Australian Society of
Exploration Geophysicists

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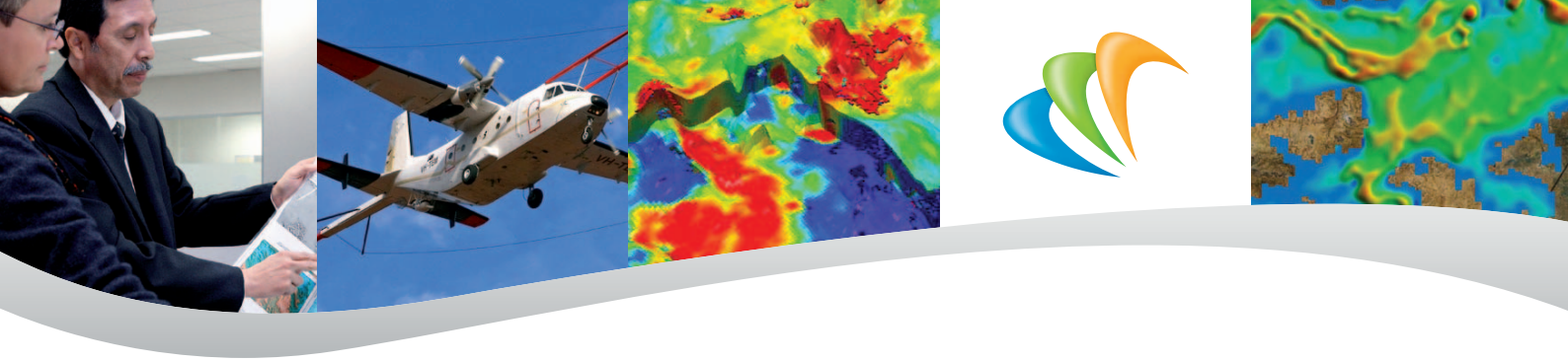
PREVIEW

NEWS AND COMMENTARY

FEATURES



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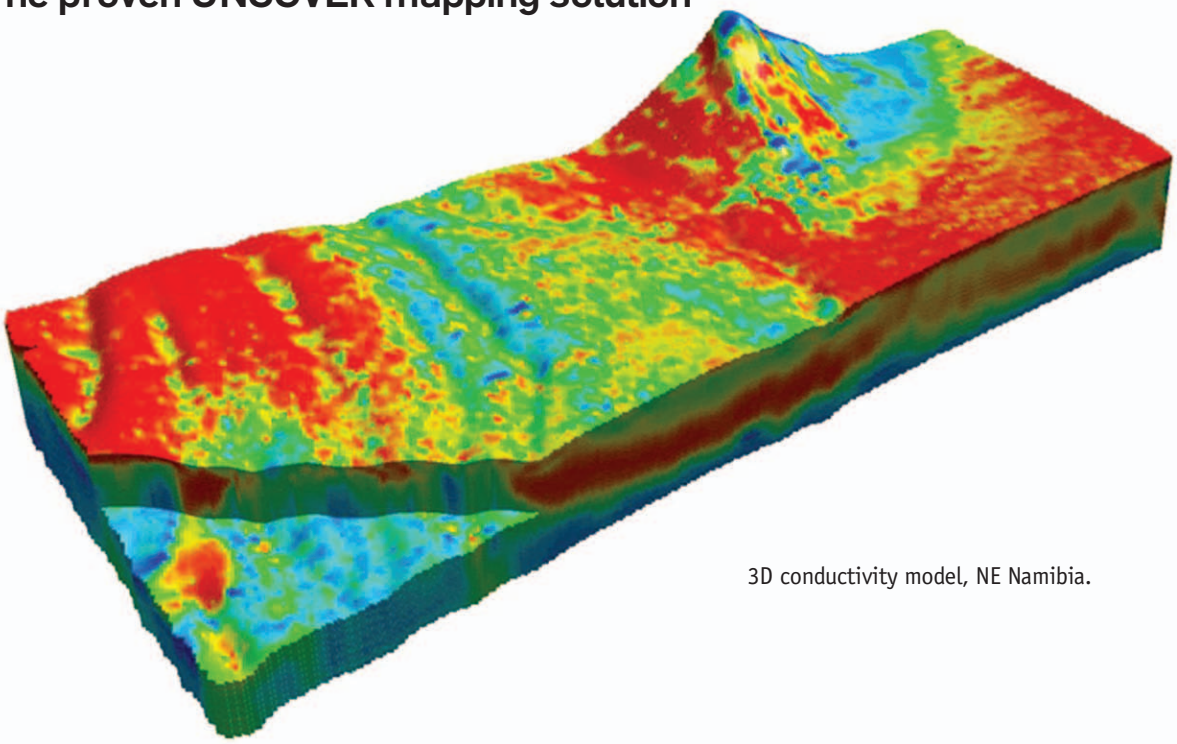

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PREVIEW

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FRONT COVER

Thomas Ostersen, a PhD student at the University of Tasmania, collecting MT data. Tom's project is co-sponsored by Mineral Resources Tasmania and is described in their report (see Geophysics in the Surveys).

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This issue of *Preview* is chock full of news and commentary. Michael Asten (*Education Matters*) has tracked down some of the postgraduate students who missed out on the December 2015 summary of student projects in geophysics in Australia. Mike Hatch (*Environmental Geophysics*) invites Members to assist with the interpretation of radar data acquired over a glacier. Mick Micenko (*Seismic Window*) considers wavelets, sandy beds and spectral decomposition and Ian James (*Webwaves*) and Guy Holmes (*Data Trends*) challenge our way of doing business. We also feature the life of Lewis Albert (Lew) Richardson – a pioneer of exploration geophysics in Australia.

One of the things that struck me as I read through the account of Lew's life was that his clients obviously valued experience over qualifications. Lew did not have many formal qualifications but he had a wealth of experience. He worked in remote areas under what were difficult, not to say dangerous, circumstances – as the photographs that accompany the article attest. The career of his son Robert (Bob) Richardson also suggests that experience is valued over formal qualifications in exploration as he rose from being his father's sidekick to being, currently, the Chair of the Board of Crossland Strategic Minerals Ltd.

The old adage that the best geologist is the one who has seen the most rocks might be translated for exploration geophysicists as the best exploration geophysicist is the one who has spent the most time in the field – and who learnt long ago never to go anywhere without a roll of duct tape!

Sadly it would seem that the younger members of our profession are missing out on field experience. I recently discovered – much to my astonishment – that it is possible to graduate with a degree in geology from a number of our biggest universities with only a week or two of experience in the field. It would seem that one of the biggest limiting factors in this regard is the cost of complying with Occupational Health and Safety considerations. Even the psychological health of students is of concern to bureaucrats in some institutions and they require that an 'independent' student advisor or mediator accompanies students and their lecturers on field trips.

Once students graduate their options for gaining that all important experience in the field are currently quite limited. The old BMR was once valued by the exploration industry as a training ground but that august institution has dwindled into Geoscience Australia and fieldwork, particularly fieldwork in remote areas, is strictly limited. The state surveys now seem to be most active in that regard and I suspect that industry, once it sputters back into life, will be mining the state surveys for personnel.

In the interim there are some amazing opportunities out there. Michael Asten (*Education Matters*) features one of these; the Collaborative Australian Sea Training Alliance Network (CAPSTAN), which is a sea-based training programme for post-graduate students on-board Australia's principal research vessel, RV Investigator. Thirty positions are available and if I was just starting out you would have to forcibly restrain me from applying for one of them!

Lisa Worrall
Preview *Editor*
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Items donated to the ASEG historic instruments collection being moved into storage. Photographs of items in this collection will occasionally appear in Preview.

Letter to the Editor

Dear Lisa

I commend Roger Henderson for all his research and writings on the history of exploration geophysics in Australia; very much appreciated by those of us approaching 50 years of membership of the ASEG! I particularly enjoyed Roger's piece (*Preview* February 2016) on Hal Thirlaway, the first lecturer in Exploration Geophysics at the University of Sydney and in Australia.

The work by Thirlaway and his group led to the installation in the late 1960s of a UKAEA-style 22 km aperture seismic array at Warramunga, near Tennant Creek in the Northern Territory. The array was installed and operated under the direction of Professor Gordon Newstead and Dr Ken Muirhead of the ANU's Department of Engineering Physics. I came to Australia early in 1970 to study for a PhD in that department under the supervision of Ken Muirhead, together with eminent Australian seismologist John Cleary (of the Research School of Earth Sciences). My project was to develop an automatic processing system for processing the Warramunga array data. When I completed my project early in 1974, I was pleased to discover that Hal Thirlaway was one of my two external examiners (the other being the outstanding Norwegian seismologist Eystein Husebye). The examination was conducted at Blacknest, home of the AWRE's seismological unit, a fine old country house near the main UKAEA facility at Aldermaston. After my (mercifully brief) oral examination was completed, Thirlaway invited Husebye and I to join him at the nearby pub 'The Pineapple' for a few refreshing beers. He was a gentleman indeed!

I will defer to Roger's research that Thirlaway first introduced the term 'Forensic Seismology' in 1961. Thirlaway certainly authored a 1973 publication in the *Quarterly Journal of the Royal Astronomical Society* titled 'Forensic Seismology' (Vol. 14, 297–310). I had my own flirtation with semasiology (sic) when in 1977 Cleary and I submitted a letter to *Nature* titled 'Seismological Solitaire'; sadly the letter never saw the presses.

Following my PhD I went on to work on forensic seismology at the large aperture seismic array NORSAR, near Lillehammer in Norway, before returning to a research position in the Department of Geology and Geophysics at the University of Sydney in 1976. Australia has still not got rid of me yet!

David King
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Life full of surprises, Branch visits, volunteers needed for the Federal Executive, geology vs geophysics

Phil Schmidt

When I agreed to stand for the role of President for 2015/16, close to three years ago, I had no idea what the future held. The industry was going gang-busters, I was entrenched as a post-retirement fellow at CSIRO and an adjunct professor at Macquarie University and I had a flow of contracts and research papers to write that was going to keep me off the streets, but then it started to unravel. While my CSIRO and Mac Uni relationships held together, contracts dried up and, dangerously, I was 'on the street' with time to kill. Then my wife began browsing certain websites, sniffing out opportunities to move closer to her Queensland roots, and so it came to pass. Remarkably swiftly I was led, somewhat dumbfounded, to become a guava farmer just south of Newrybar, inland from Byron Bay on the north coast of NSW. Newrybar is a delightful village close to Bangalow, where one can drop into a cafe and find the likes of Kerry O'Brien, aka Red Kez, enjoying the local coffee. Apart from my wife, my first CSIRO Chief, Ken McCracken, is also blameworthy. He inculcated in everyone he could influence the idea that they should change their career direction at least once in their life. Ken was always right – especially in his analysis of how the last year went, 'it was average, not as good as the previous year but better than next year' (an epithet for the industry of late?!).

As President I also undertook (personally) to visit as many Branches as I could, to meet the local Branch Executives and Members. One of the reasons the ASEG is in a healthy financial position is that many trips by FedEx Members are underwritten by the companies for whom the Members work, and this is a policy that I support. First, in September, I visited the WA Branch and later, in October, I went to Adelaide. The Adelaide trip was for a face-to-face FedEx meeting, not a Branch meeting, but I did get to meet some SA Members for drinks afterwards. Last month I visited the ACT and Victoria Branches, before finally making it to Queensland at the beginning of March. All these visits were thoroughly enjoyable and my company was happy to cover the costs despite the downturn in the industry (keeping me off the streets). Thanks to all involved, it was a privilege. I am sorry my time and resources did not extend to NT and Tasmania, although I was in Tassie and visited UTAS to flog my Qmeter at the end of 2014.

The next few months will see several long-term Members of the FedEx step down. While I have another 12 months on the FedEx, as the Immediate Past-President, after my Presidency expires at the AGM next month, some Members are reaching the point where other calls on their time are more pressing. We desperately need a Publications Chair, a role that Greg Street and I have been sharing for the past year. The other key positions are pretty much covered for the short term, but in another 12 months the FedEx could be in dire straits unless we have an influx of new talent. Both the Honorary Treasurer, Theo Aravanis, and the Honorary Secretary, Barry Drummond, will step down at the AGM, and the irrepressible International Chair, Koya Suto, has signalled his intentions to leave – but not before one last combined International/Publications task, which is to further expand *Exploration Geophysics*.

Recently my attention was caught by an article in the *Weekend Australian Magazine* (12–13 March) on the Nobel laureate; Professor Brian Schmidt, becoming the next vice-chancellor of ANU. My interest was piqued not just because ANU is my alma mater, but because I have met Brian. We were getting name tags at a meeting and he noticed that we had the same surname. Being the gregarious person he is, we ended up having a conversation about how CSIRO and the universities were about to lose even more funding, despite protestations to the contrary in the lead-up to the last Federal election. I sincerely hope he can make a difference at ANU, and that other universities take his lead, but the article did emphasise that despite Brian's personal generosity university funding is what it is and unless he can learn to say 'no' straitened times will continue. Many universities use the previous year's student intake to allocate departmental funds. Without intervention at the vice-chancellor level this practice does not bode well for the earth sciences in coming years. In the same article Brian is quoted as saying that he introduces himself as an astronomer if he is on for a chat, but as an astrophysicist if he wants to be left alone. This reminded me of the times I say I'm a geologist versus the times that I admit to being a geophysicist – and wait for the inevitable questions about what geophysicists do. It is worse in the USA where being a geophysicist is usually taken to mean that you are a seismologist and you have two levels of explaining to do, after which you resolve that in future you will only confess to being a geologist or a guava farmer!

Phil Schmidt
ASEG President
president@aseg.org.au

Welcome to new Members

The ASEG extends a warm welcome to 31 new Members approved by the Federal Executive at its February and March meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Sabry	Abdallah	Hokkaido University		Japan	Active
Abid	Ali	Kangwon National University		South Korea	Student
Tim	Archer	Reid Geophysics		UK	Active
Roman	Beloborodov	Curtin University	WA	Australia	Student
Jack	Chanmala	Rio Tinto	WA	Australia	Active
Thomas	Davies	Curtin University	WA	Australia	Student
Steve	de Boer	Gap Geophysics Australia Pty Limited	QLD	Australia	Active
Julia	Dos Santos Maia Correa	Curtin University	WA	Australia	Student
Tom	Emelyanenko	Griffith University	QLD	Australia	Student
Jonathan	Fitzgerald	Total Scan & Survey	WA	Australia	Corporate
Jeremy	Fitzpatrick	Woodside	WA	Australia	Active
Elizabeth	Grange	The University of Melbourne	VIC	Australia	Student
Aaron	Heugh	University of Adelaide	SA	Australia	Student
Afzal	Iqbal	The University of Western Australia	WA	Australia	Student
Wenping	Jiang	Geoscience Australia	ACT	Australia	Active
Harrison	Jones	Macquarie University	NSW	Australia	Student
Dorte	Macrae	Self employed	VIC	Australia	Active
Mahyar	Madadi	Curtin University (lecturer)	WA	Australia	Associate
Andrew	Mc Pherson	Geoscience Australia	ACT	Australia	Active
Nazanin	Nourifard	Curtin University	WA	Australia	Student
Jason	Nycz	Hellas 470	ALB	Canada	Active
Siddharth	Pandey	UNSW Canberra, Space Department	ACT	Australia	Student
Declan	Radford	University of Tasmania	TAS	Australia	Student
Monica	Rasmussen	Ikon Science	SA	Australia	Associate
Xiuyan	Ren	Royal Melbourne Institute of Technology University	VIC	Australia	Student
Hamish	Stein	University Of Melbourne	VIC	Australia	Student
Bheni	Supriyanto	Lampung University	Supriyanto	Indonesia	Student
Lisa	Tannock	University of NSW	NSW	Australia	Student
Tayallen	Velayatham	University of Adelaide	Selangor	Malaysia	Student
Yu	Wu	Institute Of Geology And Geophysics Chinese Academy Of Sciences		China	Student
Sabin	Zahirovic	University of Sydney	NSW	Australia	Active

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Executive Brief

Since the last issue of *Preview* in February, the Federal Executive has met twice, on 18 February and 17 March. The following is a brief summary of key issues discussed by the Federal Executive.

Society finances

The last issue of Executive Brief noted that the Society ended 2015 in a sound financial position. The accounts for 2015 have been audited and the audit report has just been delivered. At the end of 2015 the Society had net equity of $1 291 774. At the end of February, two months into the new financial year, which for the Society matches the calendar year, the net assets were $1 370 308.04, mostly reflecting membership renewals while branch activities were still ramping up for the new year. All Branches now have positive bank balances after the allocation of capitation fees due to a decision by the Federal Executive in late 2015 to forgive a long term deficit in the WA accounts. Branches should therefore be able to offer their Members a healthy technical programme in 2016.

Membership

Membership renewals were sent out at the end of 2015. At the time of the March Federal Executive meeting, 913 or 76% of our 2015 Members had renewed and 288 had not; this compares with a figure at the same time last year of 62% who had renewed. Why some Members have not renewed at this time is not known. Some may not have renewed because of the state of the exploration industry, but others may simply be late in renewing. Those who have not renewed will soon receive individual follow up emails reminding them to renew.

Membership numbers always increase during the year as old Members renew and new Members join. Figure 1 illustrates this point:

WA remains the largest Branch, while our cohort of international Members is larger than any Branch other than WA. Figure 2 illustrates the evolution of Branch numbers over the last 4 years. The blue bars for 2016 are likely to get higher as the year progresses.

The Membership Directory is developed from our database of financial Members, so Members who did not renew their membership and pay their membership dues by the end of March should note that they will not be listed in the 2016 Membership Directory as a consequence.

Conferences

Planning is well underway for our 2016 Conference and Technical Exhibition to be held in Adelaide. The meeting is being held jointly with the Petroleum Exploration Society of Australia (PESA) and the Australian Institute of Geoscientists (AIG). We have held a number of meetings with PESA but this is our first meeting jointly with the AIG. AIG have confirmed that they will also be joining us and PESA to run the 2018 meeting in Sydney.

Planning for the Asia-Pacific Near Surface 2017 meeting in Cairns is underway. A team led by ASEG Members is putting together the technical programme. Negotiations continue principally with SEG, as the other major society jointly hosting the meeting, over the split of the other responsibilities.

Education Programme

Details of the courses being offered under our Education programme are given elsewhere in this issue of *Preview*. At the March meeting the Federal Executive had quite a discussion about geophysics courses that was triggered by a request for financial support, firstly to provide geophysics courses in Myanmar, and secondly for advice on how to establish geophysics education and practice in Myanmar. Although the need was clear and the cause was considered worthy, the proposal did not receive funding at this stage. In part this was because the initial proposal needed more development, but, of greater concern, was that this was one of a number of requests of this nature that the Society has received. Undertaking this course could set a precedent for a whole programme of activities that might unbalance our overall education programme and potentially bring our tax free status into question, not necessarily because of any financial gain but because our not-for-profit status is dependent on having the majority of our Members' funds spent within Australia. The matter was referred to our Education Committee for across-the-board advice and policy development to provide a context in which we can assess our response to this and future requests.

Research Foundation

The ASEG Research Foundation has advised the Society that it has received

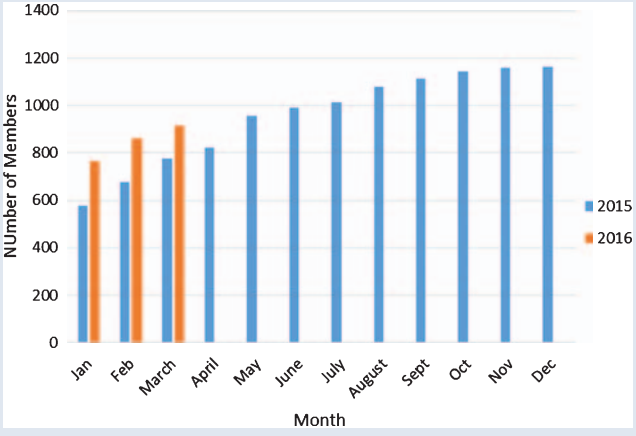

Figure 1. *ASEG 2015/2016 Membership.*

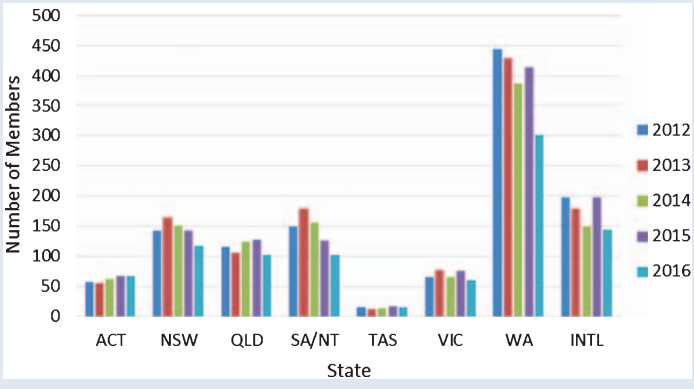

Figure 2. *ASEG Membership by State 2016.*

17 grant proposals in the 2016 round. The assessment of the applications is underway and should be completed by the end of April. The outcome will be announced by the Research Foundation subsequently. The ASEG Research Foundation was established in 1989 and remains largely funded by the ASEG but it operates independently of the ASEG as a condition of it tax free status as a research foundation. Given the growing number of applications each year, the limited funds available, and the value that grass roots research provides to the science of our profession, Members might consider making a donation to the Research Foundation by logging into https://aseg.org.au/research-foundation or by using the donation facility provided next time they renew their Society membership.

Honour for Koya Suto

Koya has been honoured with his selection by the Society of Exploration Geophysicists as their Pacific South Honorary Lecturer 2017. He will be giving lectures in the region in the first half of 2017 that will focus on students studying or considering a career in geophysics. A detailed schedule of presentations is yet to be confirmed. Koya joined the ASEG in 1975. He has served the Society in a number of capacities, including as a long term member of the Federal Executive and as editor of the Membership Directory. He was made an Honorary Member in 2010 and was Society President in 2013.

Barry Drummond
Honorary Secretary
fedsec@aseg.org.au

Final call to nominate a colleague for an ASEG Honour or Award for 2016

NOMINATIONS CLOSING 8 JUNE 2016

The ASEG acknowledges the outstanding contributions of its individual Members both to the profession of geophysics and to the ASEG, through the presentation of the Society's Honours and Awards across a range of categories. The next Awards are scheduled to be presented at ASEG-PESA 2016: 25th Geophysical Conference & Exhibition, 21–24 August 2016 – Adelaide, South Australia.

All ASEG Members, as well as State and Federal executives, are invited to nominate those they consider deserving of these awards. The available awards are:

- **ASEG Gold Medal** – For exceptional and highly significant distinguished contributions to the science and practice of geophysics, resulting in wide recognition within the geoscientific community.
- **Honorary Membership** – For distinguished contributions by a Member to the profession of exploration geophysics and to the ASEG over many years.
- **Grahame Sands Award** – For innovation in applied geophysics through a significant practical development in the field of instrumentation, data acquisition, interpretation or theory.
- **Lindsay Ingall Memorial Award** – For the promotion of geophysics to the wider community.
- **Early Achievement Award** – For significant contributions to the profession by a Member under 36 years of age. Prior to 2016, the award was determined solely on publications in *Exploration Geophysics* or similar reputable journals by the nominee, but has now been expanded to include overall contributions to geophysics, ASEG Branch activities, Committees, or events.
- **ASEG Service Awards** – For distinguished service by a Member to the ASEG.

ASEG Members are eligible for all award categories. Non-members also are eligible for the Lindsay Ingall and Grahame Sands awards. Under exceptional circumstances, the other awards may be offered to a non-member of the ASEG who has given appropriate service to the ASEG or to the profession of geoscience, and who has been duly nominated by the Federal Executive.

Nomination procedure

Any Member of the Society may submit nominations for an award. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are Members of an Australian geoscience body (e.g. ASEG, GSA, AusIMM, AIG, PESA, or similar).

Details of all award criteria and nomination guidelines can be found on the ASEG website at: https://aseg.org.au/honours-and-awards. Proforma nomination forms are available from the website or by contacting the Committee Chair directly. Nominations including digital copies of all relevant supporting documentation are to be sent electronically to:

Nominations close Wednesday 8 June 2016.

Andrew Mutton
ASEG Honours and Awards Committee Chair
awards@aseg.org.au

ASEG Branch news

South Australia & Northern Territory

The SA/NT Branch had a relatively relaxed start to 2016 with only one event since taking a break after the Christmas Party and Honours Student night that rounded off 2015. We started the year with our AGM, where a new Committee was voted in to take the lead for 2016. **Josh Sage** will stay on as President, **Adam Davey** will remain Treasurer for another year, and the majority of last year's general Members have agreed to continue as well as a few newcomers. Thanks to all the people who have volunteered to help out in 2016.

Following our AGM we were joined by **Dr Stephan Thiel** from the Geological Survey of South Australia, who presented results from some of his recent work. His excellent talk, entitled 'Magnetotellurics across scales: an informed approach to mineral exploration,' was very well received by a very diverse audience. The update on the progress of AusLAMP (The Australian Lithospheric Architecture Magnetotelluric Project) over the prospective edges of the Gawler Craton in South Australia was not only fascinating in its scope and endeavour but also thought provoking with a lively Q&A session following.

Our technical meetings are made possible by our very generous group of sponsors, which in 2015 included Beach Energy, the Department of State Development, Geokinetics, Minotaur Exploration, Petrosys, Santos, Schlumberger, Borehole Wireline and Zonge. We will be in touch shortly hoping they will return in 2016. Of course, if you or your company are not in that list and would like to offer your support, please get in touch at 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. 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.sage@beachenergy.com.au 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.

Interested Members and other parties should also keep an eye on the seminar program of the University of Tasmania's School of Earth Sciences, which regularly delivers presentations of geophysical as well as general earth science interest. Contact **Mark Duffett** taspresident@aseg.org.au for further details.

Mark Duffett
(Tasmanian Branch President)

Victoria

The ASEG Victoria Branch started the year with our traditional 'Joint ASEG/PESA/SPE 'Mid-Summer Social' held on Wednesday 10 February at the Henry and Fox. The event was well attended and gave Members the opportunity for some networking and catching up with familiar faces while enjoying a cold drink and a bit of food.

On 18 February we had the pleasure of hosting a technical meeting with **Dr Phil Schmidt**, owner of Magnetic Earth and the outgoing ASEG president, presenting 'Magnetic Exploration Projects in CSIRO from 1978 to Now'. This interesting presentation was followed by quite a few questions and some comments on the evolution of HSE regulations.

The technical meeting was preceded by the Victorian Branch AGM, where the Branch Committee was renewed. I would like to take this opportunity to give **Asbjorn Christensen**, who stepped down this year, a big thank you for all his hard work and dedication as President of the ASEG Victoria Branch for the past seven years.

Our next technical meeting will be on 27 April from 6 pm, with a presentation by **Peter Betts** about 'Structural Geophysics: Geological principles applied to geophysical data'. It will be held as usual at the Kelvin Club, accompanied by drinks and nibbles.

Seda Rouxel
(Victorian Branch President)

Western Australia

The WA Branch commenced the year with a technical evening on February 10 when **Todd Mojesky** presented a talk titled 'A NWS 4D Time-lapse Case Study: Mixing Broadband and Conventional Streamer Data'. The talk was based on a paper co-authored with **Fong Cheen Loh** of CGG and **Paul Bouloudas** of Quadrant Energy Pty Ltd and titled 'Full shot and receiver de-ghosting for Broadband and Conventional streamer 4D studies: How close can we get?'

A workshop for the oil and gas sector is scheduled for 15 March on the topic of 'Rock physics and geomechanics of fluid-induced seismicity: hydraulic fracturing, stimulation of geothermal systems and hazard assessment'. The course will be presented by **Dr Serge A. Shapiro.**

On 18 March a technical session will be delivered by **Joe Dellinger**, the SEG Distinguished Lecturer, entitled 'Forensic data processing – revealing your data's hidden stories'.

The first event for April is on 13 April when a technical session will be combined with the FEDEX AGM. The talk scheduled for this evening will be presented by **Mark Baigent** on 'Horizon Mapping and Fault detection using Airborne Gravity Gradiometer and magnetic data – Canning Basin Study'.

Prue Leeming
(WA Branch Preview *correspondent)*

Australian Capital Territory

The ACT Branch kicked off 2016 with the announcement of the ACT Branch Travel Scholarship. This year's recipient is **Manon Dalaison**, an honours student at the Australian National University. She will be using her grant to attend the 2016 ASEG Conference. Keep an eye out for her poster. The ACT Branch Student scholarship is still open and will close on 15 April.

The ACT Branch had the honour of hosting the outgoing ASEG President **Phil Schmidt** in February. Phil spoke about 'Magnetic Exploration Projects in CSIRO 1978 to now'. About 20 ASEG Members attended the talk and a lucky few had Phil's company over dinner where many good old time stories were shared. We thank Phil for taking time out of his busy schedule to travel to Canberra to remind us of the importance of magnetic exploration.

Phil Schmidt speaking to the ACT Branch in February.

March saw significant innovative modifications to Geoscience Australia's National Magnetic Calibration Facility at the Canberra Observatory by expert staff – some of who are ASEG Members.

By the time this edition of *Preview* goes to press, we will have hosted the ASEG One Day short course: Rock physics and geomechanics of fluid-induced seismicity: hydraulic fracturing, stimulation of geothermal systems and hazard assessment by **Dr Serge Shapiro** with attendance expected to hit 20.

We will have also had our AGM with a talk on the collaborative greenfields pre-drilling geophysics program in the Southern Thomson presented by **James Goodwin**.

Marina Costelloe
(Outgoing ACT Branch President)

New South Wales

In February **Mike Dentith** from the University of Western Australia gave a two day workshop entitled 'Geophysics for the Mineral Exploration Geoscientist' based on the 2014 textbook of the same name. This was a joint initiative with the GSA and AIG, with close to 30 attendees gaining a good solid introduction to geophysics (please refer to the larger article in this issue). Mike then fronted up for our monthly meeting and gave a presentation on 'Assessing terrain-scale prospectivity using geophysical data: lessons learned in Western Australia.' Mike took us through various ways that prospectivity can be assessed using geophysical data. Mike's talk was enjoyed by all with much discussion ensuing.

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 generally 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 on the NSW Branch website.

Mark Lackie
(NSW Branch President)

Queensland

The Queensland Branch held its first Branch meeting for the year on February 16. **Mal Cattach**, the Chief Geophysicist for the Gap Geo Group of companies based in Brisbane, talked on 'Sub-Audio Magnetics'; a proprietary rapid acquisition geophysical method which provides high spatial definition and/or deep penetration data related to both the electrical and magnetic properties of the earth. It was a very interesting talk with some great examples shown, in particular the results of a HeliSAM FLEM trial over the Lalor VMS Deposit in Manitoba, Canada.

At another minerals focused talk in March, the outgoing ASEG President **Dr Phil Schmidt** spoke about 'Magnetic Exploration in the CSIRO from 1978 to now'. It was another very informative talk that highlighted the invaluable contribution made to the scientific community by CSIRO scientists like Phil over the past 40 years.

April's meeting, to be held on 5 April, will also be the QLD AGM. Our very own Qld Branch Treasurer Mr **Henk van Paridon** will be presenting a talk entitled 'Coal Seismic is Not Easy'. An invitation to attend Queensland's Branch meetings is extended to all ASEG Members and interested parties.

Details of upcoming events will be posted to the ASEG website.

Megan Nightingale
(QLD Branch Secretary)

***Andrew Lewis**, **Bill Jones**, **Peter Crosthwaite**, **Marina Costelloe** and **Patrick Burke** at Geoscience Australia's National Magnetic Calibration Facility.*

ASEG calendar: technical meetings, courses and events

Date	Branch	Event	Presenter	Time	Venue
2016					
13 Apr	WA	2016 ASEG AGM and technical presentation on Horizon mapping and fault detection using Airborne Gravity Gradiometer and magnetic data in the Canning Basin	Various including technical presenter Mark Baigent	1730–2000	Minespace, 1292 Hay Street, West Perth
19 Apr	SA	Technical evening: Coal Seismic is Not Easy	Henk van Paridon	1730	Coopers Alehouse, 316 Pulteney Street, Adelaide
27 Apr	VIC	Technical evening: Structural Geophysics: Geological principles applied to geophysical data	Peter Betts	1800	The Kelvin Club, 14–30 Melbourne Place (off Russell Street), Melbourne
28 Apr	SA	Student pizza night with presentations from industry professionals on their careers and the opportunities for geophysicists	Various	1800	Sprigg Room, Mawson Laboratories, The University of Adelaide
21 Aug	SA	SEG DISC: 3C Seismic and VSP: Converted Waves and Vector Wavefield Applications	James Gaiser	TBA	TBA
26 Aug	ACT	SEG DISC: 3C Seismic and VSP: Converted Waves and Vector Wavefield Applications	James Gaiser	TBA	TBA
29 Aug	WA	SEG DISC: 3C Seismic and VSP: Converted Waves and Vector Wavefield Applications	James Gaiser	TBA	TBA

TBA, to be advised (please contact your state Branch Secretary for more information).

A proton magnetometer sensor 'bird' held in the ASEG historic instruments collection. This bird was commonly used in airborne magnetic surveys during the 1960s and 1970s. Associate instrumentation was located in the aircraft, which usually flew at 80 to 100 m with the bird towed on the end of a 50–80 m line. Needless to say, the occasional bird was lost in trees, on the ground or, in at least one case, in a communications tower. Sampling of the magnetic field using these early proton magnetometers was around 1 second, which translated to 60 to 70 m along track. The bird position was not monitored and could vary significantly with wind and turbulence resulting in a reduction of data quality - something to remember when reviewing old magnetic survey data. Modern birds carry a caesium vapour or Overhauser sensor and the sample spacing is 1–5 m.

EAGE

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4-8 September 2016

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SECOND APPLIED SHALLOW MARINE GEOPHYSICS CONFERENCE

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NEAR SURFACE GEOSCIENCE
CONFERENCE & EXHIBITION

www.eage.org/event/environmental-engineering-2016
www.eage.org/event/mineral-exploration-2016
www.eage.org/event/shallow-marine-2016

4-8 September 2016, Barcelona, Spain

The opening of the new South Australian Drill Core Reference Library

On 17 February 2016, the Honourable Jay Weatherill, Premier of South Australia, opened the new South Australia Drill Core Reference Library at Tonsley – a short distance from the Adelaide CBD – in South Australia. The ASEG was invited to a welcoming ceremony by Minister Tom Koustantonis and enjoyed an exclusive tour of the state-of-the-art facility.

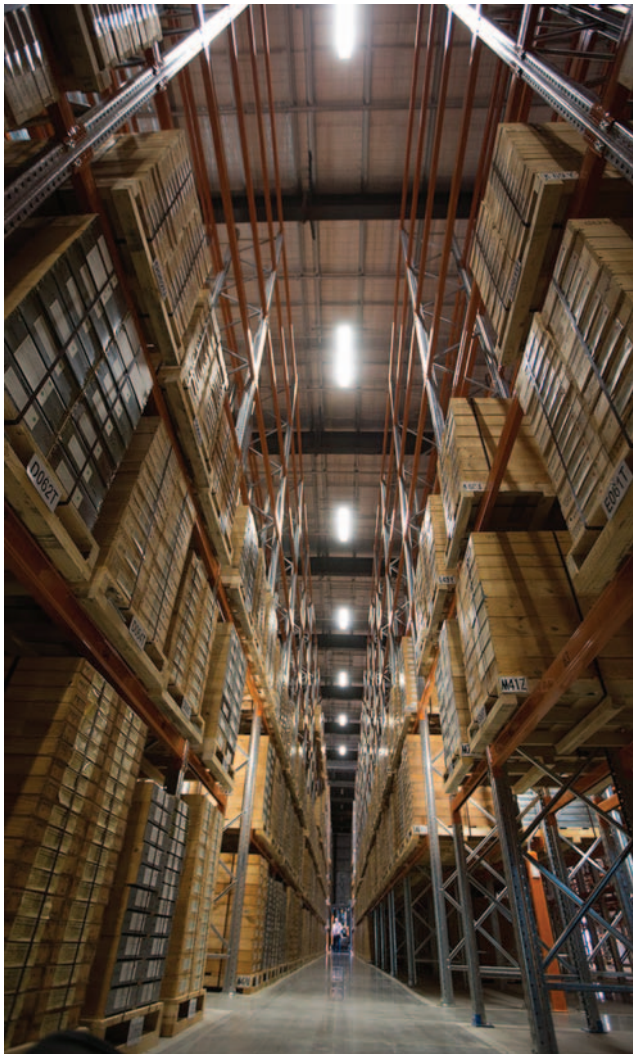
The building is a prominent feature in the Tonsley Precinct. It stands out with distinctive grey and red cladding. The tiles are at an angle giving the impression of a speeding train, but also honouring the idea of a core tray. As we entered the building we found ourselves in a neatly furnished foyer area, carpet underfoot, and a sleek desk to the side. It put me in mind of checking into a nice airport lounge or hotel.

Adjacent to the foyer area is a second, larger space where afternoon tea was being served. The large Copper sculpture entitled 'From The Hill' stood in front of the northern windowed wall. Through the doors to the south is the core viewing area: a large room with 12 conveyer belts – each designed to hold an entire pallets' worth of core.

Next to this room – and behind the first foyer area – are the administration offices, including a kitchen, a lounge, and several break-out rooms for computer work and meetings. Also here is Data Metalogenica: a collection of type sections from ore deposits around the world. Up the stairs (or the lift) leads to a conference area, including a board room (with a stunning view of the shelving), another kitchen, and several more break out rooms. A balcony looks out over the core viewing area, and following this around leads to the 3D visualisation room.

The 3D visualisation room is a classroom-sized room with a large back-projected 3D projector. As we entered we were handed 3D glasses and were treated to a 3D view of Olympic Dam – drillholes, seismic sections, hyperspectral information, landscape – all in one rotating spectacle.

Our tour guide then led us out to the vast library section of the building, by far the largest portion of the building. At 9 metres high, much of the shelves have already been filled with pallets full of core trays. We're told that this Core Library will consolidate all the previous state



The storage section of the facility will hold more than 7.5 million metres of drill core samples (photo courtesy James Knowler: http://www.theleadsouthaustralia.com.au/industries/mining-resources/hitech-drill-core-library-seeks-to-unearth-discoveries/

The Tonsley Drill Core Facility as seen from outside (photo courtesy Ursula Michael, GSSA).

The drill core viewing area has space to hold 12 pallet-loads of core (photo courtesy Ursula Michael, GSSA).

core facilities (Glenside, Thebarton, Whyalla, Moonta) into a single building. It'll still take another few months before everything is transferred, and even then the space won't be filled. They expect at least 15 more years of core will fit in the facility, and after that there will be room to extend the building further southwards. We're told that the area will fit more than 7.5 million metres of drill core sample.

We were given a demonstration of the new forklift that can reach 9 metres high, and then went to visit the loading bays and the analysis room where the Hylogger™ is operated. The plan is to log the core as it arrives at the library before shelving it. The information from the Hylogger™ feeds directly into the 3D visualisation room.

We were then led back to the afternoon tea area and chatted enthusiastically with our colleagues. Everyone agreed that the new facility is amazing. The place is beautifully furnished, professional looking, and designed in such a way to ensure the core view process runs smoothly, efficiently and safely. And best of all, viewing core will be free-of-charge (although you must book). This facility will be a real key for future discoveries in South Australia.

The facility has been officially opened; however, it won't open for business until a little later this year. Why not visit the facility while you're in Adelaide for ASEG-PESA-AIG 2016?

Philip Heath
SA/NT ASEG Branch Committee Member
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Drones in geophysics and geoDRONEology at SAGEEP 2016

The use of drones for capturing LiDAR, hyperspectral, low altitude L-band, tensor VLF-EM, magnetic, and photogrammetric data were the topics of the Drones in Geophysics technical session at the 29th Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), at the annual meeting of the Environmental and Engineering Geophysics Society (EEGS) held from 20 March to 24 March in Denver, CO. Although it is unlikely that drones will replace pilot-on-board aircraft anytime soon because of the regulatory constraints, the presenters made it clear that it will happen eventually. Moreover, based on the attendance in the session, it was evident that there is an emerging and keen interest in the using drones for geoscientific mapping of surface as well as the subsurface geology.

Drones in action at SAGEEP 2016.

The application of drone based photogrammetric methods to map surface geology was the fundamental theme of the one day short course titled geoDRONEology©: integrating drones into the geoscientific and engineering workflow. In addition to the material presented by the course instructors, Ron Bell and Rene Perez, several of the short course registrants informally presented talks about their utilisation of orthorectified photo-images and digital surface models derived from the imagery to create 3D models for analysing formational units known to be oil and gas reservoirs at depth, assessing landslides and other geotechnical hazards, and exploring for, as well as discovering, lode gold deposits. Several manufacturers of multi-rotor and fixed wing drones as well as commercial UAS mission service providers echoed the notion that the selection of a drone for geoscience should be based primarily on the data need and site conditions. It is highly probable that as the utilisation of drones increases, companies will invest in fleets of drones and numerous sensors.

Ron Bell
Aerobotic Geophysical Systems, LLC
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Geophysics for the Mineral Exploration Geoscientist: report on the Sydney short course

This is a report on the short course jointly sponsored jointly by the NSW Branch Committees of the ASEG, GSA and AIG and held in Sydney, 16–17 February 2016.

The short course entitled 'Geophysics for the Mineral Exploration Geoscientist' was presented by Professor Mike Dentith, Centre for Exploration Targeting, School of Earth and Environment, The University of Western Australia, and was based on his 2014 book.

The two day event provided a state-of-the-art overview of geophysical exploration methods without recourse to complex mathematical descriptions. It included descriptions of all the main geophysical methods used in mineral exploration; including gravity, magnetic, electrical and electromagnetic methods. Lectures were followed by practical exercises using real-world mineral exploration datasets. Course participants were guided through the basic physical phenomena, the acquisition and processing of geophysical data, the creation of subsurface models and their geological interpretation.

The course:

1. Explained the cutting-edge current practice in exploration and mining geophysics for the discovery of 'blind' mineral deposits.
2. Gave a practical guide to data acquisition, processing, and accurate interpretation of geophysical datasets.
3. Included presentation and analysis of petrophysical data, giving key information on the physical properties of rocks.
4. Emphasised extraction of maximum geological information from geophysical data, providing explanations of data modelling, and common interpretation pitfalls.
5. Provided examples from all the main types of mineral deposit around the world.

Participants in the Geophysics for the mineral exploration geoscientist short course held in Sydney in February 2016 (the presenter Mike Dentith is standing at centre).

The course targeted practising geoscientists with less than ten years of experience who have had limited exposure to formal education in the application of exploration geophysics, as well as unemployed/underemployed geoscientists and postgraduate students. The actual breakdown of the 30 attendees was:

- Early career (<10 years of experience) 8
- Un/underemployed geoscientists 10
- Postgraduate students 5
- Full fee employed (>10 years) 7

The NSW Branches of the AIG, the GSA and the ASEG underwrote the costs of the presenter's travel costs, presenter's fee and one copy of the book for each participant. There was no industry sponsorship of this event. The initial budget anticipated a net deficit for each participating society of $3267.

The event income was boosted through the attendance by seven full fee paying delegates, for a net income of $3748. Costs for the event were slightly lower than budgeted and totalled $8643, resulting in a net deficit of $4895. This result meant an event deficit for each society of $1632 – a better than expected financial outcome!

Mike Smith
General Manager Exploration
Austpac Resources, Sydney
mike_rpgeo@optusnet.com.au

ASEG-PESA-AIG 2016: update from the Conference Organising Committee

With less than four months to go, most of the conference details are being finalised.

The Exhibition Hall is filling up. At the time of writing roughly three quarters of the booths have been booked, so get in fast if your company is looking for promotion opportunities.

We're very pleased to announce that BP will be a silver sponsor of the conference. Welcome aboard BP!

Our bronze sponsors are Austhai Geophysical, CSIRO, and Velseis. Borehole Wireline will be the Lanyard Sponsor, and we have some Happy Hour sponsors lined up: stay tuned to *Preview* for further announcements. Sponsorship opportunities are still available but will close as you read this. Please contact us directly and immediately if you're interested.

The early bird registration deadline has been extended to 30 April 2016. This will give authors the opportunity to register at early bird prices once their papers have been accepted. If your paper is accepted as part of the conference, you have until 1 June to register for the conference to ensure your place in the conference programme.

Our team of paper reviewers are ploughing through around 200 extended abstract submissions. By the time of this publication the programme will be near completion.

Stay tuned to our social media channels. Our Twitter and Facebook feeds are updated most weekdays with news about geophysics from around the world, as well as photos and news from Adelaide and South Australia. LinkedIn continues to post updates on important deadlines.

The organisers have decided that the programme and timetable news and updates will be delivered through a mix traditional format (pocket programme) and online through mediums like email, Twitter, Facebook and LinkedIn. There is still an opportunity for an App, however this won't eventuate unless digital content sponsors can be found.

We look forward to seeing you in Adelaide in August!

Philip Heath
Co-chair Minerals
philip.heath@sa.gov.au

Luke Gardiner
Co-chair Petroleum
luke.gardiner@beachenergy.com.au

The Scintrex IPR-8 held in the ASEG historic instrument collection. This instrument was extensively used throughout Australia in the 1970s and 1980s. It was light, easy to use and fairly indestructible. Large areas of the west coast of Tasmania were surveyed using the IPR-8 by Scintrex using gradient array, pole dipole and dipole-dipole arrays between 1976 and 1983. However, the instrument was not waterproof. The high rainfall on the west coast meant that a hair dryer was an essential piece of equipment for every geophysical survey crew. The pictured instrument was one of those used in Tasmania on projects such as: gold in the Henty Fault Zone; copper in the Mount Lyell Field; lead/zinc around Zeehan; tin near Mount Heemskirk and for base metals around Roseberry and Mount Read.

REGISTRATIONS OPEN

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Convened by The Australian Society of Exploration Geophysicists, Petroleum Exploration Society of Australia and Australian Institute of Geoscientists

PESA Petroleum Exploration Society of Australia

Australian Society of Exploration Geophysicists

AUSTRALIAN INSTITUTE OF GEOSCIENTISTS

Near Surface Geophysics – Asia Pacific Conference 2017: update from the organisers

Planning is underway for the Near Surface Geophysics – Asia Pacific Conference that will be held in Cairns from 17–19 July 2017. This is the third planned regular Near Surface Geophysics – Asia Pacific Conference, a joint initiative of the SEG, ASEG, CSG, SEGJ and KSEG. The Conference is held every two years, the first was in Beijing in 2013 and the second was in Hawaii in 2015.

The plan is to engage both geophysicists and end users of geophysics and discussions are underway with a number of possible technical partner engineering and geoscience societies.

The committees that are in place for planning purposes, with membership from all participating societies; SEG, ASEG, CSG, SEGJ and KSEG, are:

Advisory Committee

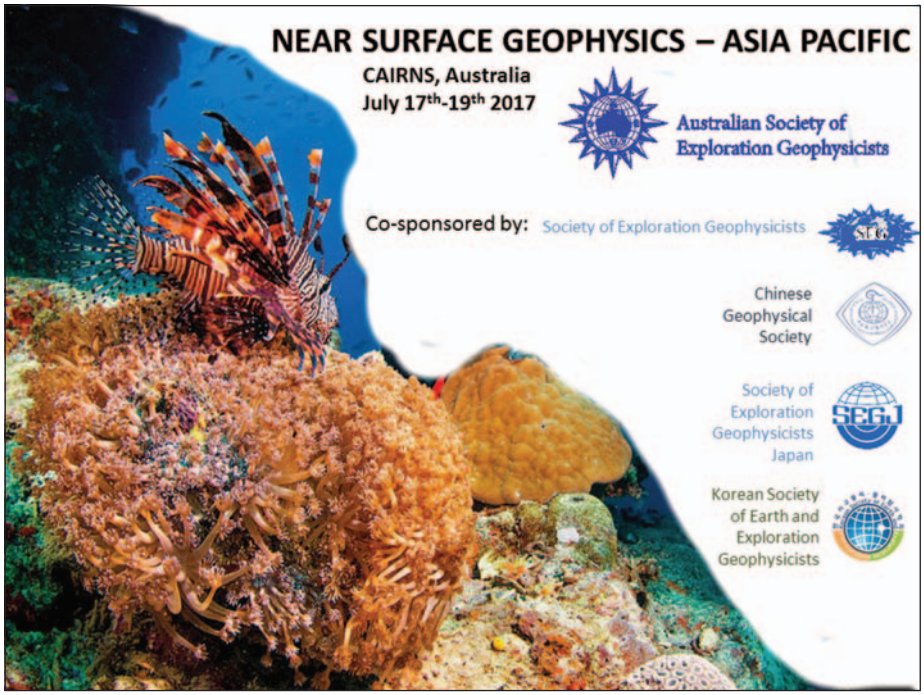
ASEG	Phil Schmidt
SEGJ	Hideki Saito
CGS	Yong Chen
KSEG	Cho In-Ky
SEG	John Bradford

Organising Committee

ASEG	Greg Street ASEG Chair
ASEG	Romney Rayner ASEG Treasurer
ASEG	Tim Pippett ASEG Exhibitions
ASEG	Ron Palmer ASEG Sponsorships
SEGJ	TBA
SEGJ	TBA
CGS	Jian Guo
CGS	TBA
KSEG	Dr Seho Hwang
SEG	Dr John Lane Jr
SEG	TBA

Technical Program Committee

ASEG	Geoff Pettifer ASEG Chair
SEG	Laurie Whitesell ASEG Deputy Chair
ASEG	Meng Heng Loke
ASEG	Binzhong Zhou
ASEG	TBA
SEGJ	TBA
SEGJ	TBA
CGS	Jianghai Xia
CGS	TBA



KSEG	Dr Myeong-Jong Yi
KSEG	Professor Dong-Joo Min
SEG	Anja Klotzsche
SEG	Andrew Parsekian
SEG	Mark Everett
SEG	James Irving
SEG	Erasmus Oware

Publicity material and the conference website are close to being finalised. Themes for the conference are also being finalised, but the following are under consideration and of interest to the participating societies. Your feedback would be most welcome.

Themes under consideration

Methods:

- Sessions devoted to the full range of Near Surface Geophysics (NSG) methods including various remote sensing, downhole, land, marine and airborne methods (seismic, magnetics, radar, gravity, electrical and EM, NMR, geophysical logging etc.)
- Full waveform seismic in NSG – new research and developments
- Passive seismic methods, surface wave methods

Geotechnical:

- Geotechnical characterisation of sites
- Local site amplification of earthquake ground motion
- Application of rock physics to geo-technical engineering
- Tunnels and cavity/rock defects detection – from the surface and ahead of the tunnel face
- Shallow marine geophysics – ports, coastal engineering and offshore platforms
- Landslides and geohazards
- Cavity and void detection
- Case studies in engineering geophysics (examples of both success and failure)

Environmental:

- Case studies in environmental geophysics (examples of both success and failure)
- Contaminated site geophysics
- Catchment/surface water – environmental geophysics, airborne geophysics
- CO_2 geosequestration

Groundwater:

- Airborne EM and groundwater – as well as general hydro-geophysics
- Case studies in hydro-geophysics (examples of both success and failure)

Utility applications:

- UXO
- Forensic applications
- UAV and agricultural geophysics
- Archaeometry – archaeology and geophysics (case studies and advances

in LIDAR, 3D radar, ground geophysics and satellite imaging)

Geology:

- Volcano geophysics
- Regolith geophysics

Mine site and mining exploration:

- Mine site geophysics
- Exploration under cover – near surface emphasis (characterising and removing the cover)

Modelling:

- Relationships and opportunities for the integration of geophysical, hydrogeological and geotechnical modelling

Workshops/courses:

- S waves (1D and 2D)
- Women in geophysics
- Engineering geophysics (state of the industry and the path forward, the application of cutting edge methods)
- Risk in site characterisation using geophysics
- Dams and Levees
- Full waveform seismic
- Integrating remote sensing and airborne geophysics for geoscientific analysis

Possible technical excursions – ideas so far:

- Great Barrier Reef (shallow marine geophysics)
- Local mine site (mine site geophysics)
- Local farms (agricultural geophysics)

Possible accompanying partner/social excursions:

- Great Barrier Reef
- Daintree Rainforest
- Crocodile tour

Geoff Pettifer
Co-chair Technical Program Committee
NSG-AP 2017
Geoff.Pettifer@ghd.com

GA: update on geophysical survey progress from the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland and Victoria (information current on 23 March 2016)

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 (km²)	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	8 Nov 2015	Dec 2015 for magnetic and elevation data	173: Dec 2014 p. 24	The magnetic and elevation data were released via GADDS on 10 Dec 2015. The radiometric data are in the final stages of processing prior to assessment by GA
Delamere/ Spirit Hills	NTGS	GA	Thomson Aviation	20 Jul 2015	96 500 est.	400 m 80 m N–S	33 690	7 Nov 2015	Expected to be supplied to GA in Jan or Feb 2016	176: Jun 2015 p. 22	The data were released via GADDS on 29 Mar 2016

TBA, to be advised.

Table 2. Gravity surveys

Survey name	Client	Project management	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
SW Yilgarn	GSWA	GA	Atlas	12 Jun 2015	27 678	2 km along public roads and tracks	175 000	100% complete to 3 Dec 2015	TBA	176: Jun 2015 p. 24	The data were released via GADDS on 11 Feb 2016
Stavely	GSV	GA	TBA	Survey Quotation Request in preparation	Approx. 8000 in 9 separate areas	500 m regular grid in 8 areas and 500 m station interval along one traverse	TBA	TBA	TBA	177: Aug 2015 p. 18	TBA
Wiluna	GSWA	GA	TBA	TBA	Approx 17 000 in 2 separate areas	2500 m regular grid	103 000	TBA	TBA	The proposed survey covers parts of the Bullen, Trainor,Nabberu, Wiluna, Sir Samuel, Madley, Herbert, Robert Standard 1:250 000 map sheets. The Quotation Request was released on 27 Jan and closed on 23 Feb. The preferred supplier has been selected by GA and GSWA and a draft Contract is expected to be executed in Apr.	TBA

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Musgraves – PACE Area	GSSA	GA	CGG Aviation	Apr 2016	8489	2 km; E–W lines	16 371	TBA	TBA	179: Dec 2015 p. 23	The proposed survey covers parts of the Mann, Woodroffe, Birksgate and Lindsay Standard 1:250 000 map sheets
Musgraves – CSIRO Area	GSSA	GA	SkyTEM Australia	Apr 2016	7182	2 km; E–W lines	14 320	TBA	TBA	179: Dec 2015 p. 23	The proposed survey covers parts of the Woodroffe, Alberga, Lindsay and Everard Standard 1:250 000 map sheets
West Kimberley and Ord-Bonaparte	WA Government: Departments of Water, Agriculture and Food	GA	SkyTEM Australia	26 Sep 2015	7837	Various + traverses	TBA	3 Nov 2015	TBA	178: Oct 2015 pp. 30–31	The release date for the survey data is to be decided by the WA Government Department of Water
Isa Region	GSQ	GA	TBA	Winter 2016. Centred on Cloncurry	TBA	TBA	TBA	TBA	TBA	The Technical Specifications of the survey are being planned between GSQ and GA	The National Collaboration Framework Agreement was executed between GA and GSQ on 16 Dec 2015. A QR was released on 24 March that closed on 15 April

TBA, to be advised.

MRT: MT surveys in progress

Mineral Resources Tasmania is co-sponsoring acquisition, processing and interpretation of magnetotelluric (MT) data on two regional transects in western and northern Tasmania respectively (Figure 1). The work is being undertaken by Thomas Ostersen (Figure 2) as part of his PhD project at the University of Tasmania. Tom is being supervised by Associate Professor Anya Reading in collaboration with Professor Graham Heinson and Dr Stephan Thiel of the University of Adelaide and the Geological Survey of South Australia. The survey is being conducted using MT instruments sourced through the ANSIR National Facility for Earth Sounding (http://ansir.org.au). Station spacing on the transects is approximately two kilometres.

AusLAMP in Tasmania

The transect data are being obtained in conjunction with the Tasmanian leg of the Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP). AusLAMP (http://www.ga.gov.au/about/what-we-do/projects/minerals/current/auslamp) is a multi-year collaboration aimed at resolving the first order electrical structure of the Australian continental lithosphere through the acquisition of long-period magnetotelluric data at ~55 × 55 km spacing. The data collection has been funded by AuScope under the auspices of Geoscience Australia, which has also provided extensive field support to both this and the transects programme. Fieldwork on the transects in particular was extremely demanding, and was carried out by participants from the University of Tasmania, University of Adelaide and Geoscience Australia. Thanks are due to Nick Smith, Jingming Duan, Goran Boren, Tanya Fomin, Matt Carey, Esi Eshaghi, Yohannes Didana, Dennis Conway and Joe Rugari for their sterling efforts.

At the time of writing, data acquisition on the transects has been finished, despite complications introduced by a spate of lightning strikes and consequent widespread bushfires. The AusLAMP station coverage has been partially completed. It is expected to be concluded in the third quarter of 2016, following a hiatus while the instruments are required elsewhere.

By illuminating major conductivity structures, this work is expected to yield important insights into Tasmanian 4D geodynamic evolution and mineralising systems, from a new perspective.

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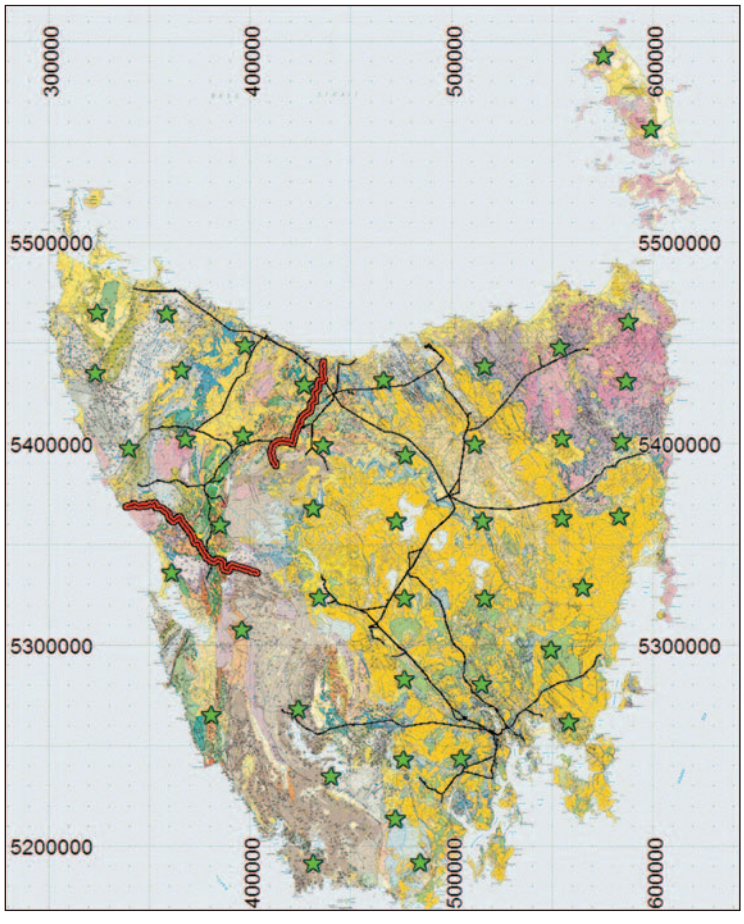

Figure 1. *Magnetotelluric transects (2 km station spacing along the red lines shown) and AusLAMP stations (green stars) currently being acquired in Tasmania, depicted on the State geological map. Black lines denote high voltage transmission lines. Coordinates in metres on MGA zone 55.*

Figure 2. *UTas PhD student Thomas Ostersen collecting MT data.*

GSSA: update

The past few months have been busy for the GSSA as we prepare for two major earth science conventions to be held in Adelaide this year. As well as preparing papers for the conferences we have busy been planning for some major regional geophysical surveys. Stay tuned to *Preview* for more news on these surveys in the near future.

The SA geophysical databases have been undergoing reviews in order to streamline our processing workflows. An upshot of this process is that stakeholders will find more regular releases of public domain geophysical surveys. In particular we're anticipating a major release of public domain gravity data prior to ASEG-PESA-AIG 2016.

The AusLAMP Magnetotelluric programme is progressing well, and at the time of writing stations in the Maralinga area have been deployed, collected, and the data being processed. Over two-thirds of South Australia is now covered with regularly spaced (at 50 km) MT stations.

On the radiometrics front we are investigating the option of moving our calibration pads to a nearby airstrip. This will allow more convenient access for aircraft wishing to calibrate their radiometrics gear. More news on this should be available in the next issue of *Preview*.

Petrophysical data is still being regularly uploaded to our databases and is available online through SARIG.

The new SA Drill Core Reference Library has been officially opened (see the article elsewhere in this issue of *Preview*); however, it won't be open to clients wanting to view core for another few months.

Over 400 legacy geophysics plans (A2 to A0 sized documents) are being scanned as pdfs to be made more easily available to the public. The hardcopies will be archived at SA State Records. The first of these (the Andamooka Bouguer Gravity contours, showing the position of Olympic Dam) is shown in Figure 1.

Phillip Heath
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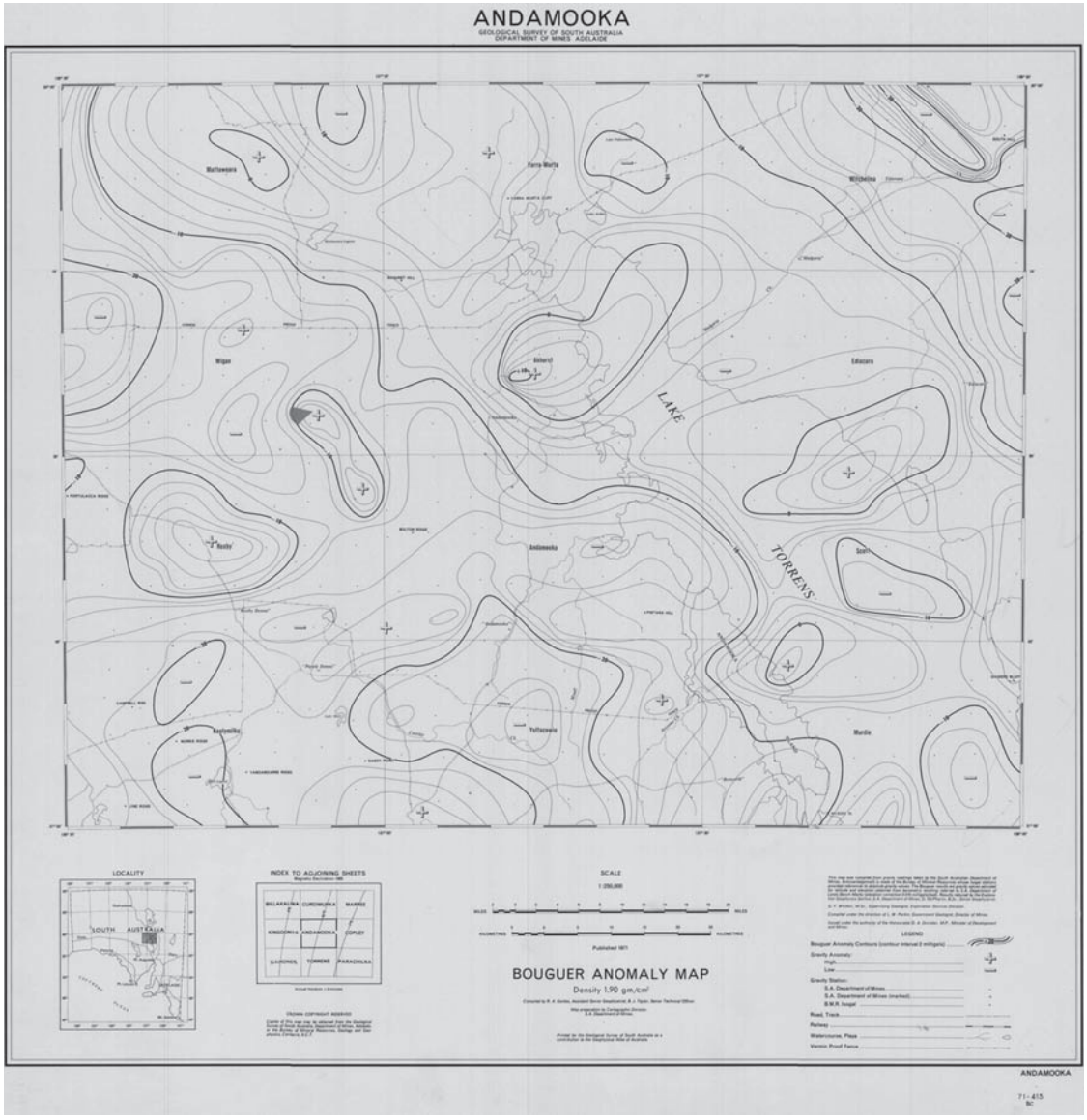

Figure 1. *Adnamooka Bouguer Gravity contours, SA plan number 71-413.*

Canberra Observed

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Resources Minister Frydenberg sees a bright future for the resource industries

There were no surprises in Josh Frydenberg's first address to the National Press Club on 16 February 2016. He outlined the importance of the resource industries to Australia, argued that the future would be bright and indicated what reforms the government was planning.

His talk had three main themes.

First he outlined the essential role resources and energy plays in our economy, something we all know. In his words:

'By tracing the history of mining and energy development in this country one can see how we turned from a series of struggling, underpopulated colonies in the early 19th century to a prosperous, cohesive Commonwealth that has continued to successfully navigate its way through choppy international economic waters in this century and the last.'

According to the Minister: 'In September 2011 our terms of trade reached its highest level in 140 years and the prices of iron ore and coal, our two largest exports, more than doubled in the decade to 2014. In the same period, investment in the resources sector topped $400 billion and the contribution of the sector to the Australian economy jumped from eight to 13 per cent of GDP. Australia is now the number one exporter of iron ore and coal in the world and by 2020 the number one exporter of LNG. We have the largest known reserves of uranium in the world and are in the top five for copper, gold, bauxite, lead, zinc, nickel and lithium.'

Addressing the **second theme** he argued that: 'There will be growing sources of demand for our exports in the future' and 'the reality is that over the decades ahead hundreds of billions of dollars will flow to Australia as both demand and supply increases'.

The extent of this demand is difficult to estimate, because of the recent falls in commodity prices. According to the Minister, despite price falls of between 43 per cent and 57 per cent for coal and iron ore between 2011–12 and 2014–15, our export earnings from these commodities fell by only 16 per cent. This reflects the lower Australian dollar, a 30 per cent increase in coal export volumes and a 60 per cent increase in iron ore export volumes.

In other words, we had to produce more to try and maintain a similar level of income. And, the question remains; how long can we keep doing this, given what has happened to coal, iron ore and oil prices in the last year?

We are now a net importer of oil, but I don't think anyone would argue that the oil price will rebound in the short to medium term. An International Energy Agency (IEA) report released in February 2016 (https://www.iea.org) concluded that:

'Only in 2017 will we finally see oil supply and demand aligned and the enormous stocks being accumulated will act as a dampener on the pace of recovery in oil prices.'

The IEA is forecasting an increase in oil demand to 2021 at an annual average growth of 1.2 Mb/d or 1.2% per annum and that the global oil demand will break through the 100 Mb/d barrier at some point in 2019 or 2020. This analysis does not allow for more chaos in the Middle East but it does suggest that we will have some breathing space to deal with our import bill for petroleum. It also sends a message to the Australian Government about continuing to encourage investment in oil exploration.

There will always be a demand for iron ore and coking coal, but given the current excess capacity in China it may be a few more years before the market recovers.

Furthermore, according to the IEA, China is now investing more in renewables than the US and the EU combined, and half of all new capital invested in the energy sector in 2014 was in renewables.

According to Wood Mackenzie (http://www.woodmac.com/reports/coal-global-thermal-coal-short-term-outlook-november-2015-34606065), 'Chinese thermal coal imports were down 26% in October (2015) to a paltry 10 Mt. That puts total year-end imports at around 145 Mt, down 61 Mt compared to 206 Mt in 2014.'

The Minister pointed to India and Vietnam as growth markets for our coal exports to counterbalance the slowdown in China. Clearly, there will always be a market for good quality coal and iron ore, but it seems that in future it's going to be just a little harder for our exporters of these commodities.

Third, Minister Frydenberg highlighted the importance of geoscience technology to exploration and development and the need for greater labour market flexibility. He complimented the companies now using automation to operate drilling equipment, trucks and trains, and emphasised the value of pre-competitive geoscience data. He quoted the situation in Western Australia where it was estimated that the rate of return for every dollar invested in pre-competitive programs has a multiplier of more than 20 times. Another example quoted was from Geoscience Australia, which undertook $3 million worth of work to obtain new information on the Browse Basin. This facilitated the discovery of the Ichthys Field and will lead to more than $70 billion in export earnings over the next forty years.

The Minister also mentioned the work being done by Geoscience Australia to undertake geological mapping of mineral deposits both near the surface and to depths down hundreds of metres. In addition he said that 'I'm currently consulting with the industry on a range of new measures that could help de-risk exploration in Australia and enhance our competitiveness.' Very encouraging words.

He then went on to the reforms he said were needed in the 'industrial relations space', where there 'needs to be better productivity to encourage greater

investment.' 'The reestablishment of the Australian Building and Construction Commission is vitally important to the resources sector and so too are reforms to union right of entry rules and Greenfield agreements.' The Greenfield issue relates to being able to extend the duration of Greenfield agreements to the duration of the construction period of any particular project. 'Otherwise you have a situation like we've seen at the $70 billion Gorgon LNG project where the completion of billions of dollars' worth of investment can be delayed while protracted and difficult negotiations take place. This is an additional and unnecessary risk that companies have to factor in to their investment decisions which deserves further consideration.'

He **concluded** with the positive message that the 'resources sector in Australia has the economies of scale, innovative practices, highly skilled workforce, and proximity and access to markets that give us the resilience we need at this time.

There is no room, however, for complacency. We are operating in a fiercely competitive global market.

We need the right domestic policy settings if we are going to seize the investment needed to meet the next wave of demand which is coming out of our region.

For these reasons and more, there's never been a more exciting time to be the Minister for Resources, Energy and Northern Australia!'

Who is Josh Frydenberg?

Well, he is a lawyer. He graduated from Monash University with Law and Economics degrees and developed his political interests there, where he was elected President of the Law Students Society. After Monash he went to Oxford University to complete a Master of Philosophy degree in International Relations.

When he returned to Melbourne he worked in a law firm and was admitted as a barrister and solicitor of the Supreme Court of Victoria. He then went to Canberra where he worked as a ministerial adviser from 1999–2004, before taking time off to complete a Masters of Public Administration at Harvard University.

In 2010 he was elected as the member for the blue ribbon seat of Kooyong and was re-elected in 2013. Tony Abbott appointed him to his ministry as Assistant Treasurer and in September 2015, Malcolm Turnbull appointed him the Minister for Resources, Energy and Northern Australia.

So now you know!

CSIRO cuts environmental science

We now know why the CEO of CSIRO (Larry Marshall) is axing 100 scientists from the Oceans and Climate Dynamics and Earth Systems Assessment programs and re-deploying resources to other parts of the organisation. It was all revealed by the Chairman of the CSIRO Board, David Thodey. He said that 'CSIRO has decided to put greater emphasis on delivering technology-enabled innovation that will re-invigorate existing industries and create new ones.' He also said, in reply to the letter of protest sent to the CSIRO and signed by over 2800 people from close to 60 countries, that: 'The overall aim of the strategy is to significantly lift Australia's technology-enabled innovation and in order to meet our national challenges including improving our prosperity and sustainability.' Beautifully crafted words full of meaning and wisdom!

In practice I suspect it means get out there and use the brains nurtured by humble taxpayers to help industry make a good profit.

Specifically the Ocean and Atmosphere and the Land and Water units will be down sized. In other words, short-term profit will take preference over national public-good strategic research, which will be drastically reduced. 'We will be losing expertise in climate research, urban liveability and sustainability, biodiversity and in environmental social and economic sciences,' according to a respected ex-CSIRO source.

I would have thought that, as the number of people on the planet increases at the same time as it is warming, we should be putting more resources into how to forecast the climate, and manage our resources so that we can use food, clean water and clean air on a sustainable basis. Instead of this, we seem to be focusing on short term economic performance.

As Michael Asten implies in his article in *The Australian* on 16 February 2016 (http://www.theaustralian.com.au/opinion/climate-change-csiro-realigns-after-groupthink-fails/news-story/f5e57f67234a11f3c963abb508346dac), a huge amount of work needs to be done before the changes in the Earth's climate can be reliably forecast in periods greater than a few weeks. At present the Government puts a much higher value on buying new defence equipment than in managing our environment. The $28 million allocated to spruik innovation might also have been useful for undertaking research.

I am told that Larry Marshall did not advise the Chief Scientist (Alan Finkel), the Minister for Innovation and Science (Christopher Pyne), or the Minister for Environment (Greg Hunt) that he was going to make these changes. There is also some doubt as to whether or not the CSIRO Board was consulted before the announcement was made.

The big question for the Government now is how is long-term strategic research going to be managed in the future? The universities can't do it. They live from hand to mouth on short-term grants; it can't be done by agencies such as Geoscience Australia and the Bureau of Meteorology because, despite carrying out some research, the core business of these agencies is to deliver data and information. So the Government had better move quickly to correct the situation. As the President of the Australian Academy of Science Andrew Holmes said: 'Why would you want to throw away something that we're good at and that's useful?' It just doesn't make sense.

Maybe the CSIRO should be split in two. One part funded wholly by the Government for public good strategic research and the other apart able to undertake short-term projects with industry. Clearly the present situation is not working.

Addendum to the piece on the Government's National Innovation and Science Agenda in the last issue of *Preview*

Readers may be interested to know that in the 2001 Federal Budget $159 million was allocated to implement the Prime Minister's Innovation Action Plan. John Howard was ahead of his time and there is now no escape from innovation, it is ubiquitous.

Education Matters

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This month we continue our series on science education in schools, with an article from Ofa Fitzgibbons of the CSIRO Education and Outreach group. This group aims to encourage science technology engineering and mathematics (STEM) education by linking practising scientists with class-room teachers in secondary schools. Such an education initiative complements programmes discussed in past issues of *Preview*, such as the ESWA field programmes (*Preview* February 2016) and TESEP workshops for science teachers (*Preview* December 2015).

We also bring news of a new initiative in marine geosciences – the CAPSTAN project, which will stir the imagination of budding scientists with an interest in all that swims, floats or sinks.

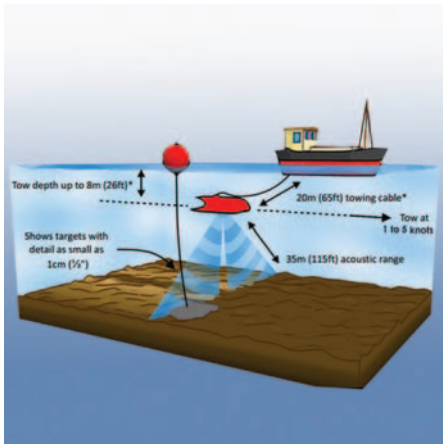
Doug Roberts brings us good news of strong interest in the ASEG Research Foundation, and lastly, supplementing our list of thesis abstracts as published last December, we have six abstracts from Western Australia, including from three ASEG Student Award winners. Special congratulations to Jacob Jackson who won the ASEG WA student night Best Presentation Award for his talk on long offset refraction tomography.

Bringing real life science into the classroom fosters STEM education

For a small group of year 4 and 6 girls at St Mary's Anglican Girls School, Karrinyup (north of Perth, WA), an introduction to engineering, mathematics and science experiments have taken a new spin thanks to Roger Fletcher. Roger is a geophysicist who worked with the school's science teacher Dencker Morrison to bring science to life in the classroom. Doing these experiments in the classrooms is a chance for Roger to share his enthusiasm for engineering, mathematics and science related subjects with the next generation. For Dencker, the experience of working closely with Roger to develop activities gave her an insight in to an area of science that she will now be able to bring to her teaching practice.

Roger Fletcher.

For a number of sessions during one school term, Roger shared some stories of his professional experience with the students, from his schooling to a degree in Material Sciences, to various jobs including doing hydrographic surveys around the world using instruments like side scan sonars.



An example of a sea sonar similar to what was used by Roger during his professional career. Image source: http://seafloorsystems.com/images/com_hikashop/upload/tritech-starfish-990f-diagram.png.

Roger's background in geophysical surveying and large engineering projects enabled him to provide real life examples of how mathematics and engineering can be used for tasks like profiling the ocean floor and dredging seabeds. He ran a number of 'show and tell' sessions with the classroom, which involved sharing visuals and images of his work experience out at sea (see pictures). These sessions offered students a practical insight into the area of surveying and geophysics.

An example of a weather station on a lake representative of Roger's work with the Centre for Water Research. Image source: Google.

Science, Technology, Engineering and Mathematics (STEM) subjects and skills are now considered essential to driving industry innovation in Australia. Yet there is increasingly more public discussion around the critical shortage of STEM skills and the declining participation rates of school students undertaking STEM subjects in school. The Scientists and

Mathematicians in Schools (SMiS) helps address this challenge.

As Australia's largest skilled volunteering programme for STEM professionals and STEM educators, SMiS offers participants the opportunity to make a positive difference to the education of Australian students from kindergarten to senior secondary. Managed by CSIRO, the programme creates flexible partnerships by matching professionals and educators and providing ongoing support to build a collaborative partnership. This means partnerships leverage the expertise of each person to create classroom experiences not otherwise possible if each participant was acting alone.

At St Mary's Anglican Girls School, Roger was able to help demystify complex mathematical themes by doing experiments with rulers and protractors to triangulate a position on a marine map of Perth. The activity also highlighted aspects of geodesy, to account for time zones and curvature of the Earth. This is one of the many ways in which a STEM professional and teacher can showcase real-world, contemporary science experiences for students.

For teachers, the programme really gives educators a chance to build on the natural curiosity the students have about how the world works. Creating modern science experiences also helps to foster their critical thinking and problem solving skills, while at the same time, allowing them to have a lot of fun with science.

For professionals and scientists, the benefits are many. 'Seeing the fascination and awe in the face of the students as they get hands on experience of building a model rocket for the school's open day is a real highlight for me', said scientist Roger Fletcher. 'I am passionate about my vocation and experience, and enjoy being able to inspire young students about science.'

Ofa Fitzgibbons

CAPSTAN: a new initiative in marine geosciences

A new programme, the Collaborative Australian Sea Training Alliance Network (CAPSTAN) is under development by ten universities and government bodies. It is the first of its kind as a sea-based training programme for postgraduate students on-board Australia's principal research vessel, RV Investigator.

In 2017–2019, three pilot voyages will be run with up to 30 postgraduate students along with research active academics and trainers. A series of stake-holder surveys is currently in progress in order to define the scope of the programme, and enrolments for master-level students on the first pilot mission in mid-late 2017, will open in 2017. Current partners include:

Macquarie University • Marine National Facility – CSIRO • Geoscience Australia • Integrated Marine Observing System • Sydney Institute of Marine Science • Department of the Environment – Australian Antarctic • University of Tasmania • Australian Maritime College • University of Canberra • Australian National University • University of Sydney • University of New South Wales • University of Technology Sydney • University of Western Australia • Western Sydney University.

The intention is to gain additional funding and collaboration from industry partners.

Up to date information is available from the project website at http://research.science.mq.edu.au/capstan/, and from the Chief Investigator, Dr Leanne Armand at Macquarie University, leanne.armand@mq.edu.au.

A record number of applications to the ASEG Research Foundation

Our Research Foundation is now in its 27th year of operation (see its history described in *Preview* December 2014, available online on our website at http://www.publish.csiro.au/?act=view_file&file_id=PVv2014n173p44.pdf). This year the ASEG RF reports a record number of applications for grants – eighteen from seven universities in total, compared with about eight per year in the past. Three sub-committees are currently assessing the documents.

Project proposals cover the full spectrum of applied geophysics, with seven in mining geophysics, eight in petroleum and two in engineering geophysics. The RF expects to distribute about $100 000, spread over three years, to support a selection of these projects.

Student geophysical projects at Curtin University and University of WA (2015)

Postgraduate Student Projects

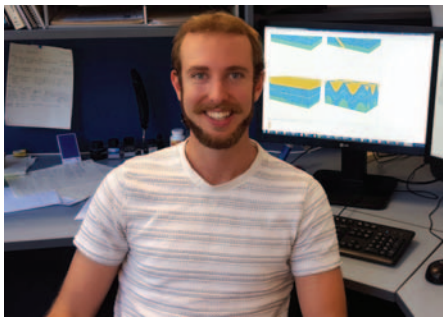
Jacob Jackson, Curtin University: *The application of long offset refraction tomography to improve seismic reflection imaging in the Perth Basin.*

Refraction tomography methods have long been applied to near surface applications including groundwater exploration. The velocity models they produce can provide information useful for static corrections and migration processing of reflection data. Typically refraction tomography is only undertaken for small offsets to create velocity models for the top 10 m of the subsurface. This investigation demonstrates that velocity information for depths of up to 450 m can be obtained when refraction tomography is undertaken using super long offsets of 7.5 km.

It is also shown that significant improvements in the imaging of seismic reflectors are observed if the tomographic model is used for reprocessing and depth conversion. The ability of refraction tomography to resolve a shallow low velocity layer and accurate high-resolution velocity variations contributes to the improved imaging. The lateral velocity changes were also found to correlate well with the seismic data and sedimentary packages delineated from log data and other velocity studies in the area. Of significant advantage is the robust depth conversion translating to improvements in depth to key formations. This provides better constraint when building large scale accurate hydro dynamic models particularly for hydro stratigraphic units below the depth of existing boreholes.

Jacob Jackson recently graduated from Curtin University with an MSc in Geophysics and previously received a BSc in Geology from the University of Western Australia. He is currently working as a contractor at Santos and is looking forward to pursuing a career that allows him to use and refine both his geology and geophysics skills. Jacob received the ASEG WA prize for Best Student Presentation and an ASEG WA 2015 Student Award.

Tom Horrocks, University of Western Australia: *Machine Learning Methods for Three-dimensional Lithology Classification from Inverted Mine-Scale Geophysical Surveys and Downhole Data.*



A robust three-dimensional lithology model is vital for mine planning and efficiency. A simple model can be entirely based on downhole lithology logs, but the interpolation required between holes introduces error. A more accurate but complicated lithology model, which suffers less from spatial interpolation error, can be built using rock properties from wireline logs and inverted 3D geophysical surveys,. However, there are common issues that arise with the latter type of modelling, namely: (i) rock properties from wireline logs must be upscaled to the voxel's scale; (ii) rock unit boundaries are difficult to extract from the inversions due to smoothness constraints in the inversion algorithms; and (iii) the final 3D lithology models often provide single 'representative' lithology estimates per-voxel, rather than estimated lithology proportions with uncertainty.

My thesis aims to design algorithms that create 3D lithology models based on lithology logs, wireline logs, and 3D inversions, while addressing the issues mentioned above. Currently, a kernel density estimation-based clustering method (written in Java) is being evaluated for boundary extraction from the inversions, and in the future machine learning pattern recognition techniques will be evaluated for unbiased prediction of both 'representative' lithology and the proportions of each lithology per voxel. The Kevitsa Ni-Cu-PGE deposit (Lapland, Finland) is used as the case study, with First Quantum Minerals Ltd providing lithology logs, inverted voxets of density, magnetic susceptibility, conductivity, and the associated wireline logs.

Tom Horrocks was awarded the 2015 ASEG WA Branch Student Award, and is a second year PhD student from the University of Western Australia, supported by the Robert and Maude Gledden Postgraduate Scholarship and by First Quantum Minerals.

Baichun SUN, Curtin University: *Seismic while drilling imaging in hard rock environment.*

Drill-bit Seismic-While-Drilling (SWD) is a passive seismic-imaging method, which is implemented by utilising the drill-bit vibration as a seismic source. A receiver array is generally deployed on the surface of the earth or in boreholes to capture the drill-bit signals. In an ideal situation, the passive signals are converted into a seismogram similar to Reverse Vertical Seismic-Profiling (RVSP) using cross correlation. This seismic method requires no additional rig time, but provides one of the benefits of acquiring the real-time seismic data used for imaging around the bore hole.

For the application of the SWD method, the energy of the drill-bit vibration is an important factor to success, so it is understood that most successful drill-bit SWD experiments were completed with a rock-crushing roller-cone bit in petroleum industry. However, there are few successful SWD experiments performed in the mining industry, even in hard-rock applications. One of the main reasons is because of the dominant use of the diamond impregnated drill-bit, which is generally quiet while drilling.

The study of this thesis focuses on application of SWD in hard-rock environments and investigates the feasibility of acquiring and utilising weak diamond drill-bit emitted signals. To study the SWD applications in hard-rock environments, three main subjects of the research are investigated and presented in the thesis. They include:

- Investigating methods that suppress strong coherent noises generated from the rig site;
- Comparing coherent signal detection methods in terms of detectability and imaging resolution, then performing velocity analysis and imaging using the acquired drill-bit signal;
- Comparing radiated energy from different drilling methods in hard-rock environments: diamond-impregnated drilling and Reverse-Circulation drilling.

Both synthetic and field data are exploited in the studies. For the field data example, there were two experiments conducted at Brukunga and Hillside in South Australia. For the purpose of drilling signal characterisations, rig coherent noise suppression and the drill-bit imaging, the data from the Brukunga experiment were investigated. Firstly, to extract the drill-bit signal from strong rig-site noise, I demonstrate the use of Karhunen-Loéve (KL) transform to separate the possible drill-bit wavefields. I show that this method is effective and has little or no contamination from the desired drill-bit wavefield when it is

applied in a SWD common receiver gather. This method is compared with f-k filter, and its advantage is demonstrated in an SWD application. Secondly, to image a diamond drill-bit with high spatial resolution using its weak wavefields, I compare different coherent signal detection methods including: semblance and Multiple Signal Classification (MUSIC). Synthetic examples are used to demonstrate the differences between the two methods. The MUSIC-coherency method manifests higher spatial resolution compared to semblance when imaging a buried unknown source. The resolution and signal detectability by MUSIC can be controlled by the signal space dimension. I show that with added coherent noise and large wavefront time-shift errors, MUSIC method still shows comparable measurement to semblance. Therefore, the MUSIC coherency method can be utilised as a good complement to semblance in terms of improved image resolution.

To understand the different level of energy radiation from different drilling techniques, I compare and analyse the energy emitted from hard-rock drilling between diamond impregnated and Reverse-Circulation (RC) drilling from the Brukunga experiment. The two drilling mechanisms generate very different seismic wavefields. From the field data, by investigating the raw data energy, frequency analysis and cross correlation test from the field data, the seismic responses from percussive RC drilling provide a strong indication that the drill-bit energy can be suitable for drill-bit seismic imaging purposes. It may also provide high-resolution images with bore hole seismic acquisition. In contrast, at comparable drilling conditions, the diamond bit drilling is quiet; its energy is difficult to detect by a surface receiver array.

The techniques studied in the thesis, such as MUSIC and KL transform, can be applied to other similar SWD experiments. Some other research topics, such as correlation of the narrow-band drilling signal and drill-bit interferometry migration, are also investigated in the thesis. All these studies highlight the importance of future research for applications of SWD in mineral exploration.

Dr Baichun Sun is currently working with Halliburton in Singapore as senior scientist. He received a PhD degree in geophysics from Curtin University, Western Australia, and previously a BSc in Physics from China. His main interest is in acoustic logging, borehole acoustic modelling and borehole seismic. He is author of four journal papers, multiple conference/workshop papers and two patents pending.

Lee Tasker, University of Western Australia: *4D Monitoring of Civil Infrastructure using Multichannel 3D Ground Penetrating Radar.*

The aim of the PhD project is to develop a 4D-monitoring tool using multichannel 3D GPR technology to scan and image infrastructure over calendar time to enhance and improve the ability to accurately identify, interpret and monitor structural defects: (1) cracking and/or voiding present within infrastructure; and (2) volumetric changes of regions experiencing structural deformation. As a result of this research geophysicists will be able to provide Civil and Asset Management Engineers with more accurate infrastructure-monitoring tool and geophysical data to better understand the material behaviour of their infrastructure over calendar time. These near-surface geophysical tools would prove most useful in the planning and prioritising of long-term maintenance of an infrastructure, saving time, money and improving the overall safety management of the infrastructure.

Lee Tasker is a PhD student at the University of Western Australia (UWA) and a Geophysics Consultant with Draig Geoscience. He specialises in near-surface geophysics, with a focus on geophysical solutions to engineering problems. Lee has a Master of Physics (MPhys) from Cardiff University, UK and a Graduate Diploma in Science (GradDipSci) in Geophysics from Victoria University of Wellington (VUW), NZ. With over eight years of professional geophysical consulting experience, he has worked both nationally and internationally on projects in the engineering geophysics, environmental, heritage and exploration fields in Australia, Mongolia, New Zealand, Pakistan and Papua New Guinea. Lee also serves as the Western Australian Members Representative for the ASEG Near-Surface Geophysics Group. He received an ASEG WA Student Award in December 2015.

Honours projects

Joshua Meertens, Curtin University: *Generation of a 1D velocity model through inversion of earthquake arrival times, Kalgoorlie, WA.*

The cause and nature of the anomalously high levels of seismic activity within the Yilgarn Craton of Western Australia is not fully understood. Earthquake monitoring in WA is sparse, and the use of inadequate Earth models impedes the ability to analyse seismic activity accurately. Current models used for routine hypocentre locations leave the near surface under-represented, an issue that needs to be further investigated since seismicity in the region is typically very shallow (<5 km depth).

A new 1-D Earth model has been generated from inversion of the first arriving P- wave and S- wave phases sourced from the 2010 ML 5.0 Kalgoorlie earthquake and aftershock sequence. The model describes two layers; a near surface layer of 0.75 km thickness with VP = 5.90 km/s and VS = 3.50 km/s above the upper crust with VP = 6.10 km/s and VS = 3.59 km/s, applicable to approximately 10 km depth. Analysis of the travel-time data provides an average VP/VS ratio of 1.70 for the region.

The new model reduces the RMS travel-time residual for this dataset by ~25% in comparison to the next best solved 1 layer case, confirming that inclusion of a lower velocity surface layer does improve earthquake hypocentre locations and more detailed crustal models are valid on large scales. Re-location of the events measured with a sparse network (a maximum of 12 stations up to 70 km away from the epicentre zone) improved focal depths significantly. With respect to the most accurate model (WA2) currently used for routine locations, events were pushed up to 1 km deeper into the focal zone identified with constrained data. It is expected that the new 'KLG' model will

improve analysis of earthquakes within the Eastern Goldfields region.

Interpretation of this period of activity supports previous conclusions that the N–NNW trending Boulder-Lefroy Fault was the major control over stress-release during this time. This structure is the likely candidate for the main earthquake rupture, although it is possible that smaller, more complex, linkage or en echelon faults may have also been activated. Observation of the focal depths is consistent with the shallow nature of seismicity seen elsewhere in the Yilgarn Craton.

Joshua Meertens completed his Honours degree in Geophysics in 2015 at Curtin University. He also received the Chevron Geology/Geoscience Honours Scholarship in 2015 and was twice a member of the 2014 Vice Chancellor's List for achieving in the top 1% of Curtin undergraduates.

Bryce TEO, Curtin University:
Permeability and electrical resistivity changes in Leederville aquifer core induced by transient physicochemical conditions.

Permeability reduction in aquifers caused by the release and deposition of in-situ colloidal particles can impact on the long-term sustainability of groundwater recharge operations. Experiments were performed on a Leederville aquifer core sample to examine the effects of near-well transient physicochemical perturbations on permeability, within the framework of colloid release and deposition processes. The flow rate, ionic strength of the injectant, and flow direction were varied in a stepwise manner. Significant permeability losses during the early injection of highly-treated recycled water indicated that colloids were sensitive to release in low ionic-strength solutions. Permeability reduction during the injection of recycled water was irreversible at low flow rates. Experiments suggest that: when native formation water was restored at each flow rate, the extent of permeability recovery depended on the distribution of pore water velocities; and under constant flow conditions, permeability recovery during the injection of saline solutions was controlled by diffusive processes in stagnant flow locations. When the direction of injection was reversed, the permeability of the sample improved, however, this improvement was not reflected when the initial direction of injection was restored – a conceptual model was described to account for this behaviour.

Bryce Teo completed his Geophysics Honours Degree in 2015, supported by Water Corporation of Western Australia. He is now a PhD student at Curtin University. His research will focus on further developing the seismoelectric method for hydrogeological applications. Bryce has been awarded an Australian Postgraduate Award (APA) Scholarship to support his PhD studies.

Editor's postscript: All postgraduate and honours students (and their supervisors) are reminded that the December 2016 issue of *Preview* will feature summaries of students projects completed in 2016. Please submit a summary of your project together with a short bio and photo by 11 November 2016. As in previous years, the best student photo (you carrying out your research) will be selected for the cover – so start thinking about how to construct that evocative image now!

Environmental Geophysics

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This month I have been presented with an interesting problem sent in by a researcher from the University of the Sunshine Coast. Adrian McCallum is a researcher in geology and geomechanics (etc.) with a bent toward subjects having to do with ice and snow (based at the Sunshine Coast!?!). I am envious of the projects that he is working on and would love to be participating in them – have a look at his USC website: http://www.usc.edu.au/university/faculties-and-divisions/faculty-of-science-health-education-and-engineering/staff/adrian-mccallum

In this project his group has gone in hard on a project to measure ice thickness on a glacier in New Zealand. In hindsight, I think that we would all agree that a few mistakes were made. Nevertheless, Adrian is hoping that someone out there in the community of geophysicists that read *Preview* knows whether it is possible to retrieve the data that is buried in the early time response of the GPR system that his team built for the project. Here is Adrian's story:

Interpreting radar data from the Bonar Glacier, New Zealand – where to from here?

Adrian McCallum
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The Bonar Glacier is a high-level valley glacier situated in the shadow of Mt Aspiring, in the New Zealand Southern Alps (Figure 1). Whilst glaciological studies have been undertaken on many New Zealand glaciers (Chinn, 2001) and mountaineers regularly access the area, no glaciological observations of the Bonar Glacier are known to have occurred (T. Chinn, pers comm., 18 June 2014).

A small glaciological expedition to the Bonar Glacier was conducted over the period 22 May to 1 June 2014 to carry out a preliminary glaciological assessment of the glacier. The intent of the research was to confirm logistical arrangements necessary to access the glacier and to obtain preliminary surface ice movement and ice thickness information.

Ongoing analysis of recorded radar data is proving challenging. This letter serves as a brief presentation of recorded data and analysis to date, the intention being to draw productive discussion and advice from the broader geophysical and glaciological community, to better allow for useful interpretation of gathered data.

Access to the Bonar Glacier was made on foot, via French Ridge from the road-head at Raspberry Flat. Testing occurred over the period 28–30 May 2014, based from Colin Todd Hut (Figure 1).

The original intent was to use commercially available Ground Penetrating Radar (GPR) equipment. However, personal communication (L. Mingo, 14 February 2014) suggested that other groups had experienced difficulty in imaging to depths of ~300 m in polythermal valley glaciers with the commercially available equipment, therefore it was decided to use a radar system that we would build in-house based upon the Narod impulse transmitter

Figure 1. *The Bonar Glacier in the Mt Aspiring National Park, New Zealand. Mt Aspiring is in the top left of the image. Approximate position of Colin Todd Hut and the access ridge (French Ridge) are noted. (Image courtesy of New Zealand National Institute of Water and Atmospheric Research (NIWA).)*

(Narod and Clarke, 1994). The system used a centre frequency of ~8 MHz, utilising 5 m long resistively loaded dipole antennae. These antennae were constructed with guidance provided from Icefield Instruments Inc. (2000); each antennae dipole arm consists of five wire-linked resistors in series, giving a total resistance of 205 ohms per arm. The ice profiling system was comprised of:

1. Narod impulse transmitter;
2. 5 m resistively loaded transmitting antenna;
3. 5 m resistively loaded receiving antenna, with 50 ohm feed-through adapter to reduce noise; and
4. Picoscope 5243A, 2-channel, 100 MHz, USB oscilloscope, for identification of received radar pulse and data recording.

Use of Gecko data acquisition software (Pettersson, 2014) was envisaged. However, incompatibility with the 5243A Picoscope USB oscilloscope meant that continuous profiling was not possible and only discrete data were obtained; forty soundings were collected over a two-day period. Data were recorded by photographing the screen of the Panasonic Toughbook laptop. Selected individual digital photographs were later digitised using GraphClick software (Arizona Software, 2010) to enable data manipulation. Figure 2 shows an example of the radar data as photographically recorded and Figure 3 shows an example

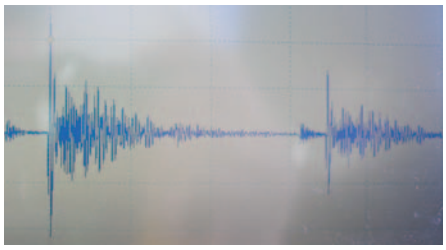

Figure 2. *Photograph of typical ice radar return. In this image, each vertical increment represents 40 mV and each horizontal increment 1.0 µs. The yellow diamond shows the value (+80 mV) at which the oscilloscope trigger was set to commence data capture.*

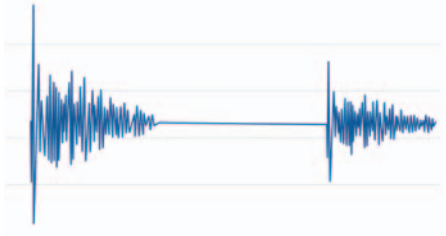

Figure 3. *Digitised version of data shown in Figure 2, created using GraphClick.*

of digitised data, generated using GraphClick. Most recorded data were of this form or similar in nature.

Upon initial examination of data such as that represented in Figure 2 we naively assessed that the second pulse of radar data may be a bedrock return. However, discussion with colleagues suggested that such an assessment was most probably incorrect and that the observed second return was likely to be an air return from the walls of the mountains surrounding the valley glacier. Cursory calculation suggests that such a suggestion was plausible as a delay of ~6 to 7 µs (as evident from the timing in Figure 2) suggests a distance to reflective air boundaries of ~1000 m; this is consistent with the geometry of the location. Later in the data evaluation process we decided that it was possible that these returns may be an artefact or 'ghosting' caused by antennae or system architecture. We are still not sure what to make of this signal.

Continuing this line of investigation, further discussion with T. Chinn (pers. comm., 18 June 2014) and application of Equation 1 (Chinn, 2001)

$$D = 5.2 + 15.4\ A1/2 \qquad (1)$$

where D is mean ice thickness (m) and A is total glacier area in km^2, suggested that for the Bonar Glacier, area ~20 km^2, the ice thickness was likely to be on the order of ~70 m.

If the speed of sound in ice is assumed to be ~1.67 × 108 m s^{-1} (Hubbard and Glasser, 2005) then a bedrock radar return may be expected ~0.4 µs after transmission. This is the zone highlighted by the rectangle in Figure 4. The

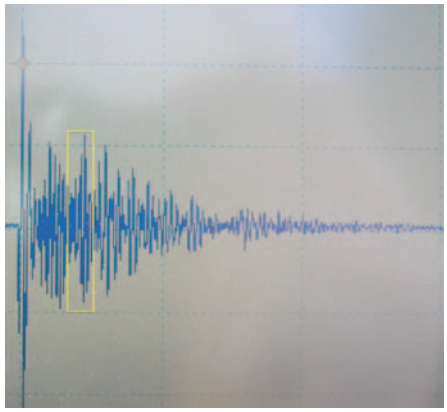

Figure 4. *Time zone (rectangle) in which a bedrock return may be expected if ice thickness was ~70 m. Data collected in this time range is 'smothered' by the transmitted radar pulse resulting in limited potential for bedrock return extraction, should it exist.*

implications of this observation is that any bedrock return (if it exists) is expected to lie within the time range obscured by the extended transmitted pulse, rendering immediate observation very difficult. We then tried to digitise the transmitted wave form, and remove that from the signal, hoping that we would be left with our bedrock reflection. However, this additional manipulation yielded no more conclusive results.

Therefore, after a series of iterative data interpretation and analysis efforts, including discussion on both system design and post-acquisition analysis, it appears that no readily extractable bedrock data is available from the acquired data. As a result, advice is sought from the broader glaciological and geophysical communities on suggested methods by which ice thickness/depth to bedrock data may be extracted from the existing dataset. We are hoping that there may be methods to remove the air/ground wave that seems to be obscuring the bedrock contact data.

Acknowledgements

This research was funded by a Faculty Research Grant from the Faculty of Science, Health, Education and Engineering at the University of the Sunshine Coast. Considerable assistance was provided by Rickard Pettersen, University of Upsalla and Laurent Mignon, Blue Systems Integration. Their assistance in facilitating the progression of this work to this point is most appreciated.

References

Arizona Software, 2010, *GraphClick*, version 3.0.2.

Chinn, T. J., 2001, Distribution of the glacial water resources of New Zealand: *Journal of Hydrology. New Zealand*, **40**, 139–187.

Hubbard, B., and Glasser, N., 2005, *Field techniques in glaciology and glacial geo-morphology*: John Wiley & Sons, Ltd.

Icefield Instruments Inc., 2000, *Ice penetrating radar – instructions for use*: White-horse, Yukon, Canada. 1.3b ed., minor changes 25 May 2005.

Narod, B. B., and Clarke, G. K. C., 1994, Miniature high-power impulse transmitter for radio-echo sounding: *Journal of Glaciology*, **40**, 190–194.

Pettersson, R., 2014, *Gecko GPR data acquisition software*.

Seismic Window

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Wavelets, sandy beds and spectral decomposition

In the exploration business there are times when a well discovers hydrocarbons but the reservoir quality is poor. As a result the initial euphoria in the office turns to a more sombre mood as press releases are rewritten and resource estimates revised. So is it possible to predict good quality blocky sands with sharp contacts from ratty, fining upwards beds and avoid the potential let down?

We could put together a sequence stratigraphy story to predict where to expect good quality sands or we could process the data some more and produce a veritable array of different inversion products, but this takes time and money, which is quite scarce these days. Can we use the regular seismic data to help? It is easy to model the seismic signature of different depositional patterns and to identify the response associated with the preferred geology. Figure 1 shows some simple models and seismic responses for a blocky bed with sharp contacts above and below, a fining upwards bed with a sharp base and a coarsening up bed. All the modelled beds are 20 m thick. As can be seen, all the models have a distinctive seismic response which should be easy to discern (Table 1). Of course we have to deal with noise including interference from surrounding reflectors but still it should be possible for a good interpreter.

One trick is to apply a –90 degree phase rotation to the seismic data. This is often used as a quick approximation of an inversion and the troughs between zero crossings now mimic the depositional motif as seen in Figure 2. Of course, not being a true inversion, the side lobes of the wavelet remain and distort the picture somewhat but the essentials are there. That's all fine, but is real data as neat as the models? The real data examples show some wiggles over the more common colour display with a gamma log overlay at a well location. Figure 3 shows a thin blocky sand with some minor fining up in the well. To the right the seismic waveform is symmetric suggesting a clean blocky sand while to the left the waveform becomes asymmetric as the trailing peak strengthens. One possible interpretation is that the reservoir to the left has coarsened at the base. Figure 4 shows a blocky bed with the gamma log suggesting shale content is increasing downwards. To the left the pattern is similar to the trace at the well intersection but to the right it appears the basal contact becomes more gradational resulting in weak trailing reflection.

Spectral decomposition is another tool that is available on workstations and may be some help in determining the reservoir quality. Put simply, a sharp boundary can be considered to have a broad frequency content while a gradational contact is relatively low frequency so, if we display the frequency spectrum at each boundary, it should be possible to identify the type of boundary present (Figure 5). The high amplitude sharp contacts do indeed have a broad frequency content peaking at

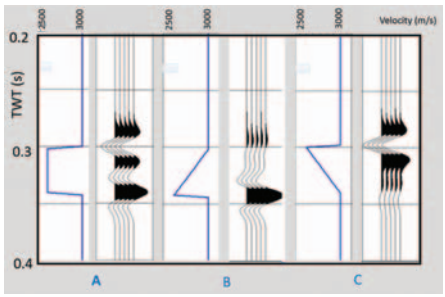

Figure 1. *Models and synthetic seismogram signature of: A – blocky bed, B – fining up bed and C – coarsening up bed. Each bed is 20 m thick and a 30 Hz Ricker wavelet was used. This wavelet has relatively strong sidelobes.*

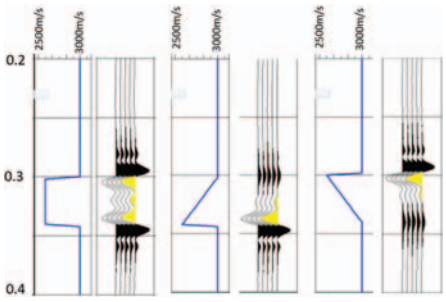

Figure 2. *Models with –90 degree phase rotation applied to wavelet that results in an approximation to inversion. An Ormsby filter was used to minimise sidelobes.*

about 35 Hz, while the gradational contacts are represented by a weak, low frequency anomaly. Expanding on this, we could create an attribute that measures the amplitude difference between high and low frequency components, say the 20 Hz and 40 Hz components (Table 2). A map of this attribute calculated along a seismic reflection could delineate areas of

Table 1. Characteristics of seismic waveform associated with various models

Model	Top	Bottom	Waveform
A. Blocky	Sharp	Sharp	Symmetric
B. Fining up	Gradational	Sharp	Asymmetric – trailing peak
C. Coarsening up	Sharp	Gradational	Asymmetric – leading peak

Table 2. Example calculation for attribute to discriminate sharp from gradational contacts. Method 1 uses spectral decomposition. Method 2 uses high and low cut filters on data

	Method 1 – Spectral decomposition			Method 2 – Band pass filtering		
	20 Hz Amplitude	40 Hz Amplitude	Difference Amp(20) – Amp(40)	Low pass 30 Hz Amp	High pass 30 Hz Amp	Difference Low-High
Sharp	0.7	0.9	–0.2	–370	–520	+150
Gradational	0.3	0	+0.3	–66	–31	–35

sharp or gradational boundaries. (A similar attribute can be created by applying a low pass and high pass filter to the seismic data and measuring the difference in amplitude of a reflector).*

Finally, a word on wavelets. The modelled synthetic seismograms in Figure 1 were calculated using a 30 Hz Ricker wavelet which is a fairly standard wavelet used by most interpreters even though it is not well understood by them. In fact most would have trouble describing the frequency content of a Ricker wavelet. Other wavelets can and should be used and some are shown in Figure 6. The Ricker, Butterworth and Klauder wavelets yield similar results. Also shown is a selection of Ormsby wavelets, which tend to have smaller side lobes, and a minimum phase wavelet that is just ugly. Interestingly, at the recent February ASEG meeting in Perth the speaker suggested the frequency content of a recent broadband processed survey contained useful frequency content as low as 2 Hz and as high as 160 Hz (like the high frequency Ormsby wavelet second from the right) which requires processing at a 2 ms sample rate to avoid aliasing. Notice how this wavelet produces a waveform that is getting close to the reflection coefficient display – which was the ultimate goal when I started working in the seismic industry.

*If you try this let me know how it went.

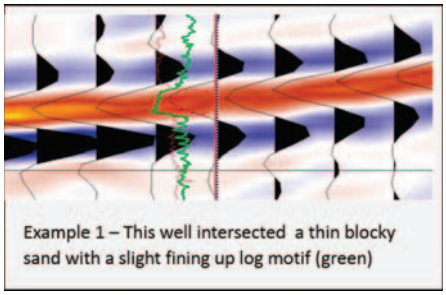

Figure 3. *Real data example with interpreted blocky bed to the right and more gradational top to the left. Good choice for the well location!*

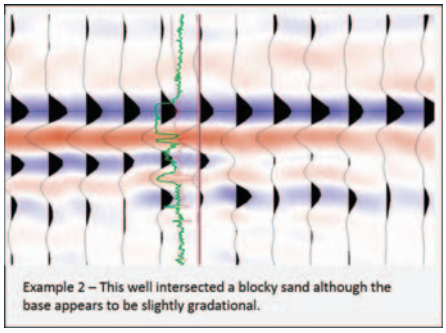

Figure 4. *Another example with the well between a blocky bed to the left with the base becoming more shaley to the right. Another good choice of location!!*

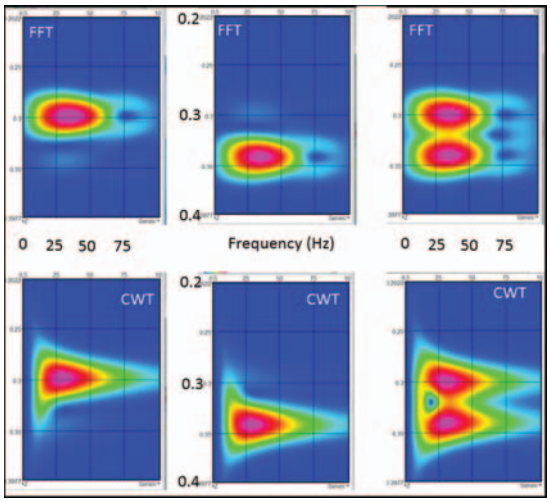

Figure 5. *Spectral decomposition display of the 3 models of Figure 1. Top is FFT version while bottom uses CWT. Horizontal axis is frequency, vertical axis is TWT. Contact attribute Amp (20 Hz) – Amp (40 Hz) = 0.8 – 0.9 = –0.1 at sharp contact and 0.3 – 0 = +0.3 at gradational contact.*

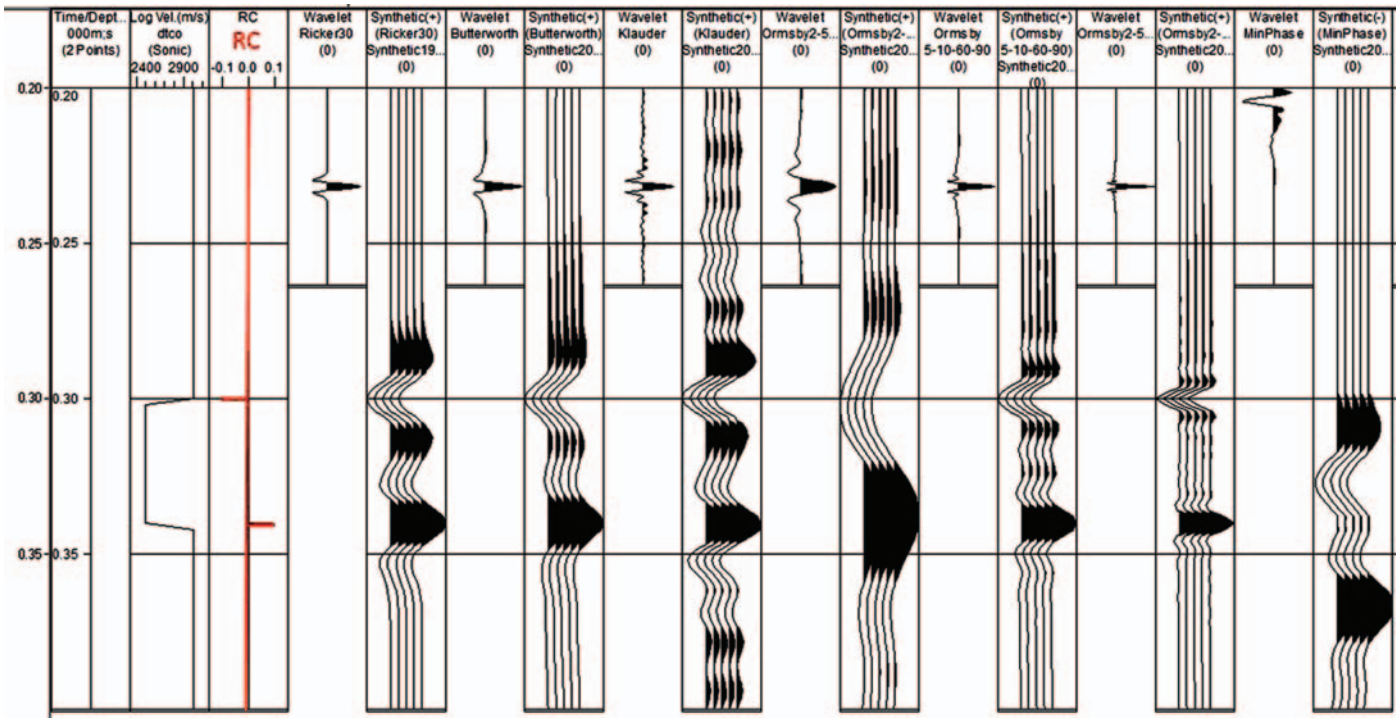

Figure 6. *A comparison of different wavelets and the resulting seismic signature of the blocky model. Left to right: 30 Hz Ricker, 10–60 Hz Butterworth, 5–60 Hz Klauder, Ormsby a) 2-5-20-30, b) 5-10-60-90, c) 2-5-100-160 and a minimum phase wavelet.*

Webwaves

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In *Preview* 178 Dave Annetts foreshadowed an introduction of the rest of the new-look ASEG Web Committee. Fresh from the 2015 ASEG-PESA COC I had volunteered to help out. We have been steadily making progress and one day you may even be able to navigate the ASEG website on a mobile device.

Based in Perth, I operate a geophysical consultancy. Terraspect is focussed on the application of seismic methods to the exploration and engineering industries. In particular, I am a land seismic processor specialising in refraction statics. I am also the agent for the GLOBE Claritas processing suite in Australia.

The Web Committee has been busy over the past few months looking at how to improve the ASEG website. This inspired me to use this Webwaves column to write about one of the approaches that is commonly used in website development. Agile is one of the foremost approaches to web and software development, and the principles of Agile development are highly transferable to the geophysics industry.

What is Agile?

The analogy I favour is that of missiles (http://www.coopersystems.com.au/what-is-agile/). Take the Tomahawk Cruise Missile. It is designed to deliver a warhead over a long distance with high accuracy. Before firing the missile the target is well defined, and any deviations are mapped out. After deployment the missile flies at subsonic speeds following a set path using the built-in GPS along with other guidance systems. This is not agile.

Instead, let us consider an air-to-air missile like the AMRAAM. The AMRAAM travels at Mach 4 and has beyond visual range capabilities. When the pilot fires the missile he is aiming at a moving target. When fired the AMRAAM flies as fast as it can at the current projected location of the target. Frequent RADAR updates allow the missile to change course and intercept the moving enemy fighter. This is agile.

Why is this relevant to us? With the traditional case, we assume that we have the perfect plan and that no additional input data will allow us to improve our results. This is a perfectly acceptable approach in an environment where there is no change in data.

With the agile case, we use continual feedback to modify our plan. Any new input data or technology is used to modify our plan and adapt to the new scenario. As explorationists and geophysicists we are constantly acquiring new data that can be used to improve our models and hypotheses. By adjusting to these new data we can truncate poor outcomes and expedite positive ones.

The Agile Manifesto for software development is simple (http://agilemanifesto.org/):

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

That is, while there is value in the items on the right, items on the left are valued more.

The Agile Manifesto is based on 12 principles, some of which can be directly applied to exploration. These are:

Welcoming changing requirements, even in late development.
- Who hasn't had a project change significantly?

Building projects built around motivated individuals, who should be trusted.
- Instead of using gangs of unskilled employees, smaller teams of highly skilled and motivated people can collaborate to produce better results.

Teams reflecting regularly on how to become more effective, and adjusting accordingly.
- A canned approach to geophysics and exploration is not very innovative. The most effective teams embrace new technologies/ideas/methods.

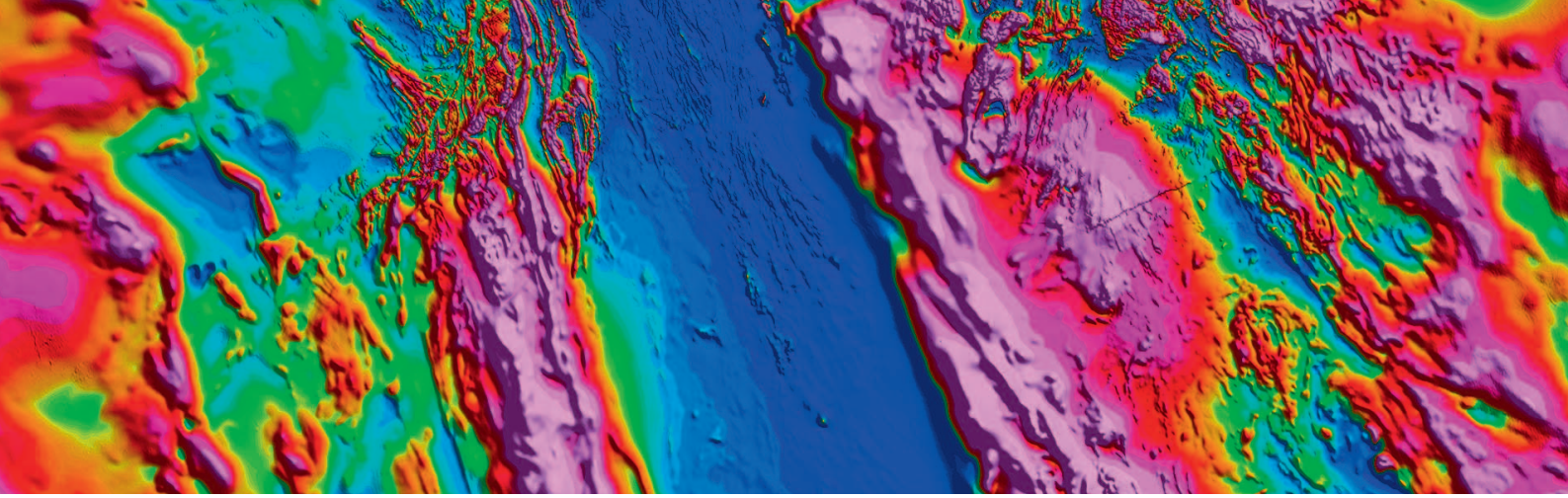
The Agile approach can be used in geophysics and exploration. It favours an environment that empowers team members; one in which they are self-organised and motivated. Frequent iterations of working models are encouraged, as is the collaboration with clients and stakeholders. With an ability to respond to change, it is ideally suited to the exploration environment where additional data are being collected.

There are plenty of useful links on the internet about the Agile approach. Here are a couple to get you started:

https://en.wikipedia.org/wiki/Agile_software_development

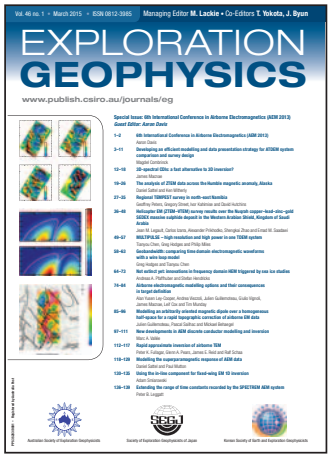
http://www.agilegeoscience.com/ (some of Matt Hall's early blog posts explore similar ideas to this article)

Thanks to Nick Edwards for his input on the Agile approach.



Exploration Geophysics

The Journal of the Australian Society of Exploration Geophysicists



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Data Trends

Guy Holmes
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The 48 hour entrepreneur

It used to be that someone would come up with a good idea and then spend many years, if not a lifetime, trying to commercialise it or to get attention for it. It was a lonely affair and in many ways it seemed that you needed more than just a great idea, you also needed a lot of luck if your idea or invention was to ever see the light of day.

It seems that sometime in the past 10 years someone came up with the ultimate great idea. That idea was to try and create great ideas on a larger scale. Like an idea farm or invention collective of sorts.

A few months ago I attended one of these idea farms, called a 'hackathon', in New Zealand. While at first I was sceptical, I was quickly converted to a believer.

A hackathon is essentially an organised event where programmers meet to do collaborative computer programming. The events are not restricted to just programmers. Anyone who wants to pay the fee and has an interest can show up, and in many cases the events are free.

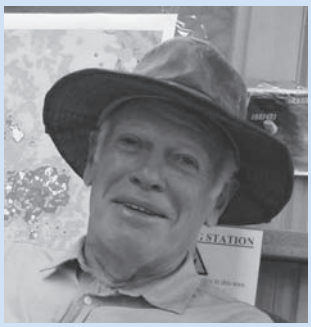
Sometimes the group that shows up (often numbered in the hundreds) is presented with a problem or series of problems. The attendees break into groups and are given the duration of the hackathon to try and solve the problem. At the end of the session each team presents its proposed solution, often with a mock up to demonstrate how the solution would work. After all possible solutions are presented, the owner of the problem chooses the team they feel could best help them solve the problem based on what was developed. There is usually a prize or, in many cases, just a commitment to use the team to try and commercialise the solution.

These events are often held over a weekend, and are conducted on this basis because the people who attend often have day jobs or are students. The weekend is used to try and short circuit what would previously have been a lifetime battle to find a problem and innovatively solve it in a commercial setting, i.e. become an entrepreneur. The recipe for this is simple; (problem + technology + sleep deprivation) ÷ team = innovation.

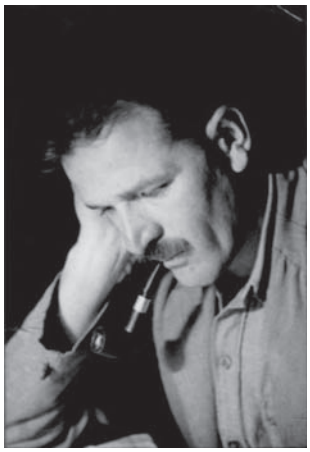
On Friday you work at the local supermarket, on Monday you return to your job to tell your boss to stick it because you are an entrepreneur. I love it, and we are seeing it work all over the world. In fact many companies hold internal hackathons with their employees to present a series of problems and allow their employees to think freely in a compressed timeframe in order to come up with solutions. Everyone is free to contribute and the ideas that flow from these open sessions can come from anywhere in the company. A receptionist can design a new way to keep sales people informed about client visits, or a sales person can come up with a new way for the receptionist to track client visits. You just never know who will come up with the next great idea.

In today's depressed market, with unemployment in our key field of geophysics running at an all-time high, we are seeing extremely smart people sitting on the side lines waiting for things to improve. If you fit this bill, then I implore you to seek out these hackathon events and put your mind to work. I would wager that in most hackathons physicists are poorly represented, but the value that we could bring from our studies and experience of complex problems could be immense.

Lewis Albert Richardson: a pioneer of exploration geophysics in Australia



Bob Richardson
bob.wherever@gmail.com



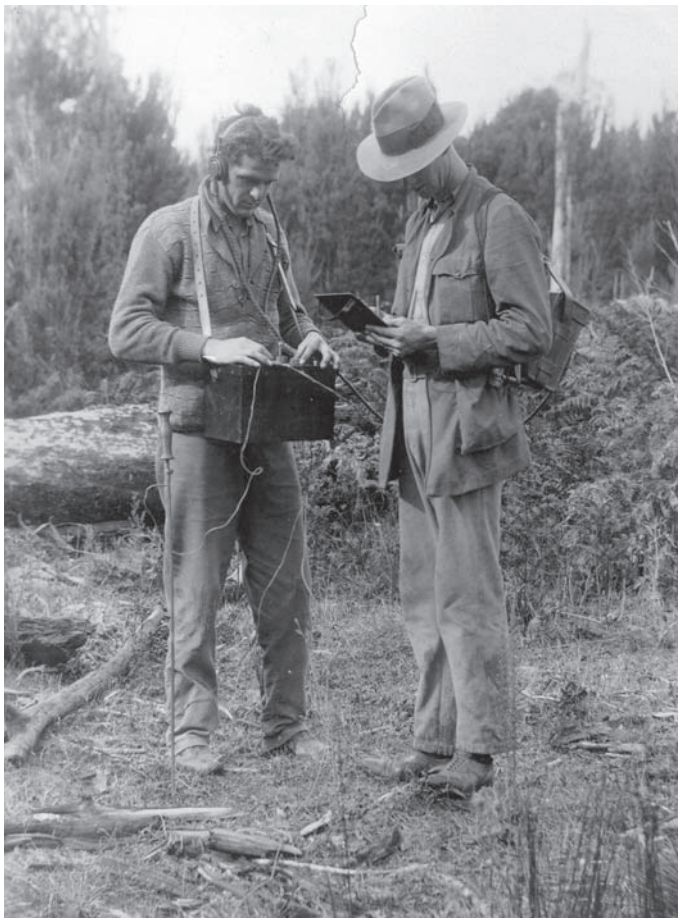
Lew Richardson ~1947.

A shooting star on the family farm may have signalled Lew Richardson's future career in the earth sciences. Lew was born on 29 April 1907 on 'Spring Farm', a small holding near Narellan, NSW producing high quality table grapes, stone fruit and apples for the Sydney market. On the night of 8 April 1928 a 367.5 gm meteorite landed on the farm, within metres of where Lew's father had been standing. Its dramatic light display and the accompanying shock waves were witnessed by Lew, who found it buried 'about six inches' into rocky ground the next morning. Very few people witness an incoming meteorite and then actually find that meteorite. According to the Australian Museum there have been only two such occurrences in recorded history in Australia. That meteorite is now held by the Australian Museum in Sydney and is called 'The Narellan Meteorite' (Hodge-Smith, 1931).

Lew Richardson was trained and worked as an articled surveyor before becoming involved in geophysics. Surveying was useful training for a geophysicist when you consider that the location of a geophysical measurement is just as important as the measurement itself. In 1928 Lew commenced his geophysical career in the Imperial Geophysical Experimental Survey (IGES), where he was attached to the No1 Electrical Party as a 'Field Assistant', a job that could be more correctly described as 'Trainee Geophysicist'. As a consequence of his surveying training and capability he was largely responsible for the survey work of the Party. He worked in most states of Australia until the end of the survey in 1930.

The IGES was funded by the British Empire Marketing Board and the Australian Commonwealth Government. Its object was '… not to prospect for minerals, but to test the applicability of various geophysical methods under field conditions in Australia which, it was considered, might be regarded as fairly characteristic of considerable portions of the British Empire' (Edge and Laby, 1931). This was a fantastic opportunity for Lew to work alongside internationally recognised scientists and engineers and to be at the 'leading edge' in exploration geophysics for the time. He also gained valuable experience on which geophysical techniques worked in Australia and which didn't. The techniques used included: magnetic, gravity, seismic, self-potential, resistivity, equipotential line, AC potential drop, and electromagnetic. The IGES conducted surveys in all states of Australia.

Following the end of the IGES in 1930, Lew continued his studies at Sydney University studying physics and mathematics up to tertiary level. However, with little financial resources and with the pressure of having to earn a living, he was unable to complete his studies to degree level. His survey training qualified him to be an Associate of the Institute of Surveyors, and in 1937 he was made an Associate of the Institute of



Conducting AC Potential Drop method during an IGES survey (Lew on left).

IGES field party conducting an equipotential survey (Lew is on the left).

Lew outside a hut used by IGES for gravity gradiometer measurements. This portable kapok lined canvas hut protected the gradiometer from temperature changes and wind.

Dr Bieler (on left) using the Bieler-Watson double detecting coil for electromagnetic measurements. Dr Bieler, an expert in electromagnetic methods from McGill University in Canada, joined the IGES as Deputy Director however he died at an early stage in July 1929.

Physics (UK), which was recognised at the time as an acceptable qualification for a professional position. During this period he worked for a while with Jack Rayner, carrying out magnetic surveys for Oil Search in Victoria. It was during those study years that he met Sir John Proud and established a connection that would become very significant down the track.

In June 1935 Lew was appointed 'Applied Geophysicist with the Aerial, Geological and Geophysical Survey of Northern Australia' (AGGSNA). With the AGGSNA party Lew completed extensive work in many areas of Northern Australia including Tennant Creek 1935–1937, Pine Creek, Wiluna, and Cloncurry. At Tennant Creek, Lew's work located and surveyed more than 20 magnetic anomalies due to deep sources. Testing of these anomalies by core drilling established beyond any doubt the presence of gold and copper ore at considerably greater depth than had been proved by existing workings. His geophysical analysis of the Peko No 1 anomaly (Rayner, 2007) showed potential for magnetic ore at depth and subsequent drilling discovered the large Peko copper deposit, which kick-started Peko Mines Ltd and ultimately the Peko-Wallsend Group.

The results of the AGGSNA work were not fully published at the time, and it wasn't until 1957 that the results were fully compiled in a landmark report by the BMR (Daly, 1957). The report illustrates the massive amount of field magnetometer work completed by Lew, all done with great care and precision using a Watts Variometer. In Daly's introduction he states 'No report on the magnetic surveys at Tennant Creek would be complete, however, without acknowledgment of the work of Mr L. A. Richardson, who was responsible for the planning and supervision of all the work.'

Lew's marriage in 1937 didn't deter him from completing the job, and he took his new bride back to Tennant Creek where they lived in a tent in the Honeymoon Ranges, some seven kilometres north of the township. When he set forth to the field with his magnetometer, he left my mother Beverly with a large .45 revolver to wave at any threatening four or two legged animals.

AGGSNA survey team, Lew in centre. The team is setting out to do a magnetic survey in a lake (not trout fishing).

Lew conducting a magnetic survey for AGGSNA in a lake near Wiluna WA, using a Watts Variometer (note the black knitted tie).

Lew tucked in for the night – a typical geophysicist's field accommodation in the AGGSNA days (not sure who or what he was going to shoot with that 12G Winchester at his elbow).

From 1938 to the end of AGGSNA in 1941 Lew was second in charge under Bob Thyer (Bob later became Director of the BMR) and he worked on many areas including Blair Athol coalfield, Croydon and Lolworth goldfield, Redbank copper and The Granites.

Following AGGSNA, together with the remaining geophysical staff, Lew was transferred to the Mineral Resources Survey, which was established in 1942 under Dr H. G. Raggat (the Mineral Resources Survey became the BMR in 1946). It was now wartime, and this organisation was directed to the exploration for minerals that were in scarce supply for the Allies, such as quartz, tungsten, uranium and copper. During this period Lew was also the principal observer of the absolute values of the magnetic field, upon which the Australian isogonic charts were founded.

In 1942, Lew was drafted into the Australian Military Forces to undertake scientific work. This included investigation of degaussing stations at Sydney, Fremantle and Darwin. Degaussing was a procedure whereby large coils were energised by DC current to produce magnetic fields to reduce the magnetic signature of ships so that they were less vulnerable to magnetic mines. Lew was also a member of the Australian Scientific Mission sent to Japan in early 1946, immediately after the end of the Pacific war. The purpose of this mission was to obtain information about the state of industry, science and the military in Japan, a country that had been opaque to the rest of the world for a long time. Lew's involvement included investigations into Japan's earthquake prediction technology and the availability of mineral resources in Japan, particularly uranium. His flight over Hiroshima had a profound effect on him and he brought home graphic descriptions of the devastation.

On Lew's return to Australia he was appointed as a Geophysicist with the newly formed Bureau of Mineral Resources, Geology and Geophysics (BMR), where he served as a party leader until his resignation in 1950. He resigned because it became clear to him that he would not advance in the organisation because of the hardening of the Public Service Board's attitude to people occupying professional positions without a university degree.

Lew then became an independent geophysical consultant – a fairly brave move at the time. His clients through the period 1950–1965 included most of the larger mining houses in Australia: EZ, WMC, BHP, Aberfoyle, ConsZinc, Australian Oil and Gas, Zinc Corp, Mt Isa Mines, and Peko-Wallsend. Peko-Wallsend was now expanding rapidly as several rich copper, gold, bismuth mines came into production at Tennant creek. The connection he made during his study years with Sir John Proud (Peko-Wallsend CEO), his earlier AGGSNA work at Tennant, and his involvement in the discoveries for Peko Mines at Tennant Creek lead naturally to a closer association with Peko, which became his largest client.

The magnetite hosted copper-gold deposits at Tennant Creek were not easy drilling targets for the following reasons:

- Most were in soil covered areas without outcrop to provide geological guidance
- The causative bodies were relatively small (but high grade) and easily missed by drilling
- The bodies were often steeply dipping and 'pipe-like' and required inclined drilling for a reliable test
- Cleavage of the country rocks caused the drill holes to deviate, sometimes perpendicular to the desired direction
- The high magnetic susceptibility of the magnetite lodes caused demagnetisation. Existing modelling algorithms could not take demagnetisation into account and gave erroneous interpretations.

Lew in Japan 1946 with Japanese geophysicists (Lew is third from the right).

Lew using a Worden gravity meter for oil exploration in the Oaklands Basin for AOG in the late 1950s.

It soon became evident to Lew that the available interpretive models were inadequate. At the time, interpretation methods were relatively crude. Magnetic anomalies could be modelled by comparing observed anomalies with calculated anomalies due to theoretical magnetic bodies shaped as spheres, or simple tabular shapes.

Together with UNSW mathematician Bruce Kirkpatrick, Lew developed algorithms and routines that enabled the calculation of magnetic anomalies due to ellipsoidal shaped bodies. The ellipsoid is the ideal model for the Tennant Creek magnetic bodies and can be used to accurately model a range of shapes from narrow pipes, to discs, to spheres and at any orientations, dip and plunge. This was a rigorous solution that took demagnetisation into account.

Lew's work was pivotal to the development of the Tennant Creek field and the growth of Peko-Wallsend as a major Australian mining house. It was also an important contribution to the science of geophysics.

During most of this period he worked with only one offsider. One of these was physicist Ian Sefton who went on to teach physics at Sydney University and, later, geophysicist Greg Kater. Following Greg's resignation in 1966, I jumped at the chance to work with my father. I was already heading down another path, and had commenced a career as a structural engineer with Transfield Corporation, but the lure of life in the bush, the excitement of the exploration industry and a fascination for the science was too much to ignore and I abandoned the engineering design office for a magnetometer and a gravity meter. Also, I was then privileged to have one of the best teachers in the field.

Lew and I established L. A. Richardson and Associates Pty Ltd (LAR) and expanded the business to meet the increasing demand from Peko and others. By 1969 we had a team of approximately 12 people, including geophysicists, mathematicians, engineers, surveyors and field geophysical technicians, and were applying geophysical methods to a wide range of commodities. Following in Lew's path, LAR was responsible for many ground breaking developments in the areas of magnetics, gravity, electromagnetics, downhole and airborne geophysics. We worked hand-in-hand with Peko's exploration division, Geopeko, on gold, base metals, tungsten, coal, uranium and mineral sands exploration in many parts of Australia. Geopeko was one of the most successful exploration groups in Australia through the 50s–80s, discovering seventeen deposits all of which became mines, including Ranger 1 (uranium), North Parkes (copper/gold) and Lake Cowal (gold). Lew and LAR made crucial contributions to many of those discoveries.

Lew targeted most of the discovery holes for Peko's earlier discoveries at Tennant Creek including Peko Deeps, Warrego, Ivanhoe, Orlando and Juno. Later, in LAR, we targeted the discovery holes for the Gecko, Argo, TC8, Juno residuals and Warrego residual deposits.

In the late 60s Lew began to have serious health problems, which slowed him down, but he continued to work until he died suddenly in January 1971. In recognition of his services to Peko-Wallsend, and the science of geophysics, Peko-Wallsend established the L. A. Richardson Memorial Prize by a gift of $5000 to the University of Sydney. The prize, valued at $200, is awarded annually to the student in final year in the Department of Geology and Geophysics who submits the most outstanding thesis on geophysics. I have had the pleasure of presenting this award many times.

Lew was a man of great courage, drive and intellect, but always very gentle and patient with others. I'm sure that many people in the exploration industry would remember him as a good listener and always a source of wise advice and encouragement.

There were many other facets of his life that are beyond the scope of this short account – his adventures on the Kowmung River in the Blue Mountains, his involvement with the Colong Committee, which stopped the mining of limestone on the Kowmung River, and his farming activities at Mittagong. These might be the subjects of another narrative.

References

Edge, A. B. B., and Laby, T. H., (eds.), 1931, *The principles and practice of geophysical prospecting*, being the report of the Imperial Geophysical Experimental Survey. Cambridge. University Press. 372 pp.

Daly, J., 1957, Magnetic Prospecting at Tennant Creek, Northern Territory, 1935–1937: *BMR Bulletin* **44**.

Hodge-Smith, T., 1931, The Narellan meteorite: a new chondrite from New South Wales: *Records of the Australian Museum*, **XVIII**.

Rayner, J., 2007, Jack Rayner and AGGSNA: *Preview*, **128**, 34–39.

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June	**2017**		
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17–19 (TBC)	3rd Near-Surface Geophysics Asia-Pacific Conference (website TBA)	Cairns	Australia
September	**2017**		
12–14	Offshore Site Investigation and Geotechnics Committee (Society for Underwater Technologies) 8th International Conference http://www.sut.org/specialist-interest-group/osig-offshore-site-investigation-and-geotechnics/	London	UK
24–27	SEG International Exhibition and 87th Annual Meeting http://www.seg.org	Houston	USA
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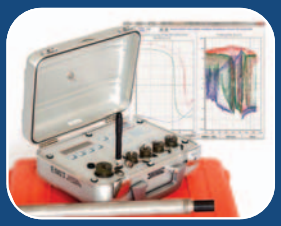

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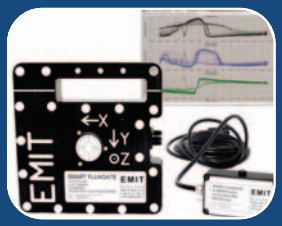

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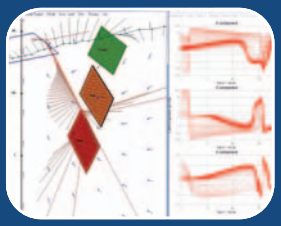

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