* so Phil Schmidt approached the IRM and the authors about republishing the paper in *Preview*. He met with an enthusiastic response, which is why you now have the opportunity to review the issue and to contribute to the debate via an online forum established by the authors.

You may notice a difference in the organisation of this issue of *Preview* as some of the Associate Editors have taken up the challenge of compiling news of interest to ASEG Members in addition to producing their usual, and much anticipated, commentary. Your feedback on the change would be welcome, as well as your contribution in the form of news that you think might be of interest to all ASEG Members. Your titbits – or more substantial items – can be sent to me or directly to the Associate Editors.

Lisa Worrall
Preview *Editor*
previeweditor@aseg.org.au

A new ASEG President

As incoming President of the ASEG for 2015 I should like to firstly thank the previous Presidents for their diligence, and for ensuring that the organisation was in better shape each time it changed hands. I also welcome Katherine McKenna as President-Elect. A number of other Members (relative youngsters like Dave Annetts) have also agreed to take on active roles on FedEx and in committees. Thanks to all of you and welcome. I can promise that collaboration on ASEG business with other Members will be a great investment in your careers.

When Koya Suto became President in 2013 he thought it would be a walk-over, a doddle, as everything was ticking over smoothly. *Exploration Geophysics* had had its first year as an international publication with SEGJ and KSEG, Dave Isles' and Leigh Rankin's *e*-book Geological Interpretation of Aeromagnetic Data had almost hit the markets, the new website and the first OzSTEP courses were about to be launched. What could go wrong? Well, we began to notice discrepancies between website and the membership database. Without dissecting the anguish that befell FedEx, suffice to say that we changed the Secretariat. Choosing another Secretariat was just as distressing but in the end TAS in Sydney came out in front. I salute Koya for overseeing this major change, which, perhaps, had been postponed for too long. Katherine and Koya are still sorting out anomalies in the database for this year's Membership Handbook. Greg Street continued bedding down the new Secretariat and addressed many related issues before moving onto fixing the website. So, I am under no illusion that, despite our very healthy financial position and the good shape that the basics (publications, website, education, Research Foundation) are in, we can continue to improve and I guess that will be my role, notwithstanding some disaster. I plan to consolidate the improvements in areas already started, particularly the website, and hopefully leave the ASEG even better than it currently is. Who was it that promised 'no nasty surprises and no lame excuses'? Well, my goal is to actually keep that promise!

Another recurring theme in previous Presidents' musings is their faltering initiation into the field of geophysics during 'busts'. Both Koya and Greg commented on their trials and tribulations as young geophysicists. This is easy to understand. Students get interested in geophysics during 'booms' but by the time they graduate the industry is 'bust'. My early career was similarly afflicted (in fact Greg and I were both students at UNE in the early 70s). After the Poseidon crash, which was emblematic of the end of the late 60s/early 70s commodities bull market, I was offered post-graduate work and jumped at the chance. After a few years at ANU I earned a doctorate in palaeomagnetism/rock magnetism (yeah, I know, very specialised) and then went on to do a post-doc in Canada with the Geological Survey of Canada. Then I got really lucky and was offered a position in Ken McCracken's new CSIRO Division of Mineral Physics (where I was part of the Rock Magnetism Group, the only group actually doing mineral physics). I know many colleagues who have stayed with industry through thick and thin, and I'm sure they are more comfortably well-off than I am, but after years of research it was in my blood and, in any case, I was too specialised to be useful to an exploration company – I still am! Like Koya and Greg, my advice to young geophysicists is to stay in the industry until the first 'bust' is over and then you will be assured of an exciting career. Also, you will not know when the 'bust' is over by reading newspapers and listening to economic gurus. Go along to monthly ASEG Branch meetings and talk to the old guard. You might be surprised to find that some of the old guard can already sniff the chance of coming opportunities.

Speaking of the Branch monthly meetings, their attendance was a subject of discussion at the Perth Council meeting. Attending monthly meetings is not compulsory, but I would highly recommend Members regularly show up and talk to other Members. This is free mentoring/tutoring and you will meet older Members who really have your welfare and the welfare of the ASEG in mind. We all want a thriving organisation that can respond to the next 'boom', which has probably already started.

I am currently involved in developing MSc projects with Mark Lackie at Macquarie University, where I am a Visiting Professor. This is quite an exciting exercise and I'll talk more about it on my national tour later in the year. My national tour will involve visiting each Branch, mainly to meet new Members and, perchance, to give them a 'state of the association' talk plus some information about my current interests/distractions. I hope to meet most Members but unless you attend your monthly Branch meetings we may not meet until the Adelaide conference.

The photo shows me flying my drone in the Flinders Ranges, SA, a couple of years ago. The drone is excellent for low level photography. I am currently adding some fluxgate sensors, which are now very low power and very affordable. Throughout my year as President I'll keep you informed of how successful, or otherwise, this venture is.

Phil Schmidt
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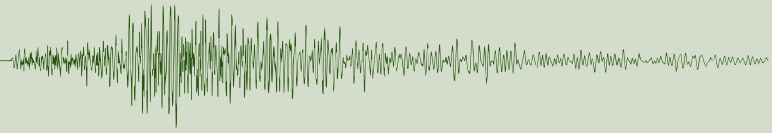
Photo: Greg Baker.



Welcome to new members

The ASEG extends a warm welcome to 43 new members approved by the Federal Executive at its March and April meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Peeter	Akerberg		WA	Australia	Active
Naveed	Akram	University of Science and Technology China		China	Student O/S
Shaun	Anderson	Queensland University of Technology	QLD	Australia	Student
Benjamin	Armstrong	Macquarie University	NSW	Australia	Student
Day	Aung			Myanmar	Active O/S
Peter	Betts	Monash University	VIC	Australia	Active
Victor	Brusche	University of Queensland	QLD	Australia	Student
Abdul Rauf	Chaudhry	Bahria University		Pakistan	Student O/S
Alex	Costall	Curtin University	WA	Australia	Student
Amanda	Crehan	BHP Billiton – Illawarra Coal	NSW	Australia	Active
Daryl	Eyles	Melbourne University	NSW	Australia	Active
Oliver	Gaede	QUT	QLD	Australia	Active
Tasman	Gillfeather-Clark	Macquarie University	NSW	Australia	Student
Jeremie	Giraud	UWA	WA	Australia	Student
Stephanie	Hawkins	Macquarie University	NSW	Australia	Student
Tahir	Hussain Soomro	Mehran University of Engineering and Technology		Pakistan	Student O/S
Amery	Jackson	University of Adelaide	SA	Australia	Student
Steve	Johnson	SkyTEM Australia Pty Ltd	WA	Australia	Active
Anton	Kepic	Department of Exploration Geophysics	WA	Australia	Active
Tshepo	Khoza	Anglo American	Gauteng	South Africa	Active O/S
Bala	Kunjan	Cue Energy	VIC	Australia	Active
Heta	Lampinen	UWA	WA	Australia	Student
Mathieu	Landry	Glencore	Québec	Canada	Active O/S
Johnathan	Leonard	UTS	NSW	Australia	Student
Preeti	Mamidi	Osmania University		India	Student O/S
Hugh	Merrett	University of Adelaide	SA	Australia	Student
Nicklas	Nyboe	SkyTEM Surveys		Denmark	Associate
Olivia	Penlington	Macquarie University	NSW	Australia	Student
Christopher	Pike	3D Oil Limited	VIC	Australia	Active
Elizabeth	Plotnek	University of Adelaide	SA	Australia	Student
Christian	Proud	Curtin University	WA	Australia	Student
Muhammad Adrees	Raza	University of Sargodha		Pakistan	Student O/S
Alec	Saxvik	QUT	QLD	Australia	Student
John	Searson	Searson Consulting	WA	Australia	Active
Brij	Singh	Indian School of Mines		India	Student O/S
Jagadish	Somigari Vemula	Osmania University		India	Student O/S
Neil	Symington	Geoscience Australia	ACT	Australia	Active
Tiffany	Waller	Queensland University of Technology	QLD	Australia	Student
Dezhi	Wang	Jilin University		China	Student O/S
Thomas	Watson	QUT	QLD	Australia	Student
James	Wordsworth	Gao Geophysics Australia	QLD	Australia	Active
Haoming	Wu	Macquarie University	NSW	Australia	Student
Marko	Zegarac	Curtin University	WA	Australia	Student

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2015 ASEG Annual General Meeting

The 2015 Australian Society of Exploration Geophysicists (ASEG) Annual General Meeting was held at the Rugby Club in Sydney on Wednesday 15 April 2015. The business of the AGM included:

- Confirmation of the minutes of the 2014 Annual General Meeting;
- Receipt of reports from the Federal Executive on the activities of the Society during the preceding financial year;
- Receipt of financial accounts and audit reports;
- Receipt of the ballot results for the election of the new office holders for the Federal Executive;
- Confirmation of the appointment of auditors for the 2015 financial year.

President's Report

- Society financially secure
- Successful 2015 conference with surplus in line with ASEG needs
- Consolidation of change of Secretariat
- Severing of relationship with CASM
- Membership database issues resolved – now using Currinda software for better management
- Record dollar contribution to Research Foundation
- Research Foundation 25 year review
- Research Foundation heading for major changes with Chairman stepping down in near future
- Supporting TESEP (Teacher Earth Science Education Programme) in Eastern Australia
- Review of finances ongoing in 2014
- Free student membership for Australian based students
- Website operational and payments on-line now easier
- Sale of *Exploration Geophysics* with SEG membership
- Push towards digital only *Exploration Geophysics*
- Expansion of *Preview*
- Start of history collection – needs work and volunteers
- President and past President visit to Houston SEG
- President and past President visit to EAGE Near Surface Athens
- OzSTEP programme launched – discussions on taking it overseas
- Successful visiting lecturers form EAGE and SEG
- FedEx and standing committees need more and younger members

As ASEG President I am pleased to report that the Society is in a good financial position and active across most states in Australia. Our membership numbers are somewhat diminished due, I believe, to the decline in exploration spending, but there remains a solid base.

The Melbourne Conference made a surplus of $450 000. The Perth 2015 conference was a major success with around 1200 delegates and a predicted surplus of $240 000 in line with the needs of the ASEG.

In 2014 the Federal Executive (FedEx) terminated the contract with CASM for the provision of professional secretarial services. We were not happy with their management of our affairs and in particular with their management of the membership databases. Under the management of Kim Frankcombe, we called for expressions of interest and interviewed three likely contenders in Sydney and Melbourne to replace CASM. The Association Specialists (TAS) a group that has run successful conferences for ASEG in the past were chosen from these candidates. Our contact there is Ben Williams and the office is in St Leonards in Sydney. Details are on our website.

Our major task in 2014 was getting the membership database under control. Under CASM there were at least three and possibly five or more databases in existence. We were losing respect from Members. Some Members were receiving multiple mailed copies of journals, emails etc. There appeared to be no link between Member's renewal preferences and what publications were being sent out. TAS recommended switching to a professional databases software provider Currinda to manage our database. This was implemented. It was not a simple task but it seems that we are now over this problem. Currinda sits behind the website so Members log in via Currinda to get access.

A more worrying note is that we appear to be losing Members. The previous state of the membership databases makes this unclear, but despite the 2015 conference our membership is down on numbers at the same time last year.

In addition, there was a major effort by the Federal Treasurer to get the ASEG finances into shape. There were many outstanding invoices, potentially written off by CASM, that were recovered by working closely with TAS. There also some provisions put in place to ensure at least some of these items no longer occur. The Treasurer has also been working with the Finance Committee to evaluate what the Society needs to keep in reserve and what kind of surpluses need to be generated by conferences. The Treasurer has instituted a new account coding system that is more logical than that used by CASM. The new system came into effect for the 2015 year. We have also developed a series of graphs that clearly show the state of finances against budget at each monthly meeting. At the end of my year as President we will have a much better idea about the state of the Society's finances.

As part of the withdrawal from CASM we also discovered we were paying for listing in White Pages in all states. We advised CASM that we had not approved this listing and left it for CASM to resolve payment.

In the 25th year of the ASEG Research Foundation (RF) the ASEG donated some $142 060 to the RF for approved projects; this was more than the Society had budgeted. Research projects have gradually become more postgraduate focused in recent years. A 25-year review paper was published in the December issue of *Preview*. While the Research Foundation is an independent entity to the ASEG it remains dependent on the ASEG for funds. To provide certainty to the RF and allow proper annual budgeting for the ASEG the FedEx has capped the annual donation in future years at $100 000, indexed for inflation. The concept of a self-funding Foundation has not eventuated but I feel that future committees of the RF should look at how this may be possible, similar to the SEG Foundation. The Chair of the Research Foundation Phil Harman has indicated he would like to step down. I would urge

potential volunteers to fill this role to contact Phil.

The ASEG also supported the TESEP (Teacher Earth Science Education Programme) in Eastern Australia with a $25 000 grant. In WA a similar programme (STWA – Science Teachers Western Australia) is funded by companies.

In 2014 Phil Schmidt took on the role of President Elect and relinquished head of the Publications Committee. This role was taken up by Peter Hatherly; who developed a draft publications strategy paper that will be considered by Council. Marl Lackie has continued as Editor of *Exploration Geophysics*. John Theodoridis finished a two-year stint as *Preview* Editor and the position was taken up by Lisa Worrall. Lisa has expanded *Preview* to an average of 60 pages (normal issues) and is examining ways to take *Preview* into digital format using an App. She has also been examining ways to overcome the problems of publication by CSIRO Publishing that plagued John Theodoridis during his term. Face-to-face meetings have been organised to try and resolve some of these problems.

The website development has been slower than we would have liked. It is operational and most of the bugs ironed out but we can improve it further. Whether we like it or not the web will be our main delivery portal for most of our functions in the future.

The future direction for the ASEG website should include:

- a seamless link to membership page and membership renewal;
- a seamless link to publications so they appear as ASEG rather than CSIRO publications;
- uploads of workshop proceedings;
- a historical library of scanned instrument manuals;
- a virtual museum of geophysical instruments with background material on use;
- seamless links to conference (and past conference) websites;
- more advertising perhaps;
- more educational material for students;
- links to instructional videos possibly on YouTube.

I am sure you can think of more things you would like BUT the Web Committee needs more people to take on these tasks. The Committee could expand to 10 people to adequately take on these tasks.

This year Wendy Watkins took on alone the task of Education Committee which is clearly a major role for the Society. With support from Koya Suto she instituted the OzSTEP programme as well as oversaw the distinguished lecturer programmes from EAGE and SEG. This Committee needs to expand in 2015 to at least three people and preferably five. Duties of these five people would be:

1. Overall management
2. Manage OzSTEP minerals programme
3. Manage OzSTEP petroleum programme
4. Manage SEG distinguished lecturers
5. Manage EAGE distinguished lecturers
6. Develop educational material on the website – 2 to 3 people

Koya Suto again filled the role of International Affairs liaison. Over the past decade Koya has built up a wide range of international contacts in Asia, Europe and North America. He has overseen the links with SEG Japan and Korean SEG as well as developed MOUs with Mongolia and Brazil. Koya represented the ASEG at four conferences since the last ASEG conference and as president I also represented the ASEG at four overseas conferences.

The SEG conference remains the most important for the ASEG to attend. From our continuing involvement we get access to SEG distinguished lecturers and short courses and, from my trip to Houston, we have negotiated a profit sharing arrangement for the upcoming AAPG conference in Melbourne. Attending these conferences is costly. The Federal Executive has initiated a review into our overseas representation so that we will be able to both target our representation where it is needed most and ensure that the Society allows enough funds for the travel if the Society's representatives are not able to get part funding by coordinating their travel for the Society with travel for business purposes.

- SAGA (Kruger NP) – Greg Street
- SEG (Houston) – Koya Suto
- SEGJ (Yokohama) – Greg Street
- SAGEEP (Boston) – Koya Suto
- EAGE (Amsterdam) – Koya Suto
- SEG (Houston) – Greg Street, Koya Suto
- EAGE NS (Athens) – Greg Street and Koya Suto
- GeoSEA (Yangon) – Greg Street

The History Committee of the ASEG is one of the most active and has enough members to be considered a Specialist Group. Mostly these are superannuated older members like myself and dominantly male. The major role has moved from history of the ASEG and Members towards history of what Members have done and trying to preserve pieces of significant older equipment. The concept of an historical collection of instruments is a reality with CGG donating a few pallet loads of equipment and more is promised from NSW Geological Survey among others. But we need a home for this equipment where it can be curated appropriately and put on display for the public. Kim Frankcombe posed the idea of a virtual collection on the website where Members could see pictures of instruments and the backing manuals as well as the history of the instrument. This is probably the easiest route to start with but it remains a goal to get some material on display in museums. It still requires work in the scanning of manuals and photographing of instruments.

Dave Robson is stepping down from the Technical Standards Committee at this meeting to be replaced as head by Tim Keeping. The Committee remains active and it is pleasing that standards developed by ASEG are being adopted elsewhere. During the year I wrote to the Head of CSIRO as ASEG President to ask him to consider taking an active role in the evaluation of 'new techniques' that fall into the 'Black Box'/'Black Magic' range. In reply he said that CSIRO had neither the mandate nor the capacity to assist.

The Federal Executive has continued the work it began in 2013 on developing and implementing a strategic plan for the Society. Our membership numbers have remained fairly static over the last decade, and our Members are ageing. The kinds of services we offer our Members have remained mostly unchanged. At the Council meeting prior to the Perth Conference we began a discussion on new kinds of services that Members want from the society. In 2014 we initiated a Specialist Group for Early Career Geophysicists with Millicent Crowe as interim Chair. The Specialist Group held its first planning meetings at the Perth Conference. We now look forward to setting up new Specialist Groups that are discipline focussed and welcome approaches for Members keen to take up this opportunity.

Greg Street
Outgoing ASEG President
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Treasurer's Report

The audited financial statements for the year ending 31 December 2014 for the Australian Society of Exploration Geophysicists (ASEG) is presented in the following pages. The financial statements refer to the consolidated funds held by the Society as a whole, including the Branches.

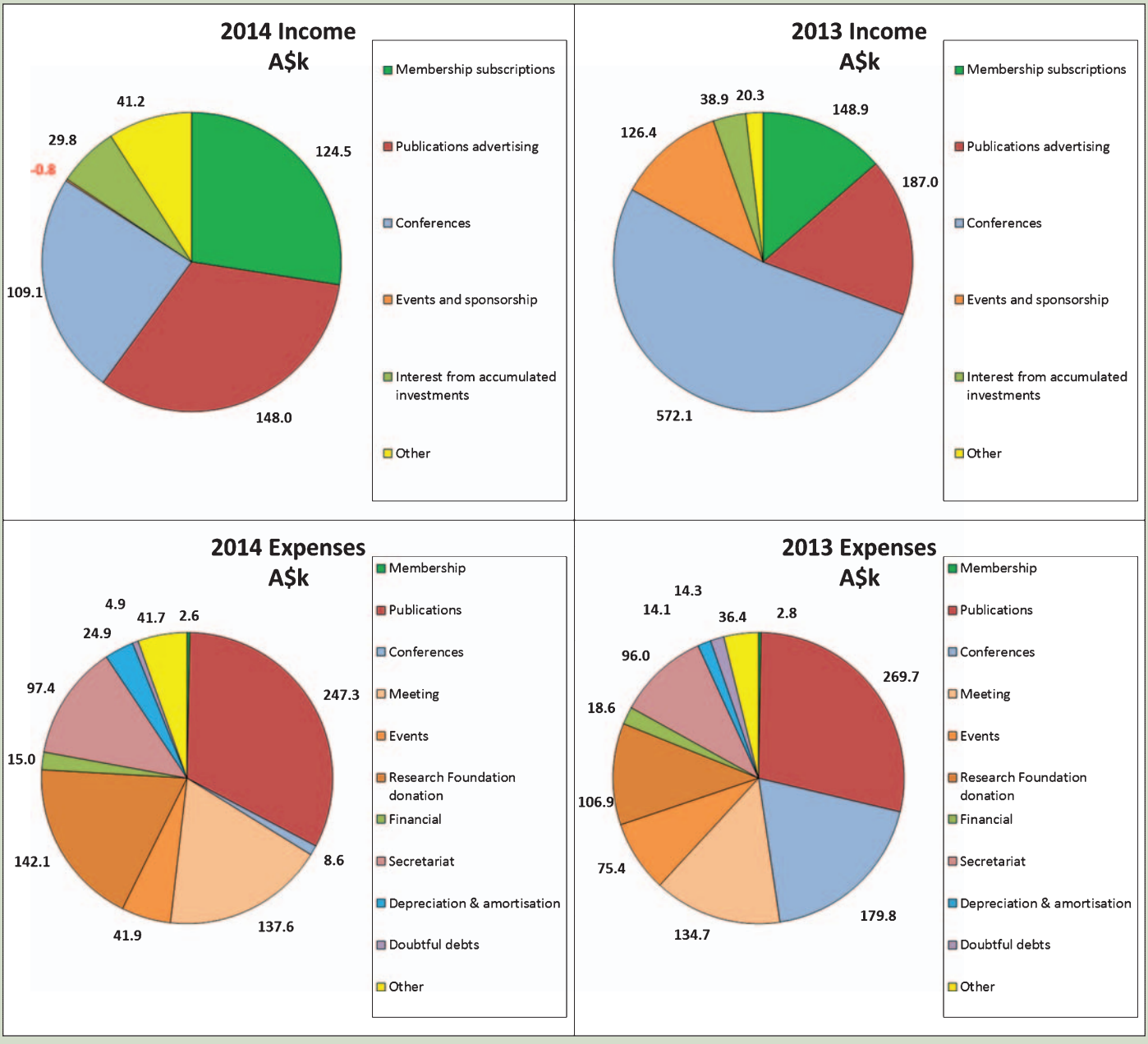
The Society's funds go towards promoting the science and profession of geophysics throughout Australia, achieved by the following means:

- Funding publications (*Exploration Geophysics*, *Preview* and the *Membership Directory*)
- Supporting Branch functions
- Funding the national administration of the ASEG
- Continuing education programmes; provision of loans and grants for conventions
- Free student membership
- Provision of subsidies for student members
- Supporting the ASEG Research Foundation

As of 31 December 2014, the Income Statement for the year shows a net loss of $312 184 and a Total Equity of $1 114 694. By means of comparison in 2013 (a conference year), the Society made a surplus of $144 579 and had total equity of $1 426 878. The Society's revenue sources and expenses in 2014 can be found in the table and charts below. Values for the year ending 31 December 2013 are again presented for comparison.

The Society is in a very sound financial position going into 2015. The equity held will cover the uncertainty of income from future conferences.

Theo Aravanis
Honorary Treasurer (2014–15)
treasurer@aseg.org.au



Charts of income and expense items.

Revenue	2014	2013	Change from 2013
Membership subscriptions	$124 491	$148 871	–16%
Publications advertising	$147 956	$186 963	–21%
Conferences	$109 143	$572 098	–81%
Events and sponsorship	–$800	$126 426	–101%
Interest from accumulated investments	$29 837	$38 914	–23%
Other	$41 198	$20 272	103%
Total	**$451 825**	**$1 093 272**	**–59%**

Expense	2014	2013	Change from 2013
Membership	$2579	$2769	–7%
Publications	$247 299	$269 650	–8%
Conferences	$8554	$179 757	–95%
Meetings	$137 570	$134 746	2%
Events	$41 904	$75 449	–44%
Donation – Research Foundation	$142 060	$106 900	33%
Financial	$15 040	$18 629	–19%
Secretariat	$97 438	$95 999	1%
Depreciation and amortisation	$24 923	$14 086	77%
Doubtful debts	$4907	$14 277	–66%
Other	$41 735	$36 431	15%
Total	**$764 009**	**$948 693**	**–19%**

Profit/Loss after income tax expense	**–$312 184**	**$144 579**	**–316%**

Election of Office-bearers

The four Directors of the ASEG who were elected at the AGM according to the Society's Constitution were:

President (Phil Schmidt),
President Elect (Katherine McKenna),
Treasurer (Theo Aravanis),
Secretary (Barry Drummond).

Outgoing President Greg Street hands the ASEG gavel to incoming President Phil Schmidt.

Appointment of Auditors

The AGM moved to appoint the following as the ASEG auditors for 2015:

TINWORTH ACCOUNTANTS & CO
Chartered Accountant and Business Advisors
Level 2, 66 Berry Street, North Sydney, NSW 2060, Australia.

Victoria

On Friday 20 March the Victorian Branch of the ASEG hosted a technical lunch meeting with the SEG Pacific South Honorary Lecturer **Greg Beresford** presenting 'Some interesting concepts associated with seismic seafloor acquisition' drawing on his many years working with Ocean Bottom Cable seismic. Many thanks to Karoon Gas for providing us with a venue in the middle of the Melbourne Comedy Festival, which sees traditional meeting venues in Melbourne completely booked out for three weeks solid.

On Thursday 30 April we hosted a technical lunch meeting at the Kelvin Club, featuring **Bala Kunjan** from Cue Energy Resources. Bala presented 'Utilizing tuning/AVO phenomena to predict oil column height in the Tui, Amokura and Pateke Fields, New Zealand'.

We look forward to seeing many ASEG Victoria Branch members at meetings in the coming months.

Asbjorn Norlund Christensen (Victorian Branch President)

Western Australia

The WA Branch had a very busy start to 2015, hosting a number of events including:

- ASEG-PESA Conference (February 2015);
- SEG Honorary Lecturer Greg Beresford (March 2015);
- SEG Distinguished Lecturer Jean Virieux (March 2015); and
- A Networking BBQ (May 2015)

As there were two technical events in March and the Easter holidays in April, it was decided not to host a technical event in April but to host a networking BBQ in May. We will return to our regular schedule of monthly technical events in June.

We had a good turn-out for the Networking BBQ, which was held on 7 May in Kings Park. Members enjoyed the chance to catch up with colleagues on a beautiful autumn afternoon. The venue in Kings Park proved very convenient and provided a lovely relaxing setting.

This year the WA Branch has changed its approach to corporate sponsorship of Technical Nights. We now have a pool of regular sponsors (Gold and Silver) which will enable us to continue to provide Technical Night events free of charge to Members. Thanks to our corporate sponsors:

- Gold:
  - o First Quantum Minerals Ltd
  - o Geosoft
  - o Resource Potentials
  - o Southern Geoscience Consultants
  - o Quantec Geoscience
- Silver:
  - o Atlas Geophysics
  - o ExploreGeo Pty Ltd

The calendar is fast filling up for 2015 including Technical Nights, technical seminars, travelling SEG lecturers, EAGE EET9, and OzSTEP workshops. Keep an eye on the ASEG website and mailouts for more information on upcoming events.

This year the WA Branch will again provide financial support to well-deserving geophysics students in WA through the ASEG WA Branch Student Award programme. Application forms for the award will be sent out shortly with a view to presenting the awards during July 2015.

Kathlene Oliver (WA Branch President)

WA Branch Networking BBQ in Kings Park.

Australian Capital Territory

The ACT branch hosted Pacific South Honorary Lecturer **Greg Beresford** speaking about 'Some interesting concepts associated with seismic seafloor acquisition' in March. There were over 30 people in attendance. As a token of our huge appreciation the local ASEG branch presented Greg with a book – 'Shaping a Nation' (http://press.anu.edu.au/titles/shaping-a-nation).

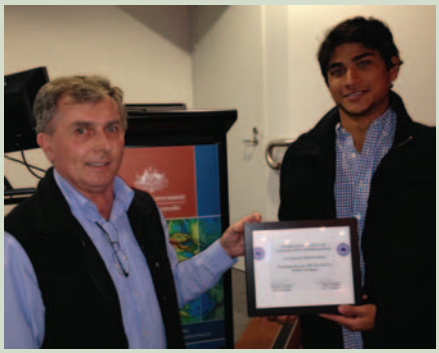
South Pacific Honorary Lecturer Greg Beresford speaking to the ACT ASEG Branch at Geoscience Australia.

ACT Student Award Prizes

The ACT Branch selected the recipients for two student awards at the end of April. **Tim Jones** (PhD student) and **Sanjay Govindan** (Honours student), both from the Australian National University, were given a 2015 ASEG ACT Branch Student Award of $2000 at our May meeting. Both have a history of academic excellence and both deserve the award. Congratulations Tim and Sanjay!

Tim Jones being presented the 2015 ASEG ACT Branch Student Award of $2000 by Ross Costello.

In addition to featuring the Branch Student Awards the Branch meeting on 19 May saw **Adam Kroll** from FROGTECH presenting on 'Unmanned aircrafts role in the future of exploration'.



Sanjay Govindan being presented the 2015 ASEG ACT Branch Student Award of $2000 by Ross Costello.

Adam spoke about UAV's and how they can potentially help all aspects of mineral exploration.

Marina Costelloe (ACT Branch President)

New South Wales

In March the NSW Branch of the ASEG hosted the SEG Pacific South Honorary Lecturer, **Greg Beresford**. Greg spoke about seismic seafloor acquisition, giving an overview of the concepts and challenges that are faced in obtaining data. Greg went through the basic theory of the technique and highlighted a few problems that he had encountered in his work and how he went about solving them. Much discussion followed his presentation and ample red wine was consumed discussing the finer points of seismic seafloor acquisition.

In April the ASEG AGM was held in Sydney. The President, **Greg Street,** gave a talk after the AGM on the barriers to adoption of geophysics. Greg went through a number of case histories where geophysics proved to be quite useful but the geophysical methodology was not adopted by the groups concerned on any ongoing basis. Much discussion followed.

Also in April we awarded the 2015 ASEG NSW Branch Student Scholarship. The recipient is **Alexandre Lemenager** from Macquarie University. The Scholarship is to assist the student with their geophysics research topic.

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

Mark Lackie (NSW Branch President)

Queensland

The Queensland Branch's calendar is brimming with exciting events for the second half of the year.

The festivities begin on Friday 24 July with the annual Zoeppritz Night Pub Crawl. This pub crawl is a relatively new tradition (established 2011). A wave of Queensland Branch geophysicists celebrates the work of Karl Bernhard Zoeppritz by demonstrating the effects of various density liquids on their propagation throughout the city.

August begets the annual ASEG/PESA Trivia Night (date TBA) with none other than our very own Branch Treasurer **Mr Henk van Paridon** donning the QuizMeister hat.

Brisbane will also host three OzSTEP courses later this year; two are petroleum based and one is minerals based. Tentative dates have been provided and will be updated on the Queensland Branch Calendar closer to the event. The first course, which is scheduled for 25 September, will be conducted by **David Lumley** and will focus on reservoir monitoring including discussions primarily on 4D seismic, but also passive seismic and 4D seafloor gravity. The second course, which is scheduled for 23 October, will be conducted by **Bob Musgrave** and will cover all things potential fields including a theory refresher, remanence, gravity and magnetic gradiometry, filtering, layer separation, interpretation of short- and long- wavelength signals, edge analysis, and inverse and forward modelling. The third course, which is scheduled for 4 November, will be conducted by **Brian Russell** and will cover concepts of AVO and Inversion. We will also be holding local branch meetings around the workshops.

Keep your eye on the Queensland events calendar on the ASEG website for updates and registration details closer to the date.

Megan Nightingale (QLD Branch Secretary)

South Australia & Northern Territory

Since the last edition of *Preview*, the SA/NT Branch enjoyed our second technical evening of the year, with presentations from two PhD Students from the University of Adelaide. **Kate Robertson**, recent recipient of the ASEG SA/NT Branch Student Travel Scholarship to attend the ASEG-PESA 2015 conference in Perth, presented her work titled 'Traversing the Delamerian and Lachlan Orogens of Victoria with MT data to illuminate geological structures, fossil fluid pathways and serpentinisation'. **Stephanie Tyiasning** presented her work, which she also presented at the recent conference in Perth, titled 'AVO Sand prediction in the Cooper Basin, Australia'. Both talks were received well by all in attendance, especially given the very diverse nature of the subject matter. We thank both Kate and Stephanie for their efforts and the time taken to join us.

Without the support of all of our sponsors our monthly technical meetings would not be possible. As such, we would like to thank all of our sponsors for 2014, including Beach Energy, the Department of State Development, Geokinetics, Ikon Science, Minotaur Exploration, Petrosys, Santos, Schlumberger, Statoil and Zonge. We are currently in the process of contacting our sponsors and are thankful to those who have returned for 2015. Of course, if you or your company are not in that list and would like to give your support please get in touch via the email below.

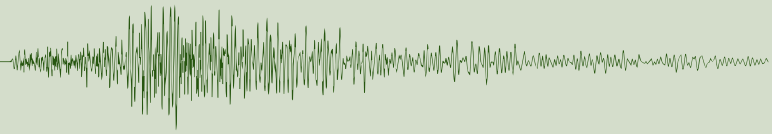
As usual, further technical meetings will be held monthly at the Coopers Alehouse on Hurtle Square in the early evening. We invite all Members, both SA/NT and interstate to attend, and of course any new Members or interested persons are also very welcome to join us. Also, keep on the lookout for OzSTEP courses to be held later in the year, more details to come in the next few months. For any further information or event details, please check the ASEG website under SA/NT Branch events and please do not hesitate to get in touch at joshua.matthew.sage@gmail.com or on 8338 2833.

Josh Sage (SA/NT Branch President)

Tasmania

An invitation to attend Tasmanian Branch meetings is extended to all ASEG Members and interested parties. Meetings are usually held in the CODES Conference Room, University of Tasmania, Hobart. Meeting notices, details about venues and relevant contact details can be found on the Tasmanian Branch page on the ASEG website.

Mark Duffett (Tasmanian Branch President)



ASEG calendar: technical meetings, courses and events

Date	Branch	Event	Presenter	Time	Venue
2015					
7 Jul	ACT	Technical Talk	Dr Jon Clarke	1600–1700	Geoscience Australia, Symonston
8 Jul	WA	Technical Night	TBA	1730–1900	City West, Function Centre, Perth
24 Jul	QLD	Zoeppritz Night Pub Crawl		TBA	TBA
12 Aug	WA	Technical Night	TBA	1730–1900	City West, Function Centre, Perth
Aug	QLD	ASEG/PESA Trivia Night	Henk van Paridon	TBA	TBA
9 Sep	WA	Technical Night	TBA	1730–1900	City West, Function Centre, Perth
5 Oct	QLD	OzSTEP: Reservoir Monitoring/4D Seismic	Prof David Lumley, UWA	TBA	TBA
7 Oct	NSW	OzSTEP: Reservoir Monitoring/4D Seismic	Prof David Lumley, UWA	TBA	Rugby Club, off 31 Pitt St, Sydney
9 Oct	VIC	OzSTEP: Reservoir Monitoring/4D Seismic	Prof David Lumley, UWA	TBA	TBA
12 Oct	ACT	OzSTEP: Reservoir Monitoring/4D Seismic	Prof David Lumley, UWA	TBA	Geoscience Australia, Symonston
13 Oct	VIC	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	TBA
14 Oct	SA/NT	OzSTEP: Reservoir Monitoring/4D Seismic	Prof David Lumley, UWA	TBA	TBA
14 Oct	WA	Technical Night	TBA	1730–1900	City West, Function Centre, Perth
15 Oct	TAS	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	TBA
19 Oct	ACT	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	Geoscience Australia, Symonston
21 Oct	NSW	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	Rugby Club, off 31 Pitt St, Sydney
26 Oct	WA	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	TBA
28 Oct	SA/NT	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	TBA
30 Oct	QLD	OzSTEP: Potential fields for mineral exploration	Bob Musgrave	TBA	TBA
30 Oct	WA	OzSTEP: Reservoir Monitoring/4D Seismic	Prof David Lumley, UWA	TBA	TBA
2 Nov	WA	OzSTEP: AVO and Inversion	Brian Russell	TBA	TBA
4 Nov	QLD	OzSTEP: AVO and Inversion	Brian Russell	TBA	TBA
6 Nov	VIC	OzSTEP: AVO and Inversion	Brian Russell	TBA	TBA
6 Nov	WA	ASEG-PESA Golf Day	ASEG/PESA	TBA	Joondalup Golf Course
11 Nov	WA	Technical Night	Student Presentations	1730–1930	City West, Function Centre, Perth
18 Nov	WA	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	City West, Function Centre, Perth
19 Nov	SA/NT	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	TBA
20 Nov	WA	EAGE (EET9) Workshop: Satellite InSAR Data: Reservoir Monitoring from Space	Alessandro Ferretti	0900–1700	CSIRO, Perth
23 Nov	QLD	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	TBA
24 Nov	WA	AGM and Christmas Party		1730 till late	TBA
25 Nov	ACT	EAGE (EET9) Workshop: Satellite InSAR Data: Reservoir Monitoring from Space	Alessandro Ferretti	0900–1700	Geoscience Australia, Symonston
30 Nov	TAS	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	TBA
9 Dec	ACT	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	Geoscience Australia, Symonston
10 Dec	ACT	SEG HL Near Surface: The curse of dimensionality in exploring the subsurface	Hansreudi Mauerer	TBA	TBA

TBA, to be advised (please contact your state branch secretary for more information).

Vale Alex Copeland (1950–2015)

It is with great sadness that we report the death of Alex Copeland. He died from lung cancer in hospital in Adelaide on Thursday 16 April. The diagnosis of lung cancer, made last year, came as a shock to all of us, particularly Alex, as he had not been a smoker.

Alex's geophysical career spans over more than 40 years, starting in 1968 when, straight from school, he joined Fairey Aerial Surveys based in Maidenhead UK. He initially trained as a cartographic draughtsman but later transferred to their newly formed airborne geophysics department, working as a data compiler. One of Alex's tasks was flight path recovery, plotting the path of the aircraft from tracking film onto map. As much of this work was undertaken on site (along with other data QC) Alex was soon working away from home on a variety of projects. Derek Minter remembers him as a popular crew member, hard working, competent and sociable. In 1974 Alex worked in Nigeria on a large airborne survey based out of Enugu for nearly a year (Figures 1 and 2). Derek says the project struggled with aircraft and electronics problems but to his great credit Alex saw it through to its conclusion.

Alex had a reputation of being something of a boy racer and Doug Morrison recalls being terrified when driving with him in Africa. Doug claims he was not alone in that regard, although they all found that a few beers helped ease the fear. Having beer in the car also came in handy one night when their favourite orange VW hunting car caught fire on route to the movies, with Alex driving. During his time in Nigeria Alex bought an E-Type Jaguar which he eventually brought out to Australia and would terrify his passengers as he worked off the Hilux blues.

Alex left Fairey to join Geometrics in 1975 as a data compiler, initially in Zambia but then transferring to the US before coming to Australia in the late '70s. It appears he did have time between data compilations to model for Geometrics' new seismograph as shown in Figure 3. Doug Morrison recalls a time

Figure 2. *Alex reviewing bush medicine in Nigeria about 1975 (photo Derek Minter).*

in the late '70s when Alex helped him unload and stack tons of paperbark fencing and spent a few hours helping to start construction of the fence at his old home at Lane Cove, Sydney. He also recalls that Alex was dating Mark Baigent's sister at the time – a small geophysical world!

Already an excellent navigator, Alex qualified as a commercial pilot in 1979 and undertook some survey flying for Geometrics in their Piper Navajo aircraft.

Figure 1. *Alex, second from left, with the Fairey Aerial Surveys team and DC3 in Nigeria, 1974 (photo from Fairey Aerial Survey History site http://www.faireysurveys.co.uk).*

Figure 3. *Alex posing for the camera with the 'new' Geometrics seismograph (thanks to Doug Morrison for the scan).*

His work with Fairey and Geometrics, took him all over the world. This formed a template for later life as Alex loved to travel, so much so that although he had lived in Australia for over 30 years and wanted to become an Australian citizen, he claimed that he could not qualify because he could never reach the minimum continuous period required to be physically in Australia. Wherever he travelled he left a trail of people with Alex stories. He had friends all over the world.

Alex moved to Adelaide for a new start in 1982 and joined Shell Australia as a field assistant in their Adelaide office. While not providing many stamps in his passport this job did give him a close up look at outback Australia and, importantly, provided him with bush driving skills, a critical tool to have for a Pom in the Australian outback. This required a tempering of the racing car driving style of his time in Africa. When Shell closed their South Australian exploration office in 1986 Alex set up an exploration service company, initially providing field assistants, camping and vehicle support. His first job in this role was assisting me in acquiring seismic refraction data for the new Olympic Dam borefield just south of Lake Eyre. It was June and we slept in swags at what was then the end of the borefield road. A road train was trucking water to Olympic Dam and operated 24 hours a day on about a one hour return cycle. Although we were camped on the open gibber plain only 100 m away from the turning circle and stand pipe we all slept soundly, thanks to hard work and the Coopers Real Ale Alex had brought. Showers were taken in the open, between road train visits, under the standpipe. The showers might not have been very long and certainly were not warm but we did use a lot of water and got wet very quickly! The highlight for Alex and his crew was on the last day when I 'disposed' of the 250 kg of unused explosives with a relatively short blasting cable.

In 1987 Alex was joined by Peter Elliot and they formed Search Exploration Services focussing on contract ground geophysical surveys. He and Peter later parted ways with Pete taking the Zonge equipment and Alex the Scintrex gear. He used the Scintrex IP equipment for several years building Search's reputation as a hard working, reliable geophysical contractor. However, like many Australian geophysicists, he started to realise that equipment designed and built on the other side of the world wasn't giving him the best answers in Australia where, electrically speaking, the overburden often looked like sea water. At this stage he could have done as most other contractors do and look for an off the shelf solution. Undaunted, or perhaps not realising the cost both in time and money in building his own system, he decided to do just that and, with help from Phil Palmer on the hardware side and John Paine on the software side, he built what is arguably the best IP system in the world – certainly the best system for Australian conditions.

Alex took his systems all over the world. I recall a job in Tunisia where Alex proudly told me that the crew I was using would have a newly rebuilt Volkswagen racing engine powering their 30 kV generator. It lasted 15 minutes before seizing (Figure 4). Off it went to the local mechanics coming back a week later, working. Again it lasted 15 minutes in the field before seizing. By this time Tony Walsh, the crew leader, was getting a roasting remotely from Alex, whilst scouring the wreckers of Tunis for a replacement engine. This time the mechanic took a closer look and discovered that the racing engine had been modified so that the oil intake had been shortened and did not reach the bottom of the sump. Depending on the angle that the truck was parked, the

Figure 4. *The Search crew in Tunisia with their shiny new, but seized, motor generator.*

Figure 5. *Alex set up for comfort on survey in PNG (photo Regis Neroni).*

engine either had oil or no oil and the crew had unfortunately chosen to park it with the intake in the air. Alex quickly acknowledged his mistake and accepted that just because an engine has 'racing' in front of its name and works on flat tracks it need not work in survey situations. He subsequently equipped his crews with turbo charged diesels, which they still use today.

Alex always managed to add a touch of class to what would otherwise have been a pretty ordinary field job (Figure 5). Lisa Vella recalls that while working at Carrapateena in 2007 (Figure 6), and despite the relative isolation, Alex managed to produce a few good bottles of red wine for dinner each night. She went on to say, 'Alex was a fine and decent man. Always kind and ready to help a younger geophysicist in need. He was a very good mentor and endlessly enthusiastic about his work and the world around him. All the while innovating with a smile on his face. There was no fanfare with Alex, just a quiet belief in himself and his company, enabling Search to develop one of the best IP systems in the world.'

Alex was a keen rugby player, playing at all levels for the Old Collegians Rugby club in Adelaide from 1982 through to the 1990s. Both Chris Yaeger, who shared houses in Adelaide with Alex for several years and gave one of the two eulogies at his funeral, and I played breakaway with Alex at five eight. We both recall breaking from a scrum or maul to chase the ball down the opposition back line only to have their winger kick the ball direct to Alex who,

Figure 6. *Alex explaining the survey at Carrapateena with Lisa Vella and Jim Hanneson looking on (photo Lisa Vella).*

with a couple of the old props, had not moved since the breakdown. He'd then somehow manage to run to the end of the paddock without being tackled. We'd come off the paddock covered in blood and bruises and he would come off looking like he'd just played a round of golf – typical back. He was a prolific try scorer and played in seven Golden Oldies Rugby World Cups as well as helping to organise the 1999 event in Adelaide. Old Collegians provided a fertile recruitment ground as many of Alex's field crew had rugby backgrounds.

Alex leaves behind Gerry Bown, his partner and business manager for over 30 years, and a great sadness in all those who knew him. He will be missed.

Kim Frankcombe
kim@exploregeo.com.au
With help from, Derek Minter, Doug Morrison and Lisa Vella

P.S. With some help from Dave McInnes, and no doubt from Phil Palmer and John Payne, Gerry has announced that she will keep Search Exploration Services running so the technology that Alex developed will continue to be available.

Vale Dave Hutchins (1948–2015)

Figure 1. *Dave Hutchins.*

David Hutchins (Figure 1) was born in Torquay, Devon, England on 21 July 1948. He completed his schooling at Newton Abbot Grammar School in 1967 before entering the University of Southampton, England where he completed a BSc (Honours, Geology) in 1970. He then joined the Ministry of Overseas Development as a Natural Resources student and attended the University of Birmingham, where he was awarded an MSc (Applied Geophysics) in 1971.

Dave's professional affiliations were: Society of Exploration Geophysicists (Africa and Middle East representative, 1984-87); Australian Society of Exploration Geophysicists; Botswana Geoscientists Association (Life Member, 1985); South African Geophysical Association; Geological Society of Namibia (Life Member).

Posted to the Botswana Geological Survey, David became aware of the need for regional geophysical data sets to aid the mapping of sub surface geology predominately hidden by more recent cover. This resulted in:

- The first national gravity survey of Botswana (1971–74).
- The first regional airborne magnetic survey of the Kalahari (150 000 line km).
- A seismic refraction survey and micro seismic studies of the Okavango Delta, Botswana.
- Geophysical field investigations for underground water and rural development including the Jwaneng Diamond Mine and the Morupule Coal Fields.

In 1985 David left the Botswana Geological Survey, where he was Principal Geophysicist heading an embryonic Geophysics Division. In 1986 he joined the Geological Survey of South West Africa (SWA)/Namibia as their sole geophysicist, initially as Principal and, since 1988, as Chief Geophysicist. David retired from the Geological Survey of SWA in 2013 but was invited to consult until his recent demise.

Included in David's achievements whilst at the Geological Survey of SWA were:

- Pre Namibian independence regional airborne magnetic surveys (78 000 line km).
- Acquisition of the first computer hardware/software by the Geological Survey.
- Consultant in the drafting of Namibian petroleum legislation.
- Compilation of the Namibian regional airborne magnetic/radiometric surveys in co-operation with the German funded Mineral Promotion Project (1992–2002) (Figure 2).
- Planning and supervision of the high resolution airborne magnetic/radiometric survey of Namibia (1994–2011), which was funded by the European Union's SYSMIN Fund, and the Namibian Government's Mineral Development Fund. 4.4 million line km of data were acquired.
- Planning and supervision of several airborne electromagnetic, gravity and hyperspectral image surveys to support the national magnetic and radiometric survey programme of Namibia.

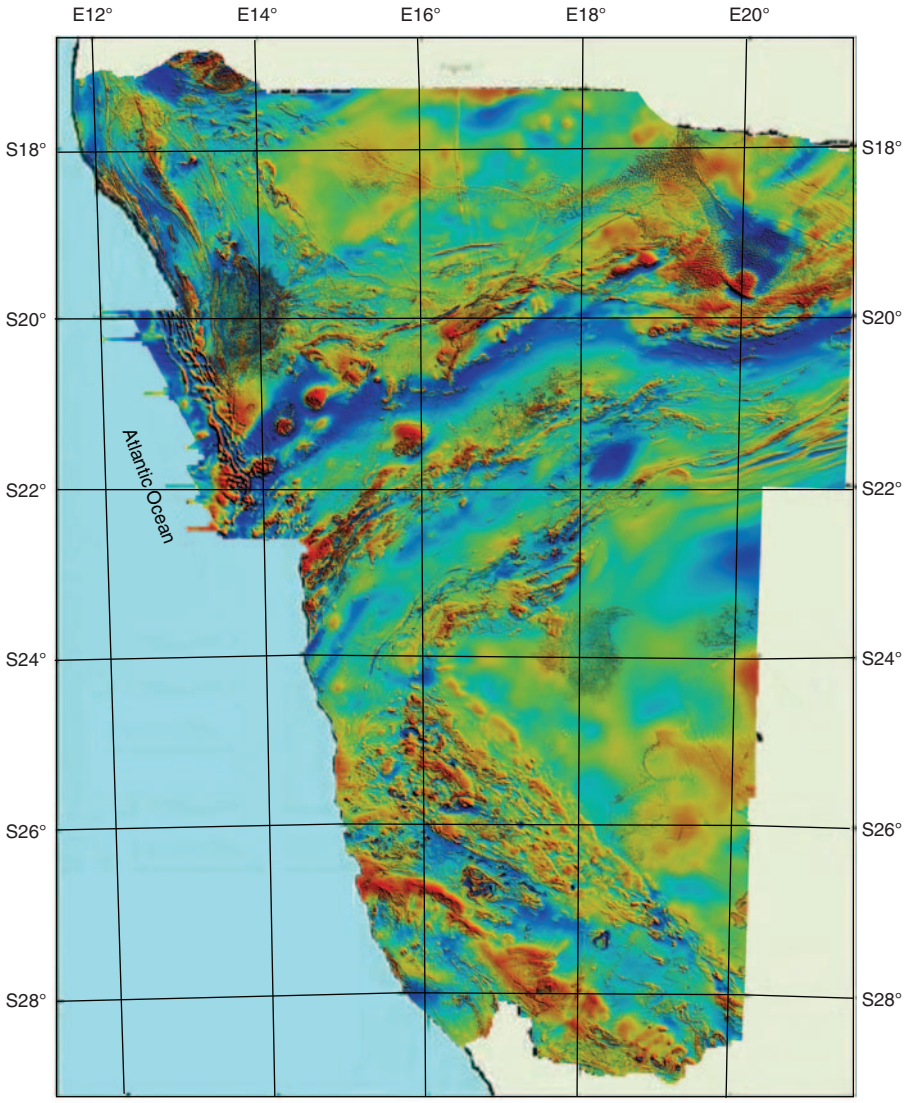


Figure 2. *Total magnetic intensity map of Namibia 4.4 million line km of data (1994–2011): a major contribution to the prosperity of Namibia.*

- Establishment of seismological and infrasound International Monitoring Station at Tsumeb on behalf of the Comprehensive Nuclear Test Ban Treaty organization (CTBTO) and the establishment of Namibian Seismological Network comprising 10 stations.
- Initiation and planning of a region by region integrated interpretation of airborne geophysical data commencing with the Karas Region, Namibia.

David travelled widely throughout the world to conferences and exhibitions promoting Namibia as a destination for exploration and mining investment. Numerous articles and papers attest to Dave's thoroughness. He also made excursions to the various contractors to check on data QC. His travels usually coincided with the latest Bowls Tournament or Cricket Test Match. His reply when this was brought to his attention was 'Now that's rather odd!!'.

Dave had the unique ability to combine business with pleasure, which could have been disconcerting to those who only saw one side of these attributes. His peers will relate (and exaggerate) many tales that seemed to have a common social theme. Nonetheless, Dave's easy going manner and apparent nonchalance belied his ability to navigate the politics of bureaucracy, contractors, and the nuances of a disparate audience. In no short measure is the exponential growth in exploration in Namibia due to the world class data sets available to the exploration community, orchestrated and driven by Dave.

In both Botswana and Namibia, Dave put in the structures to develop the qualifications of a healthy team of young geophysicists to continue the work initiated by him.

Dave's commitment to Namibia was illustrated by his becoming a Namibian citizen in February 1994.

Dave was also an avid Lawn Bowler who joined the Windhoek Bowling Club in 1987. From 1990 to 2005, Dave served on the Management Committee as President, Vice President (Competitions), Vice President (Club Affairs). Dave also served as President of the Namibian Bowling Association for 12 years. Unashamedly, Dave used his contacts with the mining community to sponsor tournaments, equipment purchase, and even club renovations. His laconic style made his requests difficult to refuse. Among many fund raising efforts, Dave initiated and raised funding for the Namibian Junior Bowls development, and travel funding for the Namibian team to World Championships.

Recently, Dave represented Namibia in the Men's Veterans competition against South Africa.

This understated man leaves behind a rich legacy in geophysical excellence. Dave will be missed by his extended family, the geophysical community, Namibian bowlers, and all those whose lives he touched.

Bob Timmins

ATSE Clunies Ross Award for Cathy Foley and Keith Leslie

Dr Cathy Foley

Leading Australian CSIRO physicist Dr Cathy Foley PSM FTSE and accomplished CSIRO engineer Keith Leslie are two of only five innovators honoured as Australia's foremost visionaries at this year's Australian Academy of Technological Sciences and Engineering (ATSE) Clunies Ross Awards. They have received a joint award honouring their contribution to Australia's scientific and economic prosperity through work that developed 'a highly sensitive magnetic device to detect ore bodies'. This technology has been responsible for discovering ore deposits with an estimated value of more than $10b globally and $4b nationally.

The select winners of the prestigious ATSE Clunies Ross Awards, Australia's premier innovation commercialisation awards, were honoured at a Gala Dinner at the Brisbane City Hall on 28 May. The dinner was attended by more than 500 eminent entrepreneurs, decision makers, government officials, researchers, academics and business leaders. Nobel

Keith Leslie

Laureate Professor Brian Schmidt AC FRS FAA gave the keynote address, which was focused on industry policy.

According to the Chair of the Awards' Organising Committee, Professor Mike Hood FTSE, 'ATSE Clunies Ross Awards are given to Australia's pre-eminent innovators who persist with their ideas to provide broad economic, social or environmental benefits. Dr Foley and Keith Leslie's collaboration and commitment to their individual roles in LANDTEM's development are part of a 25-year journey that has made LANDTEM the success it is today. Their story demonstrates the importance of unwavering dedication in bringing a scientific discovery to market. Over the coming years LANDTEM will continue to play a major role in the worldwide discovery of new mineral deposits.'

Cathy and Keith are continuing their award winning work, with a new focus that will significantly enhance the sensitivity and functionality of LANDTEM. They have also developed an improved version of the sensor electronics that will increase the depth of detection of ore bodies.

The select group of other 2015 ATSE Clunies Ross Award winners are:

- Associate Professor Jim Patrick AO FTSE, who received a Lifetime Achievement Award as one of the original engineers who pioneered the development of the multichannel cochlear implant.
- Associate Professor Leigh Ward, from the University of Queensland, who developed a standardised, specific, accurate yet inexpensive tool for early detection of lymphoedema – progressive swelling of a limb, a particular concern after cancer treatment. His device, which now has national and international acceptance, has led to improving quality of life, minimising long-term consequences for patients and significantly reducing treatment costs.
- Professor Zhiguo Yuan, from the University of Queensland, who developed a suite of innovative technologies to revolutionise the science and practice of integrated urban water management for Australian water utilities. 'Putting science in sewers' has fundamentally changed industry's understanding and practice for sewer corrosion and odour management, generating economic benefits in excess of $400 million.

The ASEG congratulates Cathy and Keith on their award.

Australian Academy of Science elects Malcolm Sambridge

Professor Malcolm Sambridge

The ASEG also congratulates Professor Malcolm Sambridge, Head of Seismology and Mathematical Geophysics at the Australian National University's Research School of Earth Sciences, on his election to the Australian Academy of Science in Canberra.

Malcolm Sambridge has made lasting fundamental contributions to the understanding of the Earth and its internal processes through new mathematical approaches to analysing complex geophysical datasets. His robust approaches to modelling diverse observational data – including statistically meaningful estimates of uncertainty – has had wide-ranging impact in geoscientific research. Malcolm's work has changed the way in which we analyse seismic waves for the structure of the Earth's interior, model landscape evolution, understand populations of mineral ages from isotopic microanalysis, and interpret infrared absorption spectra associated with hydrous crystal defects in silicate minerals.

The South African Geophysical Association's Biennial Conference and Exhibition 6–9 September 2015

Come September 2015, the hills will be alive with the sound of 'physics', geophysics to be more precise! The South African Geophysical Association's 2015 Biennial Conference and Exhibition will be, true to form, held in one of the most majestic locations South Africa has to offer, the Central Drakensberg. The Champagne Sports Resort, nestled in the foothills of the Drakensberg, below looming basaltic cliffs, will be playing host to this year's event.

The region has much on offer spanning interests from contemporary history and archaeology to fascinating palaeontology and geology. Derived from the Afrikaans name Drakensberge or 'Dragon Mountains', the original native name translates to 'Barrier of Spears', this analogy being most evident when viewed from the sprawling foothills. Reaching a height of 3450 m above sea level, the ~183 million year old flood basalt of the Drakensberg escarpment forms a cap to the Karoo Supergroup, one of the best and most complete sedimentary successions deposited during the Permian and Triassic Periods, a veritable timeline of paleontological evidence. To add to the plethora of treats on offer, a short drive north, plunging nearly 1 km off the face of the Amphitheatre, is the second highest waterfall on Earth, the Tugela Falls!

Join us for three days of comprehensive and in-depth talks, discussions and workshops, presented by the world's leading experts in all disciplines of geophysics. Delegates drawn from the private and public sectors of the mining and petroleum industries include geophysicists, geologists, hydrologists, consultants, geophysical contractors, software developers, geoscience researchers, mathematicians, academics as well as students. In alignment with SAGA's mission to foster and encourage the development of geophysics in South Africa, we are once again running our 'Adopt-a-Student' programme whereby delegates are afforded the opportunity to invest in our future geoscientists through sponsorship and mentoring.

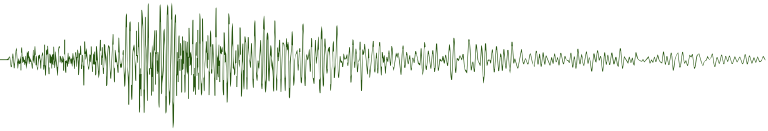
The conference features topics that matter most in modern geophysics including: Seismic Acquisition, Processing and Interpretation, Seismic Case Studies in Petroleum and Mineral Applications, Gravity and Magnetic Methods, Electromagnetics and Electrical Methods, Borehole Geophysics and Rock Physics, Case Studies Integrating Earth Science, Geophysical Modelling and Inversion, Mineral Exploration, Hydrocarbon Exploration, Mining Geophysics, Environmental and Engineering Geophysics, Groundwater Applications and Hydrogeology. There are also pre- and post-conference geological day trips and multi-day tours hosted by local experts.

The SAGA 2015 Committee is also proud to be hosting the Lalor Symposium at the conference. The Hudbay Lalor deposit is located in the Chisel Basin portion of the Flin Flon Greenstone Belt and is believed to be the largest VMS deposit found in this region to date. The discovery of Lalor by the HudBay team won the 2008 Bill Dennis Award for a Canadian discovery by the Prospectors and Developers Association of Canada (PDAC). The Lalor symposium will be chaired by Dr Dennis Woods (British Columbia Geophysical Society) and will feature a number of eminent geo-scientists who have worked on the Hudbay Lalor deposit. The geological and geophysical techniques employed to make the discovery will be reviewed.

We look forward to hosting you and your colleagues in the Drakensberg, a must-see destination! Please go to our conference website www.saga2015.co.za for more information and to register your interest.

Reece van Buren
Reece.VanBuren@CGG.com

The Drakensberg Mountains in profile.



Update on Geophysical Survey Progress from the Geological Surveys of Western Australia, South Australia, Northern Territory and Victoria (information current on 8 May 2015)

Further information on these surveys is available from Murray Richardson at GA via email at Murray.Richardson@ga.gov.au or telephone on (02) 6249 9229.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Coompana	GSSA	GA	GPX Surveys	7 Feb 2015	255 265	400 m 80 m E–W	85 910	31% complete at 8 May 2015	TBA	173 – Dec 2014 p. 24	TBA
Delamere/ Spirit Hills	NTGS	GA	TBA	Survey Quotation Request closed on 23 Apr	96 500 est.	400 m 80 m N–S	33 690	TBA	TBA	The proposed survey covers parts of the Fergusson River, Delamere, Victoria River Downs and Auvergne standard 1:250 k map sheet areas (Figure 1)	TBA
Yalgoo	GSWA	GA	TBA	Survey Quotation Request closed on 9 Apr	108 000 est.	100/200 m 50 m E–W	11 200	TBA	TBA	The proposed survey covers parts of the Badja, Thundelarra, Rothsay and Ninghan standard 1:100 k map sheet areas (Figure 2)	TBA

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Project management	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km^2)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Gippsland	GSV	GA	Atlas	30 Jun 2014	1440	12 traverses at 500 m station spacing	8358	100% complete at 21 Jul 2014	Final data expected to be released via GADDS before the end of 2014	170 – Jun 2014 p. 25	TBA
North McArthur Basin	NT	GA	Atlas	16 Sep 2014	7175	4 km regular grid with areas of 2 km infill; 1 area of traverses spaced 4 km apart with a station spacing of 1 km	71 030	100% complete at 4 Nov 2014	Preliminary final data were supplied to GA at the end of Nov 2014	171 – Aug 2014 p. 39	The survey covers all or part of Arnhem Bay, Gove, Mt Evelyn, Mt Marumba, Blue Mud Bay, Katherine, Urapunga and Roper River standard 1:250 k standard map sheets
Ngururrpa	GSWA	GA	Atlas	10 May 2015	5000	2.5 km regular grid	30 700	TBA	TBA	The survey covers parts of the Cornish, Lucas, Helena, Stansmore and Wilson standard 1:250 k map sheet areas (Figure 3)	TBA
Northern Wiso Basin	NT	GA	TBA	Survey Quotation Request closed on 12 May 2015	TBA	4 km regular grid with areas of 2 km and 1 km infill	83 240	TBA	TBA	The proposed survey covers parts of the Waterloo,Victoria River Downs, Limbunya, Wave Hill, Newcastle Waters, Beetaloo, Birrindudu, Winnecke Creek, South Lake Woods and Helen Springs standard 1:250 k map sheet areas (Figure 4)	TBA
SW Yilgarn WA	GSWA	GA	TBA	Survey Quotation Request closed on 23 Apr 2015	Up to 30 000	2 km along public roads and tracks	175 000	TBA	TBA	It is unlikely that the entire area will be surveyed in 2015. The minimum value of a contract awarded will not be less than $150 000 excl. GST (Figure 5)	TBA

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Musgrave Region	SA	GA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	The survey area is being defined in the north-west part of SA	TBA

TBA, to be advised.

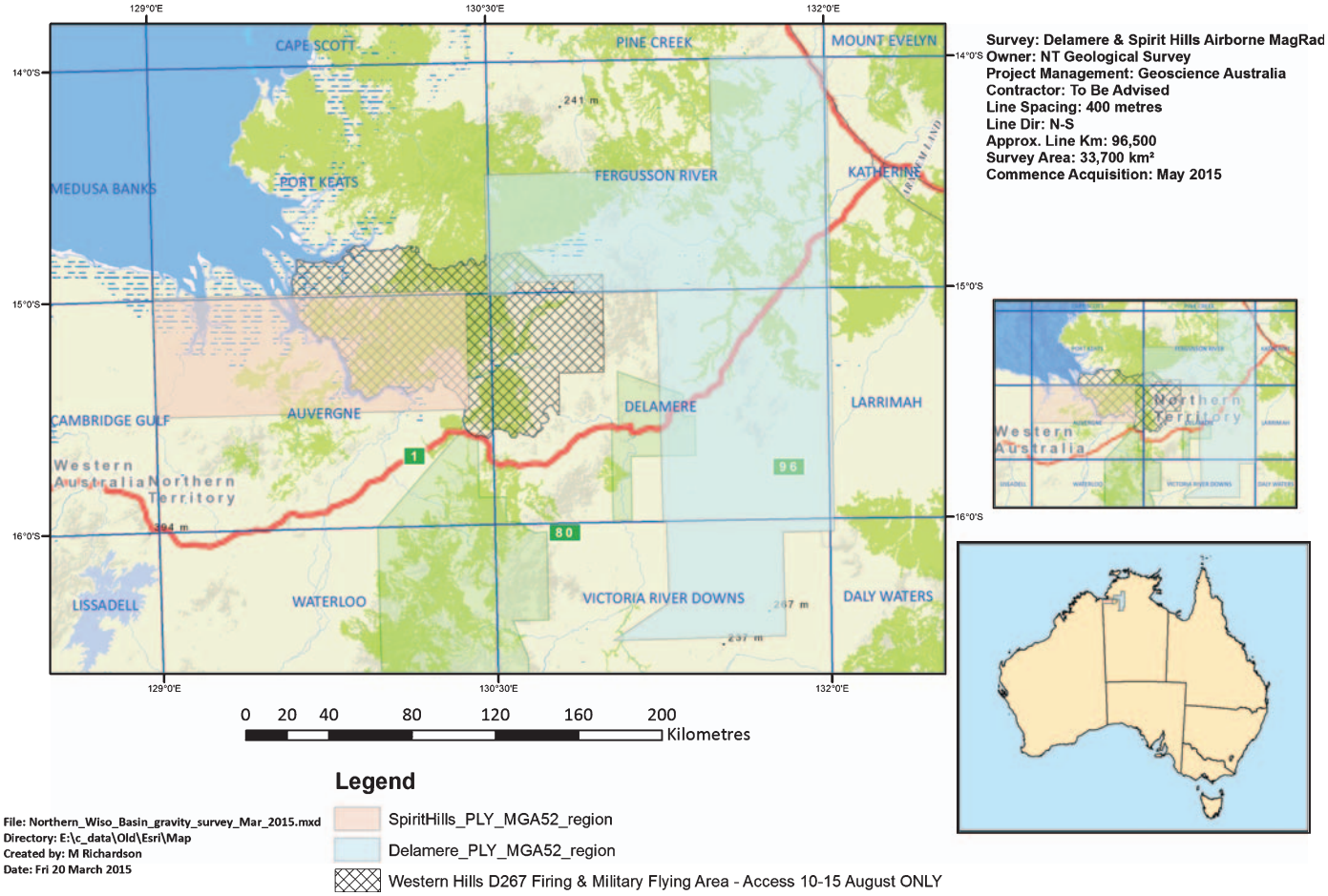


Figure 1. *NTGS Delamere and Spirit Hills magnetic and radiometric survey 2015.*

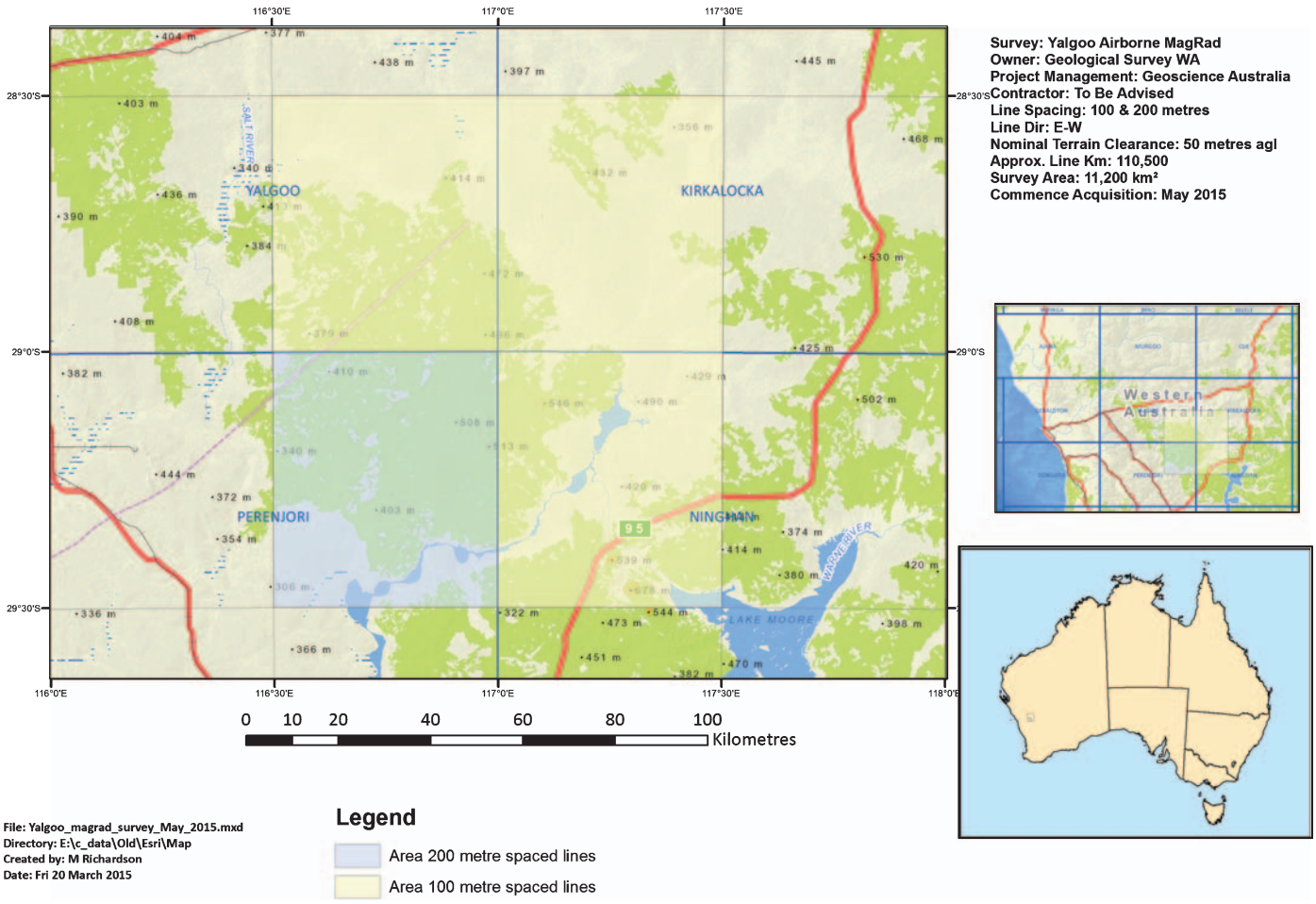


Figure 2. *GSWA Yalgoo magnetic and radiometric survey 2015.*

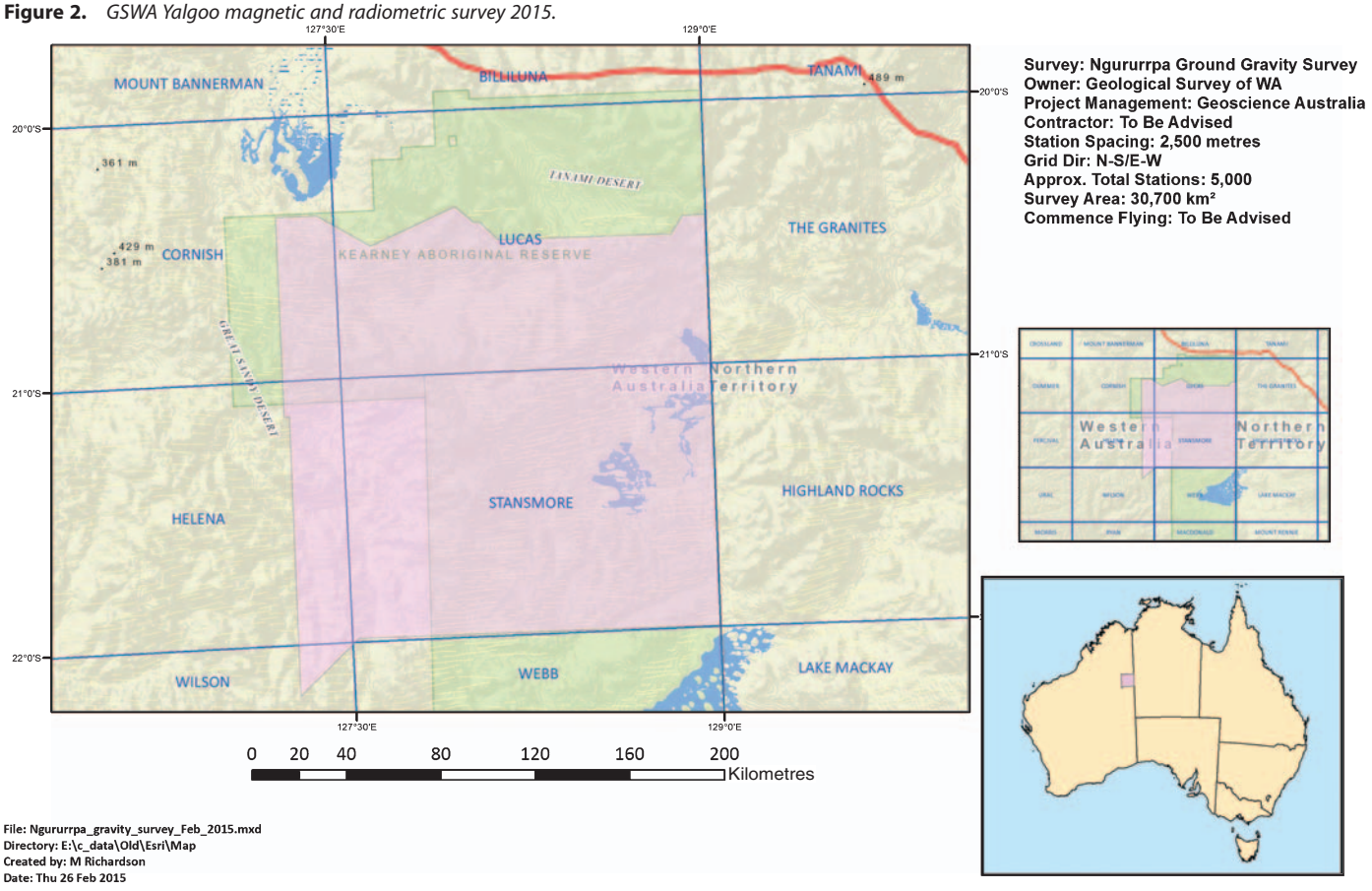


Figure 3. *GSWA Ngururrpa gravity survey 2015.*

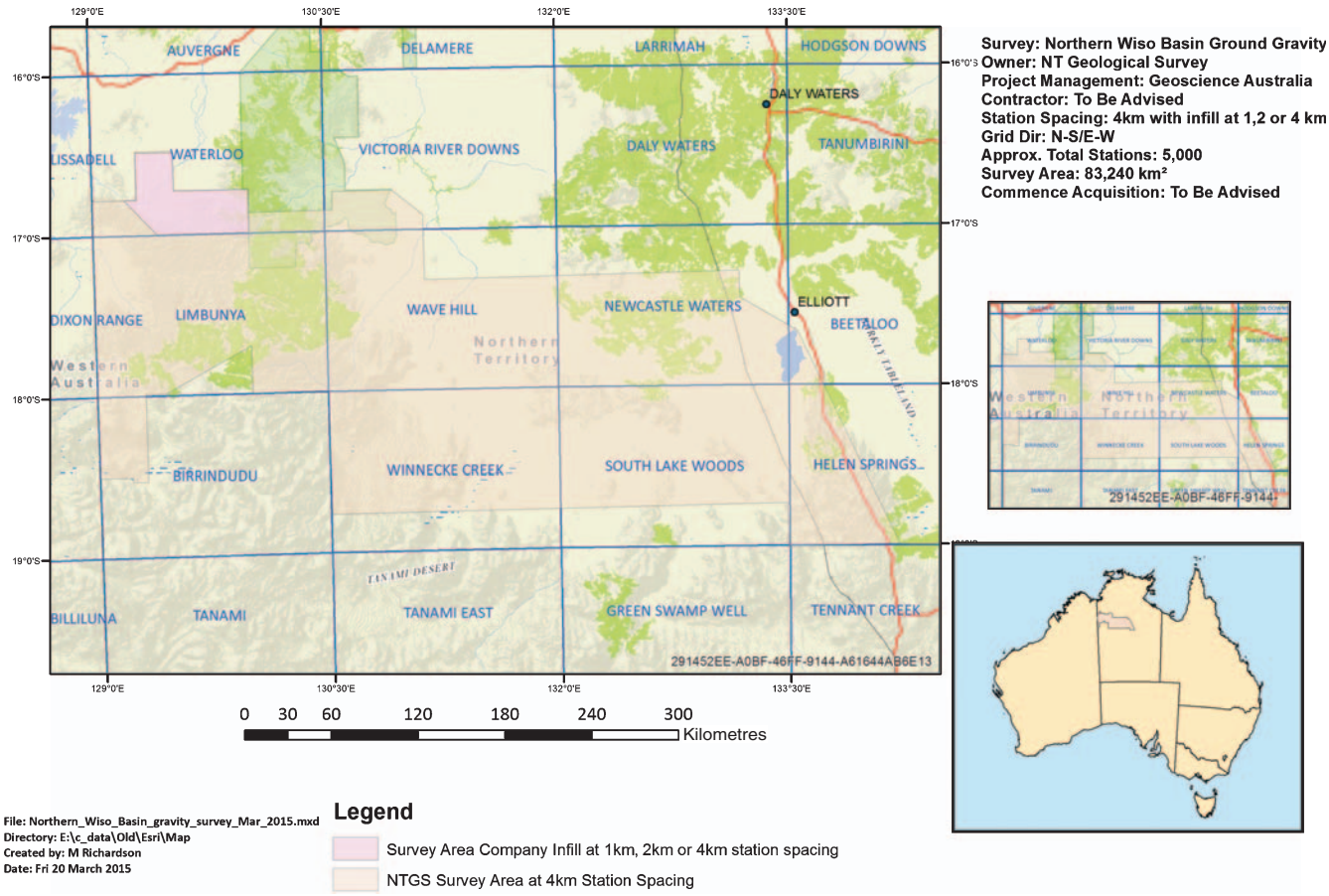


Figure 4. *NTGS Northern Wiso Basin gravity survey 2015.*

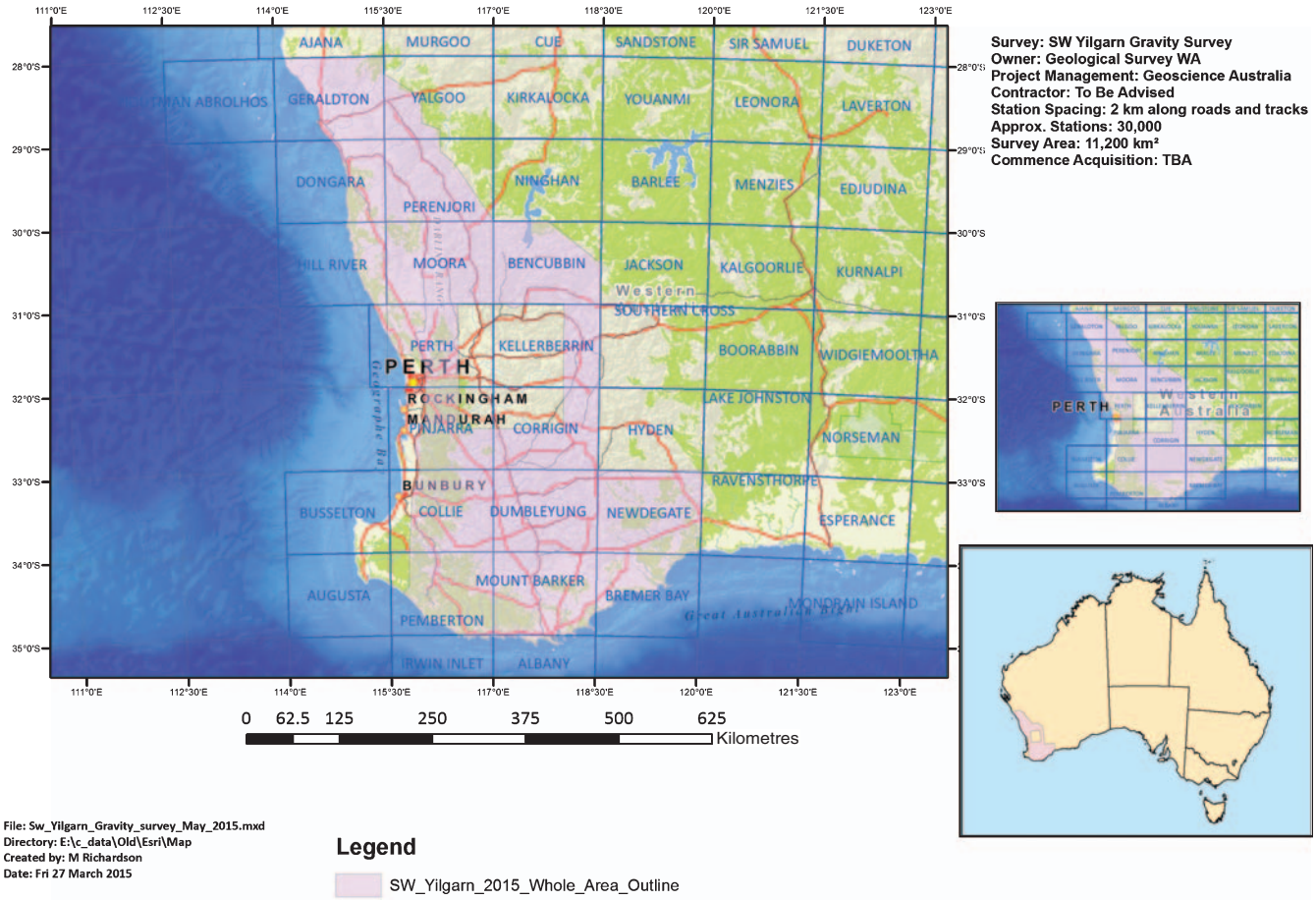


Figure 5. *GSWA Southwest Yilgarn gravity survey 2015.*

News

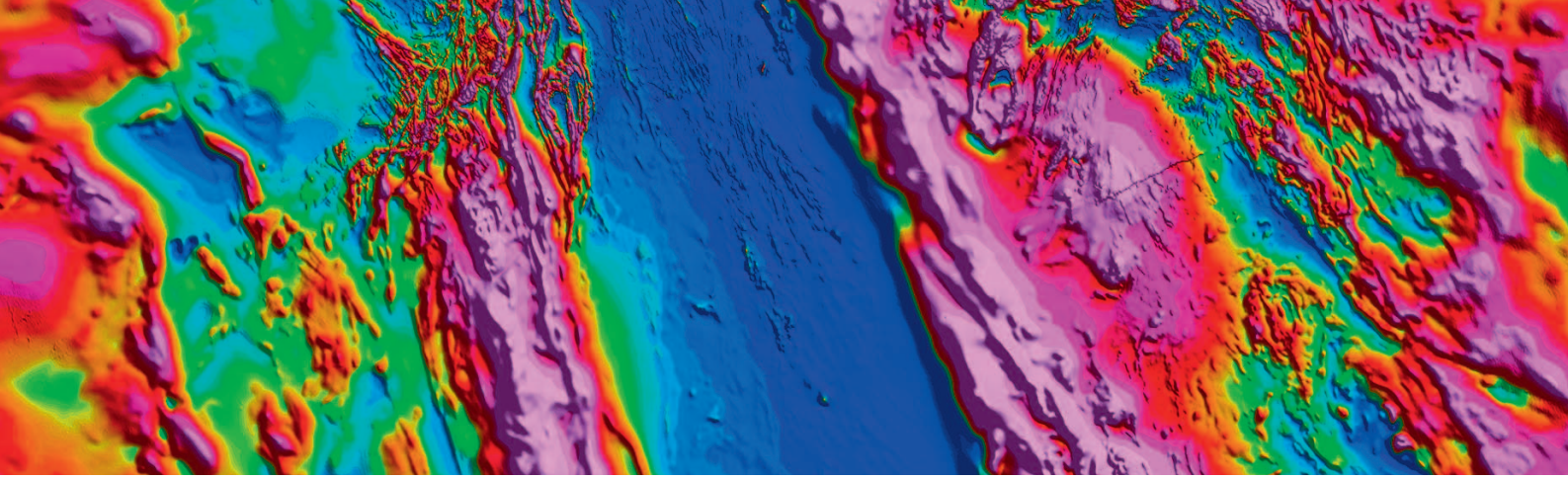
New gravity surveys in Tasmania

Mineral Resources Tasmania recently conducted a small campaign of gravity surveys, taking advantage of temporary opportunities to acquire data in areas that are likely to become significantly more difficult or impossible to access in the near future. All are of high exploration and geoscientific interest. A Lacoste & Romberg G meter (courtesy of the University of Tasmania) and Leica 1200 GNSS receivers (on loan from the Tasmanian Department of Primary Industries, Parks, Water and Environment, which also conducted the processing) were utilised. The Heazlewood and Magnet areas (Figure 1) were accessed on foot via tracks cut for MRT regional geological mapping during the previous field season. The thick rainforest of this region made for difficult differential GNSS data acquisition and processing, so LIDAR-derived high resolution digital elevation models and microbarometers were employed to provide additional constraints on station heights. The third area of MRT gravity surveying was by 4WD vehicle within the lease area of the Henty gold mine, which is currently scheduled for closure by the end of 2015, but is currently subject to ongoing exploration under joint venture arrangements. This survey was facilitated by Henty owners Unity Mining. GNSS data processing from these surveys had just been completed at the time of writing, with the resulting Bouguer gravity data to be released shortly.

Other recent significant additions to the Tasmanian gravity coverage are from two University of Tasmania Honours projects sponsored by MRT. The first was by Jie Yu in 2014 (featured in the December 2014 *Preview*) in the Mt Lindsay-Lynch Hill-Lake Pieman district, and the second survey was conducted by Will McAdam in late 2014 around the Mole Creek region (see also Figure 1).

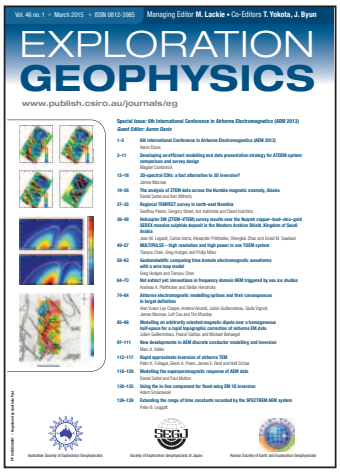
All the new data has been terrain corrected using the state 25 metre cell digital elevation model. Taken together, almost 900 new gravity stations will have been added to the state database and be publicly available via download from the MRT website by the time of publication. Contact Mark Duffett mduffett@mrt.tas.gov.au for details.

Figure 1. *The location of new gravity surveys carried out by Mineral Resources Tasmania.*



Exploration Geophysics

The Journal of the Australian Society of Exploration Geophysicists



Publishing excellent research, technical papers, case histories, advances in data interpretation and theoretical developments in applied geophysics.

Preview

The Magazine of the Australian Society of Exploration Geophysicists

News and reviews on the exploration industry, advances in geophysical techniques and communication among ASEG members.

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Science not a priority for the Federal Government in 2015

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Judging by its second budget, the Abbott Government appears to have little or no interest in any long term investment in the nation's science capacity and has applied short term band-aid measures wherever it can. The reason given is that it is waiting for the outcomes of the Research Infrastructure Review currently being undertaken by a six member panel headed by Phillip Marcus Clarke (Chairperson) and Ian Chubb (the Chief Scientist). In the meantime, I'll give you a couple of examples of the Government's short term approach.

NCRIS and the CRCs

The Government has provided $300 million over the next two years to fund the National Collaborative Research Infrastructure Scheme (NCRIS), which supports 27 research facilities and more than 1700 jobs. You may remember that the Education Minister, the Hon Christopher Pyne MP, threatened to cease funding NCRIS if the Senate did not pass his education reforms. NCRIS has been saved for another two years. However, Pyne has cut $300 million from the 'block' grants that support higher-education research and training at universities in order to fund NCRIS, so Peter is being robbed to pay Paul.

The budget papers show that the CRC (Cooperative Research Centres) Program will see its funding cut from $147 million this year to $130 million in 2017, although the forward estimates show a $167 million allocation in 2018. It is generally acknowledged that the CRC program has been very successful in bringing together researchers in business and industry to work on practical, real-world research solutions to complex problems. It is also recognised that Australia has one of the poorest records of business-university research engagement in the OECD. So it is a mystery why this program has been singled out for major cut-backs, particularly as the Government gave an earlier commitment to increase applied research with commercial potential.

The final report from the Clarke Committee is not expected until later this year, but I understand that one of the recommendations will be for the Government to implement a seven-year funding cycle for research, to be reviewed every four years. We will have to wait and see if this recommendation will be in the final report but, even if it is adopted, we all know that governments can easily change funding allocations if they feel the need.

While this uncertainty remains it will be very difficult to attract good researchers to Australia. Those who are working here at present are reportedly looking overseas for more stable funding situations.

One piece of good news is that $13 million of new funds have been provided to keep the synchrotron operating until 2017. Funds from the Victorian Government and the New Zealand Synchrotron Group also contribute to the operation of this machine.

The environment

The environment did not fare well in the budget. There are cuts to the Green Army of $73 million over four years. This money was originally taken from the Landcare program, which over the past two years has had funding cuts of almost $500 million. There are also cuts to water buy backs from the Murray Darling Basin of $22.7 million over two years from 2017–18. This could jeopardise the full implementation of the management plan for the Basin, which had bi-partisan support.

One of the few items of good news is that an extra $100 million has been allocated for initiatives aimed at protecting the Great Barrier Reef. So it's all not doom and gloom.

However, over the past two budgets, the Government has cut jobs and resources from the Environment Department and key agencies including the Bureau of Meteorology, the Director of National Parks, the Climate Change Authority, the Clean Energy Regulator, the Great Barrier Reef Marine Park Authority, CSIRO, Australian Renewable Energy Agency and the Clean Energy Finance Corporation. So perhaps we should not expect a big U-turn any time soon. One would have thought that a healthy environment and a reliable and sustainable water supply would be key planks to underpin all economic activity, but the Government appears to think otherwise.

Science Agency Funding

How well the national institutions fared in the Budget is a good measure of the health of the nation's science and technology capabilities. The table below provides a snapshot of how some of the main government agencies have been resourced from 2013/14 and what the forward estimates are through to 2018/19. Bear in mind that most numbers beyond 2016/17 are, at best, just guestimates. As we all know governments can re-allocate funds at short notice, particularly if unforeseen crises suddenly arise. And governments are adept at creating crises.

It can be seen that the Australian Institute of Marine Science fares well, presumably because the Government is starting to put more resources into managing the Great Barrier Reef.

ANSTO, the Australian Nuclear Science Organisation, has been given more money until 2016 so that the operation of the OPAL Nuclear Research Reactor and the Australian Synchrotron can be maintained until 2017. Funding will be reduced after that.

The Australian Research Council fares very badly with a fall in funding from $913 000 in 2013/14 to $780 000 in 2016/17. The National Health and Medical Research Council's funding is now more than the whole of the ARC's funding and, furthermore, the Government has committed $10 million to kick start the Medical Research Future Fund. This was the fund that was going to be funded by the GP co-payments. Well, money was found from somewhere to get it going and it is now reasonable to question whether the medical research component is out of balance with other research areas.

As for Geoscience Australia and CSIRO; you can see the numbers in the table.

GA's resource base gradually declines, but how much of this is due to the winding down of the search for MH 370 is not clear. In fact the budget papers are becoming more difficult to interpret every year. If you really want to know what is going on go to http://www.budget.gov.au/2015-16/content/pbs/html/index.htm and take a look at the portfolio statements.

Finally, a comment about CSIRO. It appears that the draconian cuts have stopped and it looks as though there should be some stability for CSIRO in the next few years.

Science Agency Funding

Agency	Resources ($M) and financial year					
	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
AIMS (Institute of Marine Science)	52	63	68	69	71	74
ANSTO (Nuclear Technology)	314	314	317	320	295	301
ARC (Research Council)	913	904	818	780	813	821
Bureau of Meteorology	346	357	348	349	312	308
Antarctic Division		171	158	141	141	141
Geoscience Australia		222	220	207	208	202
CSIRO	1305	1261	1277	1297	1303	1346
NHMRC	878	949	934	921	928	939
ABS (Bureau of Statistics)		396	489	601	410	396

The $20,000 tax break

One of the more interesting announcements in the budget was the temporary increase to the instant asset write-off, allowing small businesses to claim back purchases of up to $20 000. As many of our Members operate small businesses, I have summarised the main components of this offer.

Who is eligible?

Businesses with an annual turnover under $2 million can claim immediate tax deductions for all the sub-$20 000 purchases they make from budget night until June 30, 2017, rather than having to claim those purchases as deductions spread over several years. The instant asset write-off threshold used to be $1000. The Federal Government has allocated $1.75 billion to fund the scheme, which will run for the next two years. Businesses must be actively trading and will have to demonstrate ongoing activity via quarterly Business Activity Statements.

What's covered?

As Mr Hockey said in his budget night speech:

'If you run a cafe, it might be new kitchen equipment, or new tables and chairs.'

'If you're a tradie, it might be new tools or a computer for the home office.'

'Cars and vans, kitchens or machinery ... anything under $20 000 is immediately 100 per cent tax deductible from tonight.'

What's not?

Assets over $20 000 are not eligible for the instant tax write-off, but can be fully written off over a longer period. Any assets over $20 000 can be added together and depreciated at the same rate. These assets are depreciated at 15 per cent in the first income year, and 30 per cent per year thereafter. If the value of the pool is below $20 000 until the end of June 2017 it can be immediately deducted too. There are a few items not deductible, including some horticultural plants and any software developed in-house; but software purchased for business use can be claimed.

What else do you get?

In addition to the instant asset write-off, companies with annual turnovers of less than $2 million will have their tax rate lowered, from 30 per cent to 28.5 per cent. Unincorporated businesses, such as sole traders, partnerships and trusts, will also get a 5 per cent tax discount from July 1 up to $1000 a year.

What does this mean for you?

If you currently run or you are thinking of starting a small business it would seem that now is the time to invest in your business. Small business tax breaks may never be so good again!

What are the risks?

The Senate has to agree to these proposals. If the rush of people buying computers, laser printers and pretty much anything else a small business owner feels like buying is so large that $1.75 billion is not enough then the money may run out. So, get in early!

What are the consequences?

It is a great opportunity for everyone in a small business to improve their productivity. It will also be a great boost for China, Malaysia and Japan and any other country that exports goods to Australia. As a consequence the initiative may affect our terms of trade and make the dollar even less valuable.

Industry-student interaction a triumph for student interest and education

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The seismic services contractor Terrex Seismic recently hosted an education day and tour of their facilities for students from the Queensland ASEG branch and the QUT students' Natural Resources Society.

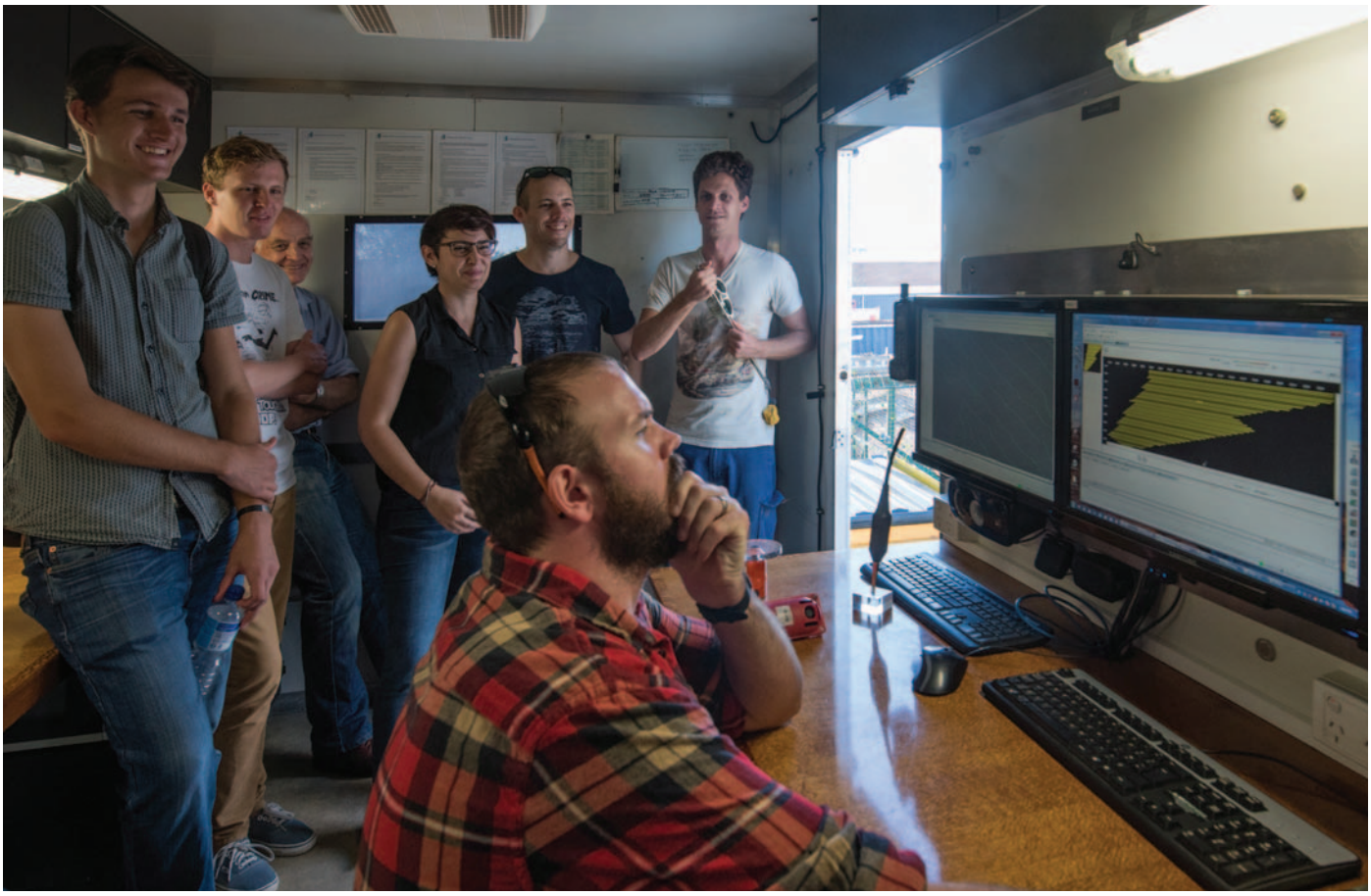
On 26 March a bus with 20 or so students arrived at Terrex's Banyo facility, to be met by Richard Barnwell, Senior Geophysicist at Terrex Seismic, with local ASEG representatives Lindsay Horn and myself.

The wonderful crew at Terrex Seismic showed us around their workshop and warehouse where they demonstrated their seismic vibrators, their geophones and showed examples of how that seismic data is recorded. After an enlightening presentation of seismic geophysics by Richard, helped out by Lindsay's experienced insight, we had a great, albeit loud, demonstration. The crew brought out one of their IVI Envirovibes and, without actually vibrating the plates, turned it on and showed us how this machine operated. We split up in groups and then took a tour through their Banyo facilities. Amongst the large fleet of vehicles and stockroom of equipment the tour came to a gravity meter demo. This was actually the first time a lot of the students have had the chance to see a gravity meter in action and with tutelage learn how to use it. After the gravity meter lesson we had a chance to view the survey equipment and understand the importance of accurate placement that finally ended with data acquisition and the recording processes. Their recording trucks in real-time detailed any seismic impulses and, when the sensitivity was increased for demonstration, it was especially interesting and educational to see a visible response from the receivers on-screen.

Overall the demonstrations were an eye-opener especially in regards to geophysics, seismic planning and acquisition, and how the data is recorded and processed. For most of the students it was their first time seeing the work that goes into acquiring seismic data, and I believe it firmly planted in us the idea of an industry that is crucial to exploration, energy and the resource industry.

The day was an excellent outcome flowing from opportunities generated when Kat Gioseffi (a second year student at QUT) and I (a then honours student at QUT) were awarded student bursaries to attend the ASEG-PESA Perth Conference last February, where we met up with Richard Barnwell at the Terrex Exhibition booth. This contact proved to be a highlight of our conference and led to opportunities to make some real connections in the geophysics and geoscience industry. The resulting students' day at Banyo, Brisbane, was the first time Terrex Seismic have done something like this, and with the help of ASEG we had a great opportunity in small partnership to introduce geophysics to the students and for them to make some contacts and actually see what it is our industry entails.

Students from QUT at the Terrex Seismic facility, Banyo, Brisbane.



Shaun Anderson of QUT monitors the truck-mounted seismic survey control centre, with students (from left) Matt Walker, Stephen Price, Katherine Gioseffi, Cameron McColl and Jimmy Recard learning about the operations. At back is local ASEG Branch representative Lindsay Horn overseeing operations.

Forthcoming lecture tours for professional development and continuing education

We have distinguished lecturers from both the SEG and the EAGE visiting Australia later this year. Check the ASEG Calendar, contact your local branch or Wendy Watkins (WWatkins@agl.com.au) on the ASEG Federal Executive for details.

Hansreudi Maurer, Professor of ETH Exploration and Engineering Geophysics at ETH Zürich, Switzerland, is the SEG's 2015 Near Surface Honorary Lecturer. His topic is *The curse of dimensionality in exploring the subsurface*, with particular application to tomographic inversions of 2D and 3D seismic data.

Professor Maurer writes:

'The term 'curse of dimensionality' refers to increases in the dimensionality of model spaces that result in undesirable increases in data sparsity, such that model parameters are no longer sufficiently constrained by the data. Although the term is usually employed in combinatorics, machine learning, and data mining, it is also directly relevant for many problems in exploration geophysics. The most obvious applications are 3D tomographic inversions, which typically include very large numbers of unknowns.

There is a further 'curse of dimensionality' and related data sparsity that may impede many geophysical investigations: 3D surveys typically involve the acquisition of data using only a 2D array of sensors distributed across the Earth's surface. As a consequence, procedures for imaging the subsurface are missing data recorded in the third dimension, depth. Similar problems affect 2D inversions of (1D) profile data.

Computational problems that need to be overcome in large-scale tomographic inversions are additional issues associated with the 'curse of dimensionality'. In particular, the rapidly emerging field of realistic 3D full-waveform inversions of elastic and anisotroic data is hitting the limits of current computer facilities. Seemingly ever increasing computing power will undoubtedly be beneficial for such endeavours. Nevertheless, suitable model parameterisations that offer appropriate spatial resolution while keeping the inversion problem computationally tractable will continue to be critical elements of any high dimension inversion endeavour.

Because of the large computational costs and the difficulties to cover extensive areas with geophysical sensors in complicated terrain, many land surveys continue to involve data acquisition along profiles. Such surveys will play a significant role for the foreseeable future. When solving the associated 2D inversion problems, the 'curse of dimensionality' strikes again. The underlying 2D assumption that subsurface properties and topography do not change in the third dimension, that is, perpendicular to the tomographic plane, is often unjustified.

The problem of data sparsity can be partially alleviated by employing optimised experimental design and optimised data parameterisation approaches. These techniques identify experimental configurations and data representations that optimise data information content and resultant models in a cost-effective manner.

In this lecture, I will illustrate the 'curse of dimensionality' by means of several examples from near-surface geophysics. I will present a variety of options for addressing the related problems, including experimental design techniques and optimised model parameterisation strategies. I will also discuss problems and remedies related to out-of-plane features in 2D elastic full-waveform inversions.'

Alessandro Ferretti, CEO of Tele-Rilevamento Europa, Milan, Italy, is the EAGE's visiting lecturer in its international continuing education and training program. His topic is *Satellite InSAR Data: Reservoir Monitoring from Space,* a one-day seminar in radar interferometry (InSAR).

Mr Ferretti has this to say about the course: 'Satellite radar interferometry (InSAR) is becoming a standard tool for monitoring surface deformation phenomena, but just a few people know the basic principles behind InSAR measurements. This EET course is intended as a guided tour of InSAR and its applications. It is *not* a course for radar specialists. It is an introduction for people who have a limited background in remote sensing, but who are interested in new technologies and in their applications. InSAR data can be used for subsidence monitoring, fault characterisation and calibration of geo-mechanical models in the oil and gas sector, for monitoring landslides, volcanoes and seismic faults and even for monitoring the stability of individual buildings. The number of applications of InSAR data is growing steadily. Therefore, it is worth spending some time to get to know what is actually behind the 'magic of InSAR', a technology capable of measuring displacements of just one millimeter on the ground from satellites orbiting the earth hundreds of kilometres above us.'

Registration for this course is via the EAGE website http://lg.eage.org/?evp=10266

The ASEG OzSTEP Courses for 2015 have been finalised. These are:

- Reservoir Monitoring/4D Seismic. Instructor Professor David Lumley, UWA (October 2015).
- Potential fields: a (re)introduction for geophysicists and geologists Instructor Dr Bob Musgrave, GSNSW (October 2015).
- AVO and Inversion. Instructor Brian Russell (November 2015).

Check the ASEG Calendar, contact your local branch or Wendy Watkins (WWatkins@agl.com.au) for details.

Australian Society of Exploration Geophysicists

Australian Specialist's Travelling Education Programme (OzSTEP)

4D Seismic Reservoir Monitoring

Date: October 2015

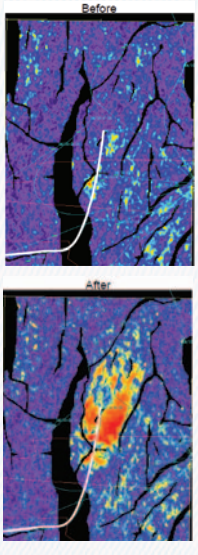
Who Should Attend: Managers and staff on development and production asset teams; geophysicists, geologists, and reservoir engineers; any others with a science or engineering background, including university students, who are interested in time-lapse techniques to monitor fluid flow in the earth.

Instructor: Prof David Lumley, UWA

David Lumley is a Winthrop Professor and Chair in Geophysics, jointly appointed to the School of Physics, and School of Earth & Environment, at the University of Western Australia (UWA). He is also the founding Director of the UWA Centre for Energy Geoscience research. Prof. Lumley has published 150+ refereed journal papers and expanded abstracts, and is the lead or senior Chief Investigator for over $130 Million in competitive research grants. He is a physicist with a focus on geophysical energy and environment applications, with prior research and operations roles in industry (including Chevron Research), and academic institutions (including Stanford University, PhD '95, and the University of Southern California). David has significant business owner experience as the Founder and Chief Scientist of 4th Wave Imaging Corp., a 4D seismic technology company purchased by Fugro in 2007. Prof. Lumley actively participates with international scientific societies such as ASEG, SEG and AGU, where he has served as a chairman and organizer of various scientific committees and workshops, and was elected as First Vice President of the SEG (2009-10) representing 35,000 members worldwide. David has served as an international Distinguished Lecturer for the SEG, SPE and AAPG societies, and has received several scientific honors including the first SEG Karcher Award for his "pioneering work in developing time-lapse 4D seismology" to image subsurface fluid flow. Prof. Lumley serves as an expert adviser to industry and government organizations, including the Western Australia state government for regional exploration and development of hydrocarbons, geothermal energy and CO2 storage, and the US National Academy of Sciences.

Course Outline:

This 1-day course is a practical overview of the most important theory, concepts and methods used in the modeling, design, acquisition, processing and quantitative interpretation of time-lapse 4D seismic data. Lecture topics include:



4D Seismic Pressure Anomaly

- 4D Rock and Fluid Physics, and various approaches to time-lapse 1D/2D/3D Seismic Modeling, to quantify how physical changes in the reservoir respond as changes in seismic data. This is useful for predicting the strength of the 4D signal, designing 4D seismic surveys and processing flows to enhance 4D signal and reduce 4D noise, and quantitatively interpreting 4D seismic data in order to estimate changes in reservoir properties such as fluid saturation and pore pressure.
- 4D Seismic Acquisition and 4D Processing techniques, to quantify non-repeatable 4D noise and suppress it, and to enhance real 4D seismic signal in the reservoir.
- 4D Quantitative Interpretation techniques to detect and analyze reservoir fluid flow anomalies, and to quantify them in terms of changes in pressure/saturation and other reservoir properties, using both qualitative and quantitative methods, including inversion.
- Monitoring aquifer drive and injected fluids such as water, gas, steam and CO2, locating bypassed hydrocarbons, identifying reservoir compartmentalization, and quantifying the hydraulic properties of faults (seals, leaks, baffles).
- Integration of 4D seismic information with geologic and engineering data to update the reservoir fluid flow model so that predictions of hydrocarbon recovery and fluid injection match the actual production data better ("4D seismic history matching").
- Time permitting… advanced 4D seismic topics including compaction, geomechanical stress, anisotropy, 4D FWI (full waveform inversion), passive and ambient noise seismology, 4D gravity.
- Many case study examples from around the world, both onshore and offshore, including primary depletion, water or gas injection, steam flood, and CO2 storage.

Australian Society of Exploration Geophysicists

Australian Specialist's Travelling Education Programme (OzSTEP)

Potential fields: a (re)introduction for geophysicists and geologists

Date: October 2015

Who Should Attend: geophysicists who wish to update/expand their appreciation of the use of potential field techniques; geologists who use gravity and/or magnetic data in mapping, exploration or interpretation (or who should do so!).

Instructor: Bob Musgrave, Geological Survey of New South Wales

Bob Musgrave is the Research Geophysicist with the Geological Survey of NSW. Bob graduated with a BSc (Hons) from the University of Sydney in 1981, majoring in geology and geophysics. Bob went on to complete a PhD (1987) at the University of Sydney in palaeomagnetism. Bob's interests in tectonics, palaeomagnetism and magnetic petrophysics led him through post-doctoral fellowships at Victoria University of Wellington (1987), the Australian National University (1988-89), and the University of Tasmania (1989-91). Bob went on to join the Ocean Drilling Program, based at Texas A&M University (1991-93), and to date has sailed on 5 ODP/IODP expeditions, the most recent in 2014. Returning to Australia, Bob was a Senior Lecturer in geophysics at La Trobe University until 2003. Bob was then a Senior Research Fellow at Macquarie University, before joining the Geological Survey of NSW in 2005. Bob is currently also a Conjoint Senior Lecturer at the University of Newcastle and an Honorary Associate of the University of Sydney. Bob's initial interest in palaeomagnetism has broadened over the years into a diverse range of applications, from magnetostratigraphic dating and tectonics, to magnetic petrophysics studies of hydrocarbon migration, gas hydrate accumulation, and the relationship of mineralisation processes to remanence-dominated magnetic anomalies. His work with GSNSW has emphasized applications of magnetic and gravity studies, including novel data filtering and presentation, long-wavelength interpretation and integration with passive seismic datasets, and joint magnetic and gravity inversion of complex tectonic settings. His research has yielded more than 50 peer-reviewed publications.

Course Outline:

Prerequisites: basic geology. No prior geophysical training is necessary, and the maths will be kept "light", so the course should be accessible to all geoscientists – but there will be the opportunity for more sophisticated discussion for those with established skills in geophysics.

Session 1 - Basics:

- Course overview and scope
- Basic form of potential field anomalies
- Data acquisition
- Scalar, gradient and tensor data. Earth's gravity and magnetic fields

Session 2 - Physical properties :

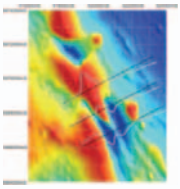
- Density and magnetic susceptibility
- Remanence
- Magnetic properties and mineralisation
- Microbes and magnetic diagenesis

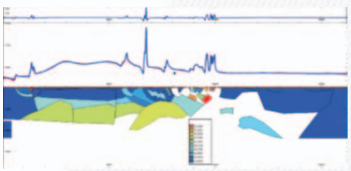
Session 3 - Data presentation and filtering :

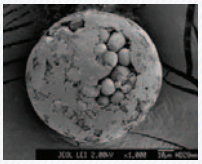
- Derivative filters; phase filters and the tilt filter.
- Edge analysis ("worming").
- Euler depths; spectral depths. Curie depth.
- Isostatic correction.
- Tensor and gradient data interpretation.

Session 4 - Potential field inversion :

- Source mapping; derivative maps; inferring lithology.
- Direct inversion, and its limitations.
- Geologically constrained inversion.
- Remanence and inversion.
- Case studies.







Australian Society of Exploration Geophysicists

Australian Specialist's Travelling Education Programme (OzSTEP)

AVO and Inversion Methods in Exploration Seismology

Dates: 2nd Nov (Perth), 4th Nov (Brisbane) and 6th Nov (Melbourne)

Who Should Attend: Geoscientists with a solid background in exploration seismology who wish to broaden their knowledge of AVO and inversion methods and their applications.

Instructor: Dr Brian Russell

Brian Russell graduated from the University of Saskatchewan (BSc) in 1973 with a major in physics, and received a BSc (Hons) (1975) at the same university, a MSc in geophysics from Durham University (1978), U.K., and a Ph.D. from the University of Calgary (2004), all in exploration geophysics. He joined Chevron as an exploration geophysicist in 1976 and subsequently worked for Teknica and Veritas before co-founding Hampson-Russell Software with Dan Hampson in 1987. Hampson-Russell is now a subsidiary of CGG, where Brian is Vice President, GeoSoftware and a CGG Fellow. Brian is involved in the development of new AVO, rock physics, inversion and seismic attribute techniques as well as presenting courses throughout the world. He is a past-President of both the SEG and Canadian SEG (CSEG) and has received Honorary Membership from both societies, the CSEG Medal and the Cecil Green Enterprise Award from SEG. He is currently Chairman of the Board of the Pacific Institute for the Mathematical Sciences (PIMS), an Adjunct Professor in the Department of Geoscience at the University of Calgary and at the School of Energy Resources at the University of Wyoming, and is registered as a Professional Geophysicist (P.Geoph.) in the Province of Alberta.

Course Outline:

- Part 1: The rock physics basis of AVO and inversion
- Part 2: Post-stack seismic inversion and wavelet analysis
- Part 3: Pre-stack inversion and AVO methods and case studies.
- Part 4: Azimuthal amplitude and velocity analysis for fracture determination.
- Part 5: Stochastic inversion methods.
- Part 6: Applications to unconventional plays.

Environment Geophysics

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Welcome to *Preview* readers this month. In this column Tim Munday from the CSIRO tells us about the application of geophysics to food and water issues in Western Australia. Tim is a Research Group Leader in the Discovery Program of the Mineral Resources Flagship as well as a Project Leader in the Land and Water Flagship. He has an interest in the application of geophysical technologies in addressing Australia's shallow cover issues, which by their nature have relevance to minerals and groundwater exploration (and is firmly convinced that the two are inextricably linked).

Water, food and geophysics: the West Australian way

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In the first of several articles I'll briefly review how and why the West Australia Government has embarked upon an extensive programme of geophysical data acquisition to help secure the State's water future. There are two primary drivers for this – one being a huge surge in demand from its mineral and energy resource sector in the past 10 years; the second being a response to projected increases in the State's population (2.4 million in 2014 rising to 6.4 million by 2061 (ABS 2013)), coupled with a recognition that Australia's population is also forecast to increase to ~48 million over the same period. This projected growth and associated global population rises will increase world food demand by >70% by 2050.

Here, I focus on activities linked to WA's *Water for Food* programme. This programme, funded through the State's Royalties for Regions initiative, is a $40 m programme aimed at accelerating understanding of regional groundwater resources whilst optimising pastoral tenure across the State. In large measure this effort builds upon the recognition that water is a key enabler for almost all of the WA's economic activities (www.water.wa.gov.au/Future+water/Water+for+growth/default.aspx). The *Water for Food* programme, extending from the Kimberley region in WA's north, to the Great Southern region in its south, is fast-tracking water investigations, creating the potential for new irrigation precincts and the expansion of agricultural and pastoral opportunities in regional Western Australia. The intent is to enable West Australia's fresh food and animal protein production to increase by at least 50% by 2020 and twofold by 2050. The challenge, for all involved, has been to deploy technologies that assist in delivering information on groundwater and aquifer systems in a spatially consistent and timely manner, in regional parts of the State where existing hydrogeological data is relatively sparse and/or limited.

To assist, the relevant State Departments, including the Department for Water (DoW) and the Department for Agriculture and Food (DAFWA), have set out to use hydrogeophysical methods, and in particular airborne electromagnetics (AEM), as a basis for characterising groundwater systems present in the key areas identified for development. To date, *Water for Food* regional AEM surveys have been acquired over the La Grange catchment, which lies between Broome and Port Headland; the lower Gascoyne River east of Carnarvon; and over the West Midlands area west of New Norcia. These surveys have involved the use of a combination of fixed-wing and helicopter time domain EM systems, with the survey design and system flown defined by the targets of interest and the scales at which resulting information is required. The 'targets' have included the extent and geometry of salt water intrusion along the coast; aquifer geometry; and the nature and spatial variability of groundwater quality. In all cases the results from the AEM data have been used as a framework for follow-up hydrogeological investigations.

In the lower Gascoyne region, DAFWA in collaboration with CSIRO, used helicopter AEM data to map attributes of the unconfined alluvial aquifer beneath and adjacent to the ephemeral Gascoyne River, concentrating on spatial variations in groundwater quality. The primary purpose of the project was to improve groundwater resource management along the reach of the river, from the Carnarvon township inland by some 50 kms. In particular, the aim was to use the AEM to identify additional groundwater resources

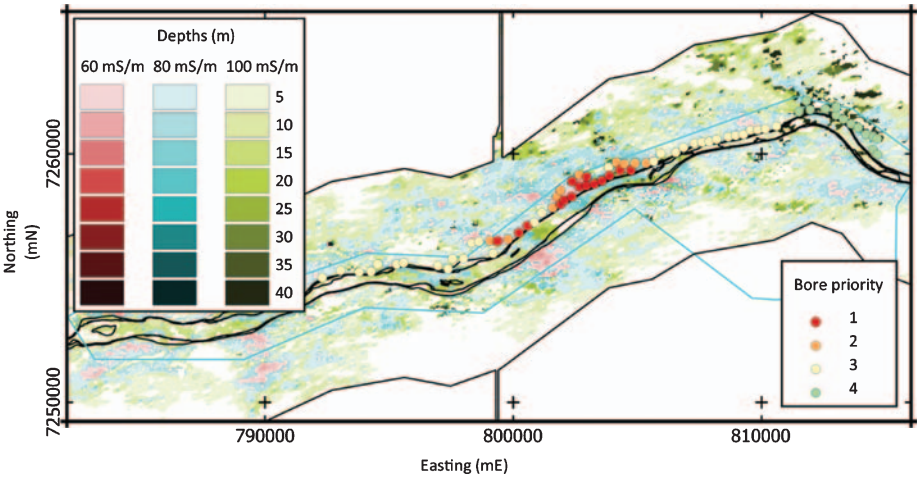

Figure 1. *Plan map of drilling sites and priorities determined from the interpretation of helicopter TDEM data. The priority sites are superimposed on a conductivity-contour depth grids derived from an inversion of the AEM data. In this study, sites only on the northern reach of the river (defined by the black lines in the centre of the image) were targeted. Other options for siting production bores remain on the southern bank (see Davis* et al. *2015).*

for securing and extending the current area of irrigated agriculture along the river. Information was required at a fine scale (vertical < 5 m, lateral < 150 m). The inverted AEM data provided drill targets (see Figure 1) close to the river, which were interpreted to represent zones of preferential recharge in flood events, and as sites where higher yielding sandy facies in the alluvium might also be present. As such, they are now targets for production bores intended to supplement irrigation development east of Carnarvon. This work is ongoing, and further information can be obtained from the DAFWA Project Leader: Dr Richard George (richard.george@agric.wa.gov.au).

References

ABS, 2013. 3222.0 – Population Projections, Australia, 2012 (base) to 2101. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/3222.0Main%20Features32012%20%28base%29%20to%202101?opendocument&tabname=Summary&prodno=3222.0&issue=2012%20%28base%29%20to%202101&num=&view=

Davis, AC, Munday, TJ, and George, RJ, 2015. Gascoyne River airborne electromagnetic survey III: Drilling Target Selection Report. CSIRO: Water for a Healthy Country Flagship Technical Report (EP-13-12-353).

Broadband: improving frequency content

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Broadband technology is used to increase the frequency bandwidth of seismic data using various acquisition and processing techniques. It should now be standard practice for all new seismic surveys.

For many years most interpreters and processers have worked together to try and boost the high frequency content of their data in a bid to get better resolution of seismic reflections. Broadband technology attempts to boost the low frequency content of the data, which is arguably even more important. In one of the many Joint Venture meetings I attended recently, one of the presenters displayed some new seismic lines and expressed surprise that the sections looked so much better when the low frequency content was only improved by a few Hertz – the low end went from 8 Hz to 4 Hz. This is not really a surprise. Frequency content is calculated in octaves and this new seismic had a full octave improvement. The 4 Hz extra at the low end is equivalent to improving content from 60 Hz to 120 Hz at the high end (4 Hz extra at the high end would hardly be noticed but at the low end its crucial). The old data of 8–64 Hz had a range of 3 octaves while the new data had a 4 octave range.

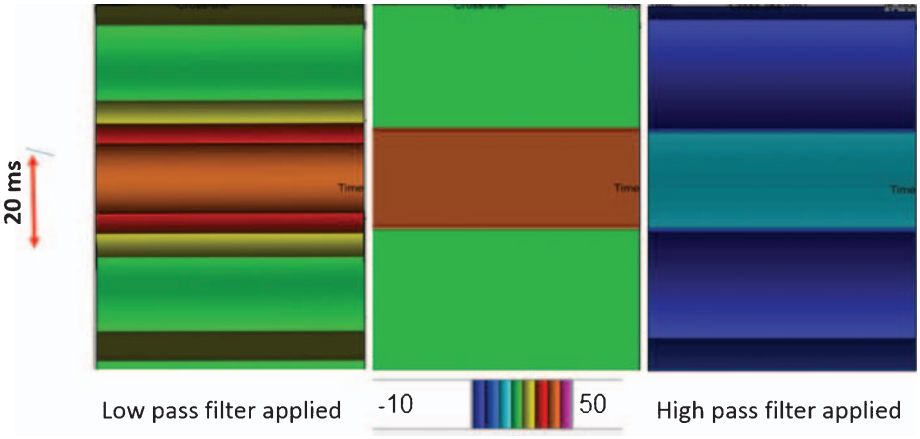

Figure 1. *Model of a 20 ms thick bed with low frequency (left) and high frequency (right) versions. The low frequencies preserve the amplitudes while the high frequencies retain information about the boundaries.*

But why is the low frequency so important?

Actually all frequencies are important but the low frequencies carry critical amplitude information and this is required for quantitative interpretation and characterisation of rocks and fluids associated with seismic reflections. Prior to the rise of broadband considerable effort was applied to creating a low frequency model of the missing 2–8 Hz (say) content for seismic inversion projects. Now we only have to model the 2–4 Hz range.

Figure 1 illustrates the respective benefits of low and high frequency content using a model of a 20 ms thick layer. The centre panel shows the input model with amplitudes shown in colour. On the left the model has a low pass filter applied and as you can see the peak amplitude in the layer (brown) and the amplitude of the background (green) are similar. But while the amplitudes are retained the thickness information is lost. The high pass filtered version of the model on the right retains the location of the top and bottom of the layer but the amplitude information has been lost. There is a trade-off between high and low frequency information – do you want amplitude or thickness information or do you want both?

Well, we have to work with the data we have, but if I had to choose I would opt for the low frequency end so that I could calculate accurate rock properties for reservoir characterisation. But I don't have to choose – with broadband technology I can have both.

Global drilling activity in the petroleum sector continues to decline

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Baker Hughes has issued the rotary rig counts as a service to the petroleum industry since 1944, when Hughes Tool Company began weekly counts of U.S. and Canadian drilling activity. In 1975 Hughes initiated the monthly international rig count. These counts are an important indicator, not only for the drilling industry and its suppliers but for the whole petroleum exploration industry.

The most recent results are plotted in Figures 1 and 2. Figure 1 covers the period 1975 through early May 2015 and Figure 2 shows an expanded plot for the period 2000 through early May 2015.

I am still surprised by the domination of the North American industry, in spite of the fact that petroleum exploration has been a global activity for many years. For example, in March 2015 the total global count is given as 2557 of which 196 were in Canada and a staggering 1110 in the United States 2015. In comparison, the Australian count usually varies between 15 and 30 per month. In March this year only 19 rigs were listed as being in operation. So there should be a lot of oil still in the ground ready to be

found and extracted, in both Australia and overseas.

As to be expected the correlation between the oil price and the number of rigs is very strong, but the time difference between the two curves has shortened significantly in recent years. In Figure 1 the price curve leads the rig count curve by about two years, but in the last seven years the time difference has been reduced to only a few months (see Figure 2).

The variability in the number of rigs operating is significant. During the Global Financial Crisis the numbers dropped from over 3500 to 2000 and the recent fall from the drop in oil prices was of a similar size (3700 to 2250). It must be very hard for the service industries to plan ahead for the purchase of new rigs and other exploration facilities in this somewhat chaotic economic environment.

There is clearly going to be an increase later this year, in both the oil price and the number of rigs operating. After the GFC the recovery period was about two years. It will be interesting to see how long it takes this time.

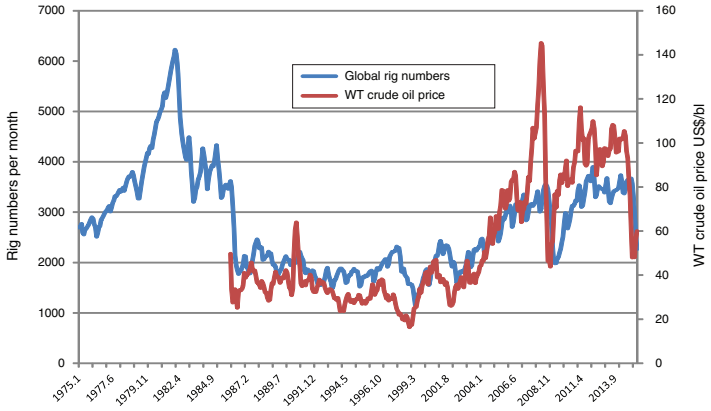

Figure 1. *Monthly global rig numbers and the oil price from January 1975 to May 2015. These are taken from the Baker Hughes rig count (see: http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountsoverview). The oil price is the monthly spot price for West Texas crude (http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M) and the price has been adjusted to May 2015 US dollars to correct for the US consumer price index (http://www.bls.gov/cpi/cpid1503.pdf).*

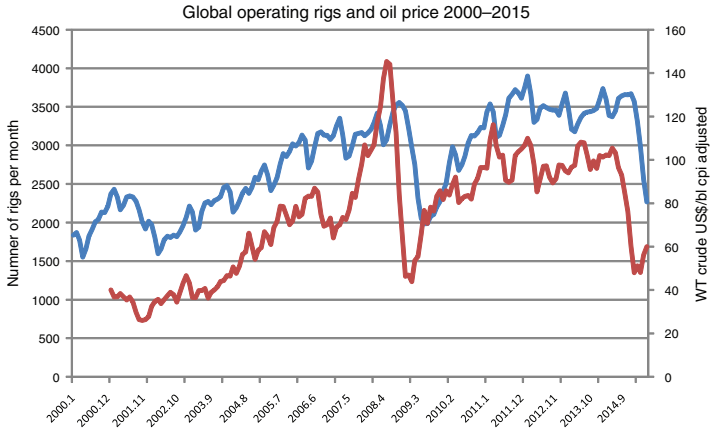

Figure 2. *Monthly global rig numbers and the oil price from January 2000 to May 2015. The caption is the same as for Figure 1.*

Seismic boats stacked

As a further indication of the downturn in the petroleum industry, PGS and Polarcus have announced they have cold stacked some vessels despite some robust multiclient sales.

Chief executive Officer Rod Starr commented that the current market environment can be best described as uncertain, while releasing the Polarcus first quarter 2015 financial results. In response to continued reduction and deferral of spending by oil companies Polarcus has stayed true to its 2015 agenda announced in February, 'this focus has included the difficult yet necessary decision to cold stack Polarcus Nadia at the end of the quarter', he said.

Jon Erik Reinhardsen, President and CEO of PGS said while announcing his company's first quarter results '…in adapting to the weak market we have decided to cold stack Ramform Challenger and Ramform Explorer after they complete this year's North Sea summer season'.

Perth Basin action

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The Perth Basin in Western Australia has been producing hydrocarbons for over 30 years and, despite the recent downtown, two recent announcements suggest that this Basin will continue to be productive.

On 6 May, Norwest Energy NL (ASX:NWE) reported their acquisition of the Arrowsmith 3D seismic survey has been successfully on time and within budget. Norwest will now commence processing and interpretation of the data.

The survey covered an area of106 km² within exploration permit EP413 between

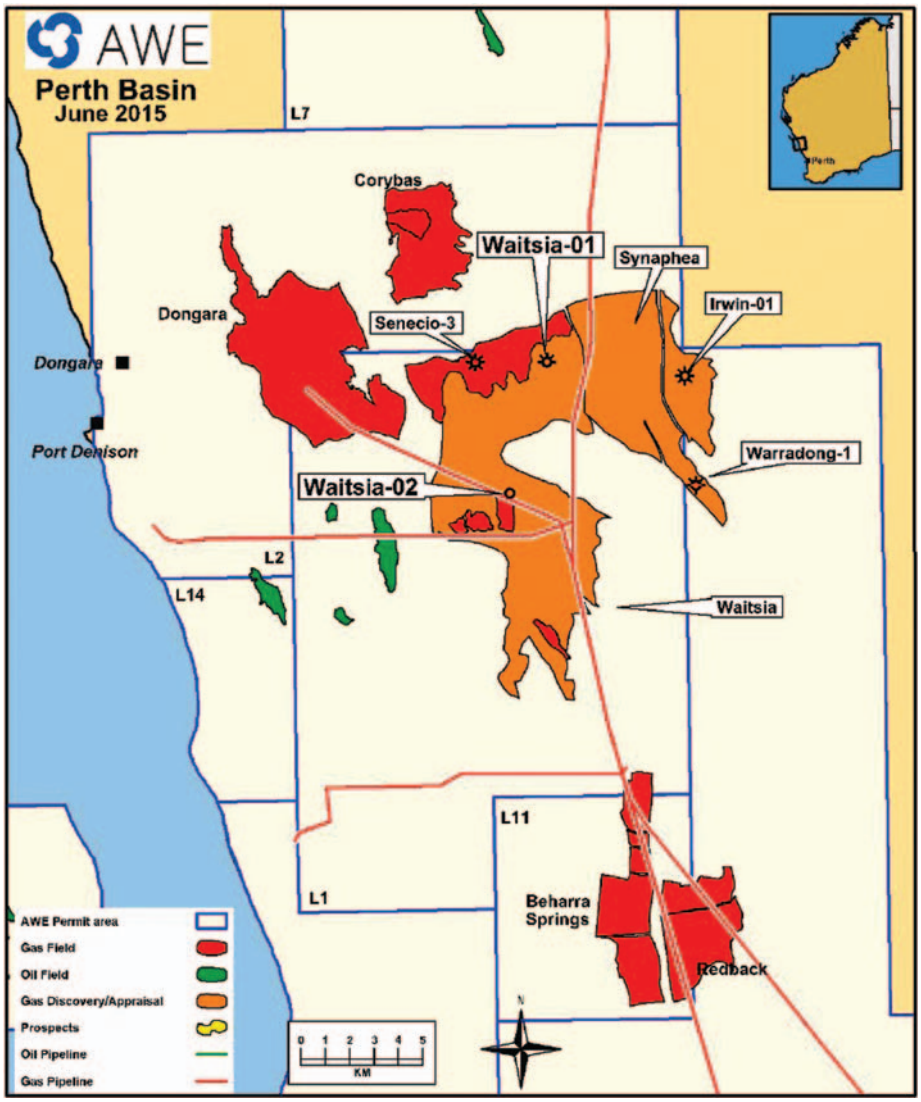

Figure 1. *Location map of Irwin-1 and surrounding wells and prospects.*

Eneabba and Dongara, 250 km north of Perth. The objective of the survey was to assess the extent of the resource surrounding the existing Arrowsmith-2 well location and to assist in defining the optimal location and target formation for Norwest's first horizontal well, Arrowsmith-3.

Vegetation rehabilitation will now commence and will include annual audits to demonstrate progress. Norwest is confident of meeting all rehabilitation milestones set by the various government agencies. The State offset requirement comprises funding to a value of no less than $200 000, triggered if after 5 years the Environmental Protection Authority determines significant residual environmental impacts remain. The Commonwealth offset requires an upfront unconditional provision of funds to the Department of Parks and Wildlife to purchase no less than 290 Ha of land with similar environmental values to the area cleared.

On 7 May 2015, AWE Limited (ASX: AWE) announced the initial results from the Irwin-1 exploration well, which is also located in the onshore Perth Basin. The well was drilled to a total depth of 4049 m and intersected the primary target Dongara/ Wagina sandstones at 3146 m. The Dongara / Wagina sandstone is a tight gas reservoir.

A 32 m gas column is indicated by wireline logs, sidewall cores and gas samples and an interpreted gas-water contact at 3085 m TVDSS. This contact is the same depth as interpreted in the Warradong-1 well located 4.6 km to the south which suggests the wells may have tested a single large gas accumulation. AWE estimates a gross 2C contingent resource of 15 Bcf of gas in the Irwin structure and 134 Bcf of gas in the neighbouring but possibly connected Synaphea structure located in the neighbouring permit L1. The portion of the Synaphea structure updip of Irwin-1 has not been drilled.

Irwin-1 also targeted the Kingia Sandstone which was found to be water bearing. This outcome was not unexpected as the Kingia was penetrated below the interpreted gas-water contact at

Table 1. Initial gross 2C Contingent Resource estimates for Irwin and Synaphea structures (ASX: AWE)

Fields/Permits	Reservoir Interval	Discovered Original Gas in Place (Bcf)			Contingent Resources (Bcf of gas)		
		P90	P50	P10	1C	2C	3C
Irwin (EP320, L1)	Dongara/Wagina	34	38	43	11	15	21
Synaphea (L1/L2, EP320)	Dongara/Wagina	282	330	387	101	134	178

Table 2. Initial net 2C Contingent Resource estimates for Irwin and Synaphea structures (ASX: AWE)

Fields/Permits	Reservoir Interval	AWE equity	AWE Share (Bcf of gas)		
			1C	2C	3C
Irwin (EP320, L1)	Dongara/Wagina	33% – 50%	5	7	10
Synaphea (L1/L2, EP320)	Dongara/Wagina	33% – 50%	50	66	88

Table 3. Initial net 2C Contingent Resource estimates announced to date for the north Perth Basin (ASX: AWE)

Fields/Permits	Reservoir Interval	AWE equity	AWE Share (Bcf of gas)		
			1C	2C	3C
Irwin (EP320, L1)	Dongara/Wagina	33% – 50%	5	7	10
Synaphea (L1/L2, EP320)	Dongara/Wagina	33% – 50%	50	66	88
Senecio (L1/L2)	Dongara/Wagina	50%	20	35	65
Waitsia (L1/L2)	Kingia/High Cliff	50%	33	145	585
		TOTAL net to AWE	**108**	**253**	**748**

Waitsia. However, the Kingia reservoir is thicker than, and of similar quality to, that in Waitsia located 8 km to the west. This confirms that the Kingia reservoir system is laterally extensive, as assumed in the assessment of the previously announced gross 2C Contingent Resource estimate of 290 Bcf of gas for the Waitsia field. Aquifer pressure measured at Irwin-1 also supports the interpreted mid-case gas/water contact for the Waitsia field.

The tables were included in the AWE announcement and indicate a significant 2C Contingent Resource in this onshore area only a short distance from Perth.

Feature Paper

Preface

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Which of the magnetic flux (induction, B) and the magnetic intensity (H) is fundamental and which is derived has been argued about in the literature for some time. Another dilemma is whether magnetisation (M) should take the units of B (Tesla) or H (Amps/metre). These issues are both dealt with in a recent article published by the Institute for Rock Magnetism (University of Minnesota) in the *IRM Quarterly* **24**, 4. The article goes one step further and proposes a new unit for magnetisation: the Néel. This is an important initiative and the article is reprinted, with permission, in this issue of *Preview*.

As there is a very small overlap of readership between the *IRM Quarterly* and *Preview,* reprinting was enthusiastically endorsed by the authors and the IRM, for which they are gratefully acknowledged. For those a bit rusty on B, H and M, a very readable article by Mike Jackson of the IRM can be found in *IRM Quarterly* **18**, 1. If I were to give a course on magnetism I would start with Mike's primer.

The *IRM Quarterly*, which is freely available at the address below, is always full of interesting 'hot off the press' research results, biographies, histories and essays on all kinds of magnetic phenomena: http://www.irm.umn.edu/IRM/quarterly.html

A new basis for the SI system of units: occasion to reconsider the presentation and teaching of magnetism

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The metric system of physical units, now formalised as the SI system (Système International d'Unités) began with the definition of the metre as one ten millionth of the distance from the pole to the equator along the meridian through Paris. Then, with the metre specified, the kilogram was defined as the mass of a cubic decimetre of pure water at 0°C and, with the second established as a specific fraction of the assumed constant duration of the solar day, the MKS (metre-kilogram-second) system became the basis of an international agreement on units. There have been numerous revisions of the system and its definitions, driven by demands for reproducibility and accuracy, incorporation of units for electricity and magnetism and making use of improvements in measurement techniques. For some time there were platinum standards for both the metre and kilogram, but now there is only one remaining material artefact, the standard kilogram kept in Paris. The need to supersede it has been recognised for many years and a change is imminent. A forewarning was recently published by the chairman of the CODATA Task Force on Fundamental Constants (Newell, 2014). It will be more dramatic than the earlier redefinitions of standards. Four fundamental physical constants, Planck's constant, h, Boltzmann's constant, k, the elementary electric charge, e, and Avogadro's number, N_A, will no longer be parameters with measurement uncertainties, but will become constants with defined values. A consequence is that some presently defined constants will be treated as measured parameters with attendant uncertainties. One of them is the permeability of free space, μ_0, presently defined as $4\pi \times 10^{-7}$ H m^{-1}, and we need to consider the implications of this for the magnetism community.

μ_0 is the coefficient relating the magnetic intensity, or flux density B, to the field strength, H, in a vacuum: $B = \mu_0 H$. Historically, the Gaussian electromagnetic system of units was used, with $\mu_0 = 1$ by definition and the numerical values of B and H equal in a vacuum, although their units were recognised

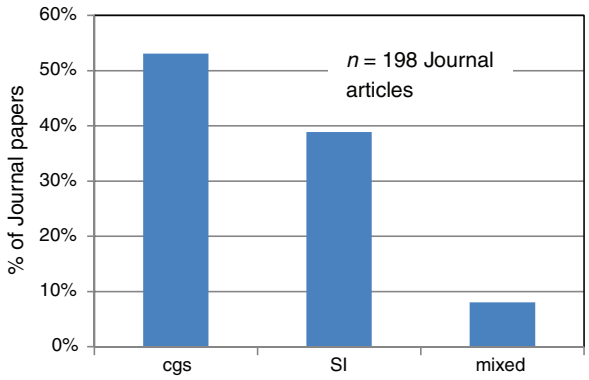

Figure 1. *Magnetism units used in several recent Physics and Engineering Journals. Data collected from the following journals: J. Magnetism and Magnetic Materials (v 384, 15-June-2015; vol. 382, 15-May 2015); Phys. Rev. B (vol. 91, no. 2, 1 Jan 2015, no. 6, 1 Feb 2015), Phys. Rev. B Condensed Matter/ material physics (91, No1 1 Jan 2015), J. Appl. Physics (vol. 117, Issue 17, 07 May 2015), and IEEE Transitions on Magnetics (Jan 2015).*

to be different, B in gauss and H in oersted. The difference becomes obvious when materials are involved and a value of permeability, μ, differing from μ_0 is required. The ratio, μ/μ_0, could be either slightly less than unity (for diamagnetic materials), slightly greater than unity (for paramagnetic materials) or, in the most interesting cases of ferromagnetic materials, much greater. A value for μ, or susceptibility $\chi = (\mu/\mu_0 - 1)$, was an immediately obvious indication of how strongly magnetic a material was. To retain that simple indication without the inconvenient and non-intuitive numerical values of μ in the SI system, some authors (e.g. Harnwell, 1938) wrote permeability as a product ($\mu\ \mu_0$), with μ, the relative permeability, coinciding with the definition of permeability in the Gaussian system. But many practitioners of material magnetism avoid these problems altogether by continuing to use the Gaussian electromagnetic units, oersted and gauss, which remain the practical units of the subject, sometimes with conversion to SI units for political correctness in publication. A brief survey of magnetic units used in 198 peer-reviewed papers in 6 physics and engineering journals published in 2015 shows that Gaussian units are still preferred over SI by magnetists outside the GP community (Figure 1). In addition, Table 1 shows the variety of units used in figures of hysteresis loops (M-H, B-H) within the same group of publications.

The electromagnetic unit system (emu) worked well in the restricted sphere of magnetic and electromagnetic studies, but did not include phenomena involving electric fields, for which a separate system of electrostatic units (esu) was used. The logical advantage of the SI system is that both are combined in a single comprehensive system in which μ_0 and the permittivity of free space, ε_0, are related by $(\mu_0\varepsilon_0) = 1/c^2$, where c is the speed of light, which, in both the present and proposed revised SI systems is a defined constant (as h, k, e and N_A will become in the revised system). This will give the individual parameters, μ_0 and ε_0, anticorrelated observational uncertainties, but for most purposes those uncertainties will be inconsequentially small (0.32 ppb, Newell, 2014). However, the formal uncertainty in μ_0, with the vacuum condition $B = \mu_0 H$, re-opens the contentious debate about the roles of the H and B fields in presentations of the magnetic properties of materials in general and rocks and minerals in particular.

When the rock magnetism community became constrained by the general adoption of SI units for all science, a quasi-political

Table 1. Labelling of hysteresis loop axes from published figures in several recent Physics and Engineering Journals

Magnetization axis Label	Field axis Label
Am^2/kg	T
Am^2/kg	A/m
emu/g	T
emu	T
emu oe/mole	T
A/m	kOe
J(T)	kOe
J(T)	μ_0H (T)
μ_0M (T)	A/m
moment/μ_B	T
moment/μ_B	Oe
G	kOe
Arbitrary	T, kOe, A/m

μ_0 = permeability of free space; μ_B = Bohr magneton; moment = not specified but presumably in the same units as μ_B; J = magnetic polarization, G(gauss), Oe(oersted), emu (electromagnetic unit), T(tesla), A (ampere)

division developed between H-fundamentalists and B-fundamentalists. To many of us who came into the subject from a Physics base, H is primary and B is a material dependent consequence, but others took an opposite view, treating B as fundamental. A third, agnostic, stance was to argue that, as long as μ_0 was regarded as a fixed constant of nature, with the vacuum relationship $B = \mu_0 H$, there is really no difference between the approaches, but that argument fails with μ_0 relegated to the status of an observed parameter with attendant uncertainty, however small that may be. A historical review of the B and H problem appeared in IRMQ **18**(1) (2008) and now is a good time to revisit it and initiate a discussion that may lead to a resolution of the problem of units applied to the magnetic properties of solids.

The philosophical significance of the change in unit definitions is summarised by Ampere's theorem, one of the fundamental bases of electromagnetism. It considers a loop l enclosing a total current i which is equated to the integral of the magnetic field around the loop

$$\int \boldsymbol{H}.\mathbf{dl} = i \qquad (1)$$

This equation is independent of the medium and variations in it on the path of the integral. In a vacuum it can be rewritten

$$\int \boldsymbol{B}.\mathbf{dl} = \mu_0 i \qquad (2)$$

but if the medium is not a vacuum, then a value of permeability differing from μ_0 is required. The simple case of homogeneous media represented by these equations makes it clear that the current causes H and that B is a consequence that depends on the medium. Eq. (1) is definitive for H, but it has not been used as such, because there is an independent definition of B and with $H = B/\mu_0$, and μ_0 a fixed constant, H could not have an independent definition. Definitions aside, Eq. (1) makes it difficult to avoid fixing the unit of H as A m^{-1} but this is rarely used. In the conventional SI presentation of magnetic properties the inconvenience of this unit, and its awkward conversion to

the practical units (oersteds) by the factor $4\pi\times10^{-3}$, has been a stumbling block to recognition that H is a primary field and has contributed to attempts to write it out of magnetism altogether in introductory physics textbooks (e.g. Tippler and Mosca, 2008; Halliday, Resnick and Walker, 2014) and to lose sight of the underlying basic physics. Crangle and Gibbs (1994) have proposed a variation of SI magnetism units that eliminates the usage of the H-field entirely (see Table 2).

B has been defined in terms of the force exerted by a field on an electric current or moving charge. A charge q moving at speed v in a direction perpendicular to B experiences a force F, in a direction perpendicular to the B-v plane, of magnitude given by

$$F = qvB \qquad (3)$$

As the defining equation for B, Eq. (3) can be rewritten in an equivalent form in terms of a current instead of moving charge without affecting the definition. This means that the dimensions of B prescribe its unit as newtons per ampere metre (N A^{-1} m^{-1} or kg A^{-1} s^{-2}), and named the tesla. But this is not the conventional interpretation. Rather, the tesla is seen as the unit of magnetic flux density, Wb m^{-2}, with the weber, the unit of flux, being the quantity of fundamental interest. The reason why B appears in Eq. (3) and not H can be seen by considering the force between two currents as the variation in their mutual potential energy with separation. Each current produces a field H, but its potential energy in the field of the other one depends on the magnetic flux crossed as it moves and therefore on a product of H and B fields. We return to this point below, in considering the definition of the ampere.

The conclusion that magnetic energy is a product of H and B is useful to an understanding of the nature of our units problem. To confirm its validity we can check the dimensions of the product $H\times B$, (A m^{-1})×(N A^{-1} m^{-1}) = N m^{-2} or J m^{-3}, that is, energy per unit volume. Conventionally magnetic energy per unit volume has been written as $B^2/2\ \mu_0$, but this is unhelpful to its application to magnetic materials and it is better recognised as $H\times B/2$, with the factor ½ invoking an assumption of linearity in the $B - H$ relationship, that is

Table 2. Comparison of Magnetism Units, Expressions and Values for Different Unit Systems

Symbol	Kennelly	Kennelly (Neel unit)	Sommerfeld	Crangle-Gibbs
	$B = \mu_0 H + M$		$B = \mu_0 (H + M)$	$B = B_0 + \mu_0 M$
H	[A/m]		[A/m]	none
B	[Tesla] ([weber/m^2])		[Tesla] ([weber/m^2])	[Tesla] ([weber/m^2])
B_o	---		---	[T]
μ_0	$4\pi x10^{-7}$ H/m		$4\pi x10^{-7}$ H/m	$4\pi x10^{-7}$ H/m
m(dipole moment)	[Wb m]	[Neel m^3]	[A m^2] ([J/T])	[J/T]
M(magnetization)	[T] ([Wb/m^2])	[Neel]	[A/m]	[J/T m^3]
σ (magnetization/mass)	[Wb m/kg]	[Neel m^3/kg]	[A m^2/kg]	[J/T kg]
χ (by volume)	[T m/A], [H/m] or [Wb/m A]	[Neel m/A]	dimensionless	[J/T^{2}m^3] or [m/H]
χ (by mass)	[Wb m^2/A kg] or [H m^2/kg]	[Neel m^4/kg A]	[m^3/kg]	[J/T^2 kg]
Saturation Mag. Magnetite (by volume) Magnetite (by mass)	0.6 T (0.6 Wb/m^2) $1.15x10^{-4}$ Wb m/ kg	0.6 Nl $1.15x10^{-4}$ Nl m^3/kg	480 kA/m 92 Am^2/kg	480 J/T m^3 92 J/T kg
Dipole moment of Earth	$1x10^{17}$ Wb-m	$1x10^{17}$ Nl m^3	$8x10^{22}$ Am^2	$8x10^{22}$ J/T
Bohr magneton	$1.165x10^{-29}$ Wb m	$1.165x10^{-29}$ Nl m^3	$0.927x10^{-23}$ A m^2	$0.927x10^{-23}$ J/T
NRM (basalt, by volume) NRM (limestone)	$1.26x10^{-6}$ T (1.26 μT) $1.26x10^{-10}$ T (126 pT)	1.26 μNl 126 pNl	1 A/m 10^{-4} A/m	1 J/T m^3 10^{-4} J/T m^3
χ_0 (MD magnetite, by vol) χ_0 (basalt)	$3\mu_0$ ($3.77x10^{-6}$ H/m) $10^{-3}\mu_0$ ($1.26x10^{-9}$ H/m)	3.77 μNl m/A 1.26 nNl m/A	3 10^{-3}	$3/\mu_0$ ($2.39x10^6$ J/T^{2}m^3) $10^{-3}/\mu_0$ (796 J/T^{2}m^3)
χ_0 (MD magnetite, by mass)	$7.25x10^{-10}$ Wb m^2/A kg	$7.25x10^{-10}$ Nl m^4/kg A	$5.8x10^{-4}$ m^3/kg	$10^{-4}/\mu_0$ (79.6 J/T^2 kg)
N (demagnetizing factor)	$0\le N\le 1/\mu_0$ [m/H]	$0\le N\le 1/\mu_0$] ([A/Nl m])	$0\le N\le 1$ (dimensionless)	$0\le N\le \mu_0$ [H/m]
μ (permeability)	$\chi+\mu_0$ ([H/m])	$\chi+\mu_0$ [Nl m/A]	$\mu_0(1+\chi)$ [H/m]	$1+\mu_0\chi$ (dimensionless)
Energy of dipole	MH [J/m^3]	MH [J/m^3]	μ_0MH [J/m^3]	MB_o [J/m^3]
Demagnetizing Energy	$(1/2\mu_0)$NM^2 [J/m^3]	$(1/2\mu_0)$NM^2 [J/m^3]	$(\mu_0/2)$NM^2 [J/m^3]	$(\mu_0/2)$NM^2 [J/m^3]
Néel Relaxation time	$\tau = \frac{1}{f_0}\exp\left[\frac{vM_sH_c}{2kT}\right]$		$\tau = \frac{1}{f_0}\exp\left[\frac{v\mu_0M_sH_c}{2kT}\right]$	$\tau = \frac{1}{f_0}\exp\left[\frac{vM_sB_c}{2kT}\right]$

Nl (Neel), Wb (weber), T (tesla), A (ampere), H (henry), J (joule), B_0=magnetic induction in free space (=$\mu_0 H$)

$$\text{Magnetic field energy} = \int B.\mathrm{d}H \qquad (4)$$

with the assumption $B \propto H$. In dealing with magnetic materials, we need this integral but must abandon the linearity assumption and consider the more general situation of a hysteresis loop. This is a plot of B vs H, so that energy is represented by area in the diagram and the area enclosed by a loop is the energy dissipation per cycle. This basic relationship is lost in the now common, but fundamentally and dimensionally invalid, practice of plotting two different versions of B. The phenomenon of hysteresis introduces an irrefutable argument that, at least in dealing with magnetic materials, H is the primary, causative field. The principle of causality disallows any effect that precedes its cause. As we commonly observe, B lags H. B is not causal but a consequence and the same applies to magnetization, M, which is a contribution to B, additional to $\mu_0 H$, a point that we return to. Table 1 lists the combinations of axis labelling for hysteresis loops found in a survey of recent papers. Confusion reigns!

There is another question arising from the energy argument implied by Eq. (3) that needs to be resolved in selecting units for magnetisation, demagnetising fields and demagnetising factors. The force on a current-carrying conductor depends on B and therefore so does the torque on a current loop. This means that the report by Whitworth and Stopes-Roe (1971), that the torque on a permanent magnet depends on H not B, appears as a paradox. Their magnet was not physically equivalent to a current loop. It means that magnetisation does not respond to a field in the same way as a current loop and must be recognised as a B field, interacting with H of the external field and not as an internal H field interacting with B of the external field. The unit of magnetisation must reflect this, with corresponding demagnetisation factors. It means that the conventional SI presentation (Sommerfeld system) of the relationship between B, H and magnetisation, M, that is

$$B = \mu_0 (H + M) \qquad (5)$$

is fundamentally flawed and the system needs to recognise the validity of the Kennelly system in which

$$B = \mu_0 H + M \qquad (6)$$

The point is that M is an addition to B and not an addition to H, as implied by Eq. (5). For hysteresis to make sense, a M vs H loop must represent energy, with M having the same dimensions as B. This is recognised in two major books on magnetism (Chikazumi, 1997, and Cullity, 1972[1]), although rather pointedly most of their data are presented in oersteds and gauss anyway. This leads us directly to a suggestion about the units for M.

Although it is dimensionally the same as B, it needs its own unit. In recognition of Louis Néel (1904-2000), who was awarded the 1970 Nobel prize in Physics for fundamental contributions to the magnetism of materials, we propose the Neel (Nl) as the unit for M. It is crucial to avoid writing the unit of M as A m^{-1}. Our choice of units and corresponding conversion factors are given in Tables 2 and 3.

Now we face the possibility of a circular argument involving the definition of the ampere, which is specified by the force between a pair of infinitely long parallel currents. If the currents, i, are equal and separated by a distance d then the force between them per unit length is

$$F/\,l = \mu_0\, i^2/\, 2\pi d \qquad (7)$$

with μ_0 necessarily involved because this force is the variation with d of the magnetic field energy ($H \times B$). In the revised SI system circularity of the argument will be avoided by referencing everything to fundamental constants, but this means that a dramatically new, simpler system of units could be developed. The revised SI units system will still be a patched up arrangement loaded with historical compromises. We will have 7 fundamental constants, including c, h, k, e, N_A, with values defined by what they happen to be in the existing system. They will each have 8 or more digits with high positive or negative powers of 10. Instead of having fundamental constants that are consequences of history we could produce a new set, redefined from scratch, to yield a system of units that have practical values, perhaps unrelated to existing units, that solve the problem of magnetic units and avoid residual illogicalities. In particular the mass unit, kilogram, is an admission that the primary unit is the gram with the mole in its wake and the prefixes micro-, milli-, mega- etc. thrown out of kilter. If such a new system becomes possible it will a very long term prospect and cannot be seriously addressed here. Our immediate aim is a minimalist resolution of the disruption to magnetism studies that has resulted from introduction of the SI system. We recommend the following:

- Rejection of Eq. (5) in favour of Eq. (6)
- Adoption of the Neel as the unit of magnetisation
- Consistency in plotting hysteresis loops (M-H or B-H) with the x-axis in units of the H-field (in A/m) and the y-axis in units of M (in Neel) or B (in Tesla). This means that measures of coercivity (H_c, H_{cr}, MDF) should be in units of A/m and not T or mT.
- Acceptance of self-demagnetising factors, $N = H_{demag}/M$, with $N_1 + N_2 + N_3 = 1/\mu_0$ for three orthogonal directions.

Table 3. New SI units and their Sommerfeld and cgs equivalents

Symbol	Sommerfeld	Conversion Factor[1]	Kennelly	Cgs unit[2]
	$B = \mu_0 (H + M)$		$B = \mu_0 H + M$	$B = H + 4\pi M$
H	A/m	1	A/m	$4\pi\ 10^{-3}$ Oe
B	Tesla	1	Tesla	10^4 G
m (dipole moment)	A m^2	μ_0	Neel m^3	$10^3/\mu_0$ G cm^3
M (magnetization)	A/m	μ_0	Neel	$10^{-3}/\mu_0$ emu/cm^3
σ (magnetization/mass)	A m^2/kg	μ_0	Neel m^3/kg	$1/\mu_0$ emu/g
χ (by volume)	--	μ_0	Neel m/A	$1/4\pi\mu_0$ emu/cm^3 Oe
χ (by mass)	m^3/kg	μ_0	Neel m^4/kg A	$10^3/4\pi\mu_0$ emu/g Oe

[1]*Multiply a number in Sommerfeld units by conversion factor ($\mu_0 = 4\pi\ 10^{-7}$) to covert to Kennelly units (e.g., 1 Am^2/kg = μ_0 Neel m^3/kg).*
[2]*Cgs unit conversion to Kennelly units (e.g., 1 Neel = ($10^{-3}/\mu_0$) emu/cm^3).*

[1]*It should be noted that in the second edition of Cullity (Cullity and Graham, 2008), the conventional SI system (based equation 5) is used.*

Difficulties in presenting magnetism in the SI system have been aired for many years (Stacey and Banerjee, 1974; Crangle and Gibbs, 1994; Moskowitz, 1995; Dunlop and Özdemir, 1997), but a solution to the problem has not been obvious, or not sufficiently obvious to lead to a generally acceptable resolution. It is essentially a question of units and the planned SI revision makes a revisit opportune. This note aims to provoke a clarifying discussion. To facilitate the process we have set up an online forum, which may be accessed through the IRM web site (www.irm.umn.edu), or directly at https://groups.google.com/a/umn.edu/forum/#!categories/magmeasure-peat/units.

References

Chikazumi, S. 1997, *Physics of Magnetism,* 2nd edition, Volume 94 of International Series of Monographs on Physics, Oxford University Press.

Crangle, J., and Gibbs, M., 1994, Units and unity in magnetism: a call for consistency, Physics World, Nov. 1994.

Cullity, B. D. 1972, *Introduction to Magnetic Materials,* John Wiley & Sons.

Cullity, B. D., and Graham, C. D., (Eds), 2008, *Introduction to Magnetic Materials*, 2nd edition, Wiley IEEE Press.

Dunlop, D. J., and Özdemir, Ö., 1997, *Rock Magnetism: Fundamentals and Frontiers*. Cambridge University Press.

Halliday, D., Resnick, R., and Walker, J. 2014, Fundamentals of Physics, 10th edition, Wiley.

Harnwell, G. P. 1938, *Principles of electricity and electromagnetism*. McGraw-Hill.

Moskowitz, B. M. 1995, Fundamental physical constants and conversion factors. In T. J. Ahrens, ed., *A Handbook of Physical constants 1: Global Earth Physics.* Am. Geophys. Un., pp 346-355.

Newell, D., 2014, A more fundamental international system of units.: *Physics Today*, (July), 35–41. doi:10.1063/PT.3.2448

Stacey, F. D., and Banerjee, S. K. 1974, *The Physical Principles of Rock Magnetism*, Elsevier.

Tippler, P. A., and Mosca, G. 2008, *Physics for Scientists and Engineers, 6th Edition*, W.H Freeman and Company.

Whitworth, R. W., and Stopes-Roe, H. V., 1971, Experimental demonstration that the couple on a bar magnet depends on *H*, not *B*.: *Nature*, **234**, 31. doi:10.1038/234031a0

The application of geophysics to the sport of cricket

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Dedicated to the memory of Vincent Kong, a great colleague and friend, whose inquisitiveness encouraged us in our endeavour.

Introduction

Over the years interest in sports science has boomed with current research in using technology to monitor athlete performance and the motion of balls or other equipment during a game, for example the tracking of golf swings or ball bounces to improve umpiring decisions. The contribution of geophysics to sport is, as far as we have found, only indirect at best (searching within the SEG cumulative index yielded no relevant results). In this paper we detail how we have applied geophysics directly, in particular the seismic method, to the sport of cricket.

Cricket

The game of cricket is relatively straightforward. A *batsman* uses a wooden bat to defend a set of three wooden *stumps* at one end of a *pitch* (ideally made from heavily compacted grass) while a *bowler* attempts to knock them over by bowling a hard leather ball from the other end of the pitch. The batsman aims to hit the ball in order to acquire *runs* without the ball being caught in-flight by a *fielder*. Although the ball can be bowled so that it doesn't bounce on the pitch it typically bounces, or 'pitches' on the pitch before it reaches the batsman. As the combined width of the three stumps is only 22.9 cm and the pitch is over 20 m long, accurate bowling is very important. A fast bowler can bowl the ball at between 135 and 150 km/h, making it extremely difficult to judge with the naked eye where the ball has pitched. Determination of the accuracy of a bowler requires the ability to plot a 'pitch map' showing where each ball has bounced. Such ability is currently offered by a television-based system called Hawk-Eye, which employs six or

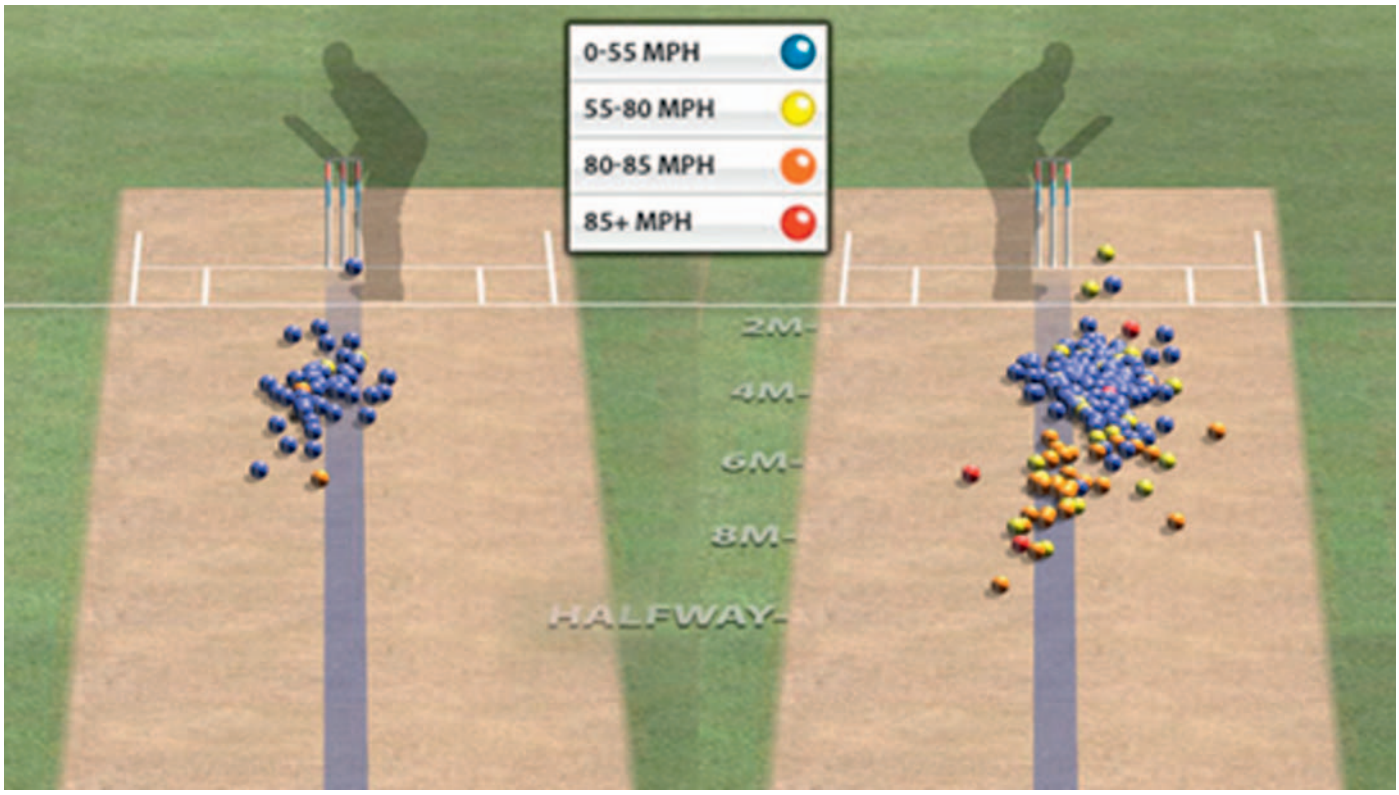

Figure 1. *'Hawk-Eye' pitch map from a match between Australia and Sri Lanka in 2012. Downloaded from www.cricinfo.com.*

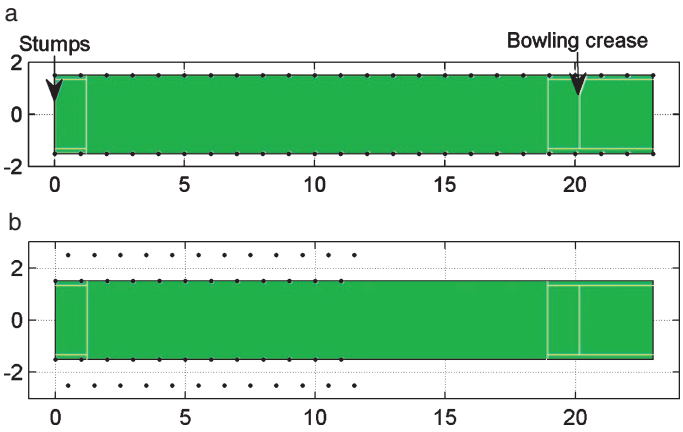

Figure 2. *Diagrams of the layout of our spreads. Each black circle is a geophone position. All distances are in metres.*

seven high speed cameras placed at different angles to track the ball (Figure 1). Unfortunately this system is expensive, often prohibitively so, even for international professional competitions. In this paper we describe the use of a small, low-cost, seismic recording system to determine where a ball has pitched.

Experimental setup

Our initial layout consisted of two lines each of 24 geophones placed either side of the pitch (Figure 2a and Figure 3a). The inline spacing was 1 m and the cross-line spacing 3 m (the width of the pitch). After analysing the results we found that this layout did not have sufficient cross-line sampling to give an accurate cross-line position so we altered it to have four lines

Figure 3. *Photos of the (a) initial and (b) improved layouts. The positions of some of the geophones are indicated by red arrows.*

Figure 4. *(a) Photo of the 'calibration' test with the thrower in the foreground, the target area is between the two red cones. Tests acquired with (b) a bowler and (c) batsman and wicket keeper.*

each of 12 geophones, two either side of the pitch. The lines within each pair were separated by 1 m with an inline separation of 1 m. The two lines were offset in the inline direction by 0.5 m (Figure 2b and Figure 3b).

To determine the accuracy of our method we acquired a 'calibration' test where the ball was thrown at a known target placed on the pitch (indicated using small plastic cones, Figure 4a). For this test the acquisition system was triggered manually but for later tests involving a bowler (Figure 4b) plus both a batsman and wicket keeper (Figure 4c) the system was triggered by the bowler stepping on a piece of wood placed over a geophone. When the ball was being bowled an observer noted where the ball had pitched and this was recorded for comparison with the position estimated from the seismic data.

Processing

When the ball hits the ground it creates a small seismic wave that propagates through the ground in all directions and whose shape in the x-y-time domain is a cone. If we can successfully fit a cone to the recorded data we can infer that the apex of the cone is the position and time at which the ball pitched. The first stage in processing the data was to pick the first breaks. This was done using a simple cross-correlation method, with each trace being correlated with the trace having the strongest amplitude (i.e. that closest to the pitch of the ball). We then fitted a cone to the time picks from traces with an amplitude above a certain threshold (to avoid using traces too far from the pitch of the ball) using unconstrained nonlinear optimisation.

Results

An example record from the calibration test is shown in Figure 5 (the geometry corresponding to this record is shown in Figure 6). The impact of the ball is clearly evident and the hyperbolic nature of the first-break picks indicates that we should be able to identify the pitch of the ball accurately using a conic fit. The results from the calibration test for three different targets are shown in Figure 7. The scatter of the points is affected by the skill of the thrower as well as the uncertainties of the pitch estimation. Overall, however, the pitch of the ball has been estimated correctly to within ±0.1 m (the distance between the pitch estimate and the target). The target near the end of the pitch (the black points) has a larger spread of results as there are insufficient picks on one side of the cone for an accurate fit.

Figure 8 shows the results from the tests where the ball was being bowled, each line connects the 'actual' (we only had an estimate of the position to within ±0.5 m) position with that estimated from the seismic data. The average position error is just over 0.5 m and, given the accuracy of the calibration tests, it is likely that the seismic-derived position is more accurate than that estimated by the observer.

As seen in Figure 9 the presence of a batsman does not affect the success of the algorithm nor does the batsman running down the pitch or the ball landing on the pitch after being hit by the batsman.

Conclusions

A 48-channel seismic acquisition system, coupled with basic processing, proved effective in locating the position at which a cricket ball impacted the pitch with an accuracy of ±10 cm. This method offers the ability to create 'pitch-maps' at a fraction of the cost of television-based systems. We hope that this work will encourage others to look for other ways in which geophysics can be applied to sport.

Acknowledgements

The authors thank Nader Issa for his assistance with the initial test and for reviewing the paper and Aimé Fournier for help with the processing algorithm.

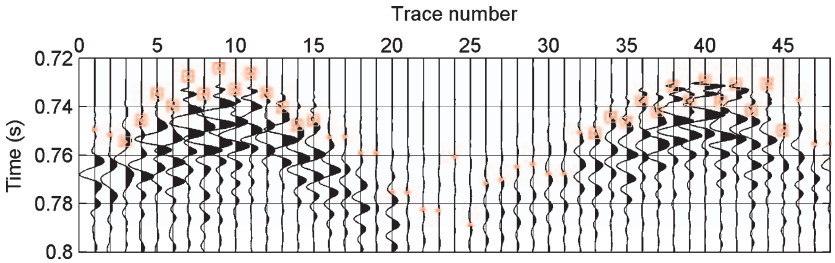

Figure 5. *An example record from the calibration test. The red dots are the first-break picks, the red boxes indicate those picks that were used to determine the pitching position.*

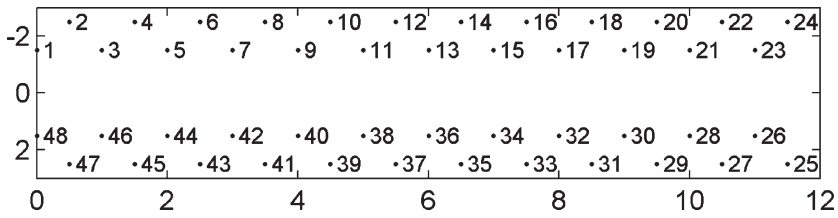

Figure 6. *The geographical position of each trace shown in Figure 5 and Figure 9.*

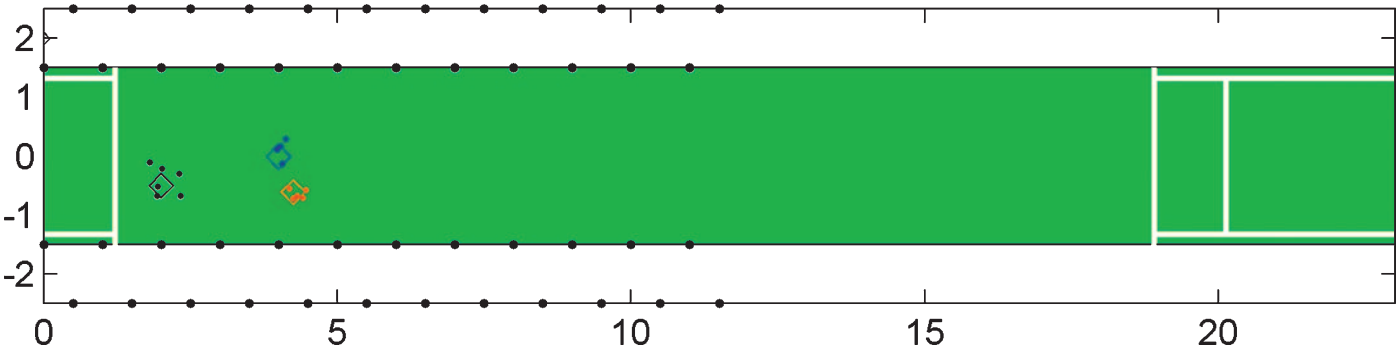

Figure 7. *Results from the calibration test. The position estimated from the seismic data is shown by a coloured point and the actual pitching area by a diamond with corresponding colour.*

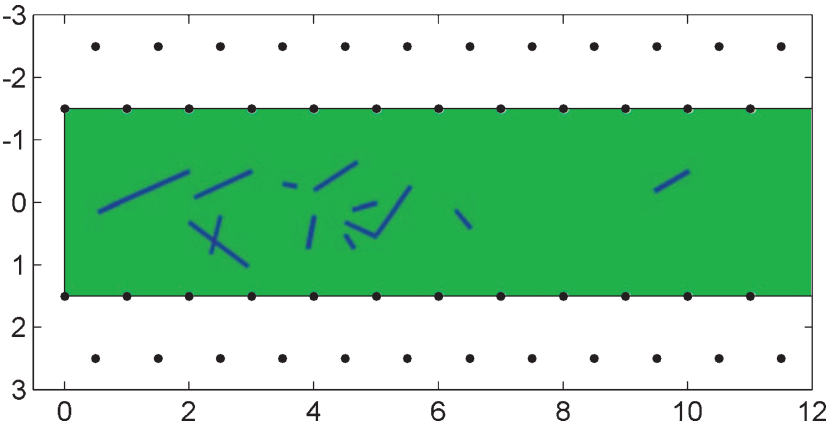

Figure 8. *Results from the bowling test, the lines connect the 'actual' position to that estimated from the seismic data.*

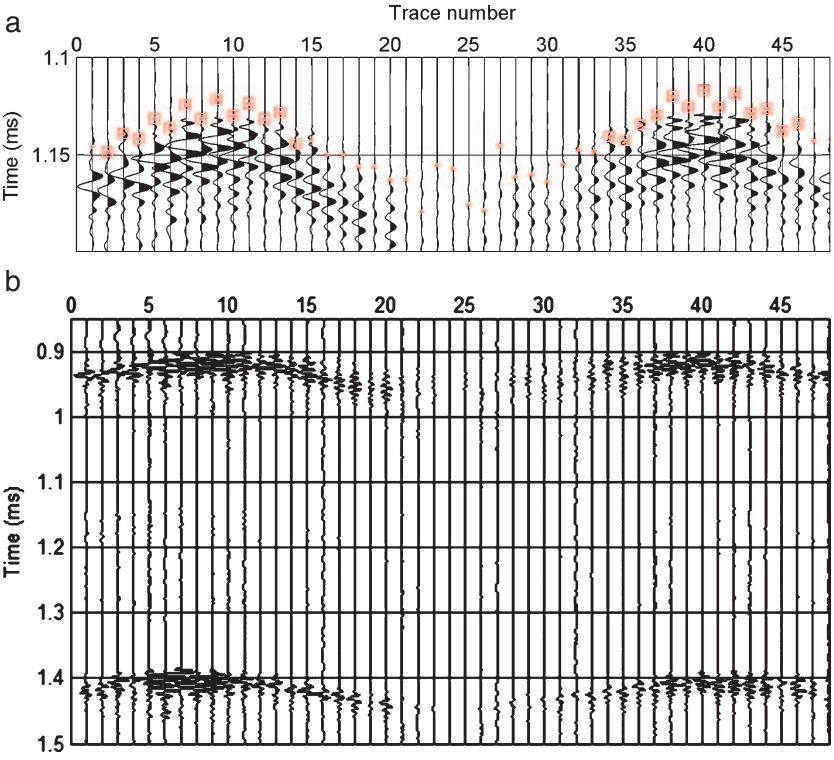

Figure 9. *Example records with (a) a bowler and batsman and (b) an event from the ball being bowled (0.9 s) and being hit down the pitch (1.4 s).*

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7–10	2nd Near-Surface Geophysics Asia-Pacific conference (NSGAP) http://www.seg.org/events/upcoming-seg-meetings/2015/ns-asia-pacific-2015	Hawaii	USA
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October	**2016**		
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12–15	79th EAGE Conference and Exhibition 2017 http://www.eage.org/	Paris	France
July	**2017**		
17–19 (TBC)	3rd Near-Surface Geophysics Asia-Pacific Conference (website TBA)	Cairns	Australia

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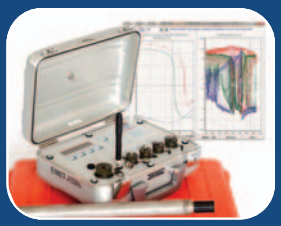

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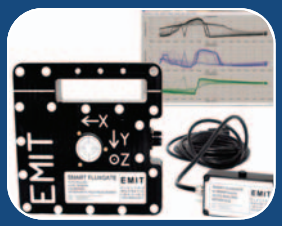

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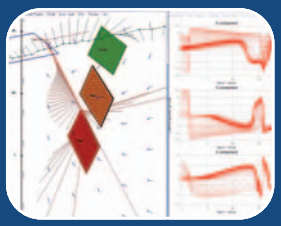

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