Australian Society of
Exploration Geophysicists

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PREVIEW

NEWS AND COMMENTARY

FEATURE

ASEG CORPORATE PLUS MEMBER

AEGC2019
Data to Discovery

Australasian Exploration Geoscience Conference
2-5 September 2019 • Perth, Western Australia

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FRONT COVER

QUT and UQ students on a tour of the Velseis facilities in Brisbane. See *Education matters* for the full story.

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Editor's desk

This issue of *Preview* features an article by Tim Dean and his colleagues on the use of geophysics in the search for Perth's lost World War 2 gun emplacements; a quest that has obviously given them a great deal of pleasure – and garnered a lot of interest in the popular media!

Our regular commentators have also been pleasurably busy. David Denham (*Canberra observed*) pounced on the report of the Resources 2030 Taskforce as soon as it became available to the public, and has summarised key points for *Preview* readers. He also takes a look at the latest data on global demand for oil, and exploration investment in minerals and petroleum. Michael Asten (*Education matters*) features a student trip to the Velseis facilities near Brisbane. Mike Hatch (*Environmental geophysics*), who like Tim Dean has featured in the popular media (his interview with Macca on *Australia all over* must have been a corker), reflects on how best to explain what we do to the uninitiated. Terry Harvey (*Minerals geophysics*) considers geophysical inversions and asks if we are any closer to finding the proverbial Volkswagen in a cubic mile of rock. Mick Micenko (*Seismic window*) contemplates advances, or lack thereof, in time to depth conversions, and Dave Annetts (*Webwaves*) reviews the state of the Union, aka the latest version of ASEG website, on the occasion of its second birthday!

On a more serious note, and as foreshadowed by an all Member email and by the President in her *President's piece*, *Preview* and *Exploration Geophysics* will be produced by Taylor & Francis Group from the beginning of 2019. Taylor & Francis are an international publishing house with a lot of experience in producing and marketing scientific journals. They have only limited experience with producing and marketing magazines, and will be on a bit of a steep learning curve with *Preview*. Readers are asked for their understanding and patience during the transition process.

The December 2018 issue will be the last issue produced by CSIRO Publishing and, as it will be our bumper Christmas issue, we intend to see them out in style. Don Emerson has co-opted Phil Schmidt's assistance with a long overdue look at the properties of pyrolusitic supergene manganese oxides – a cracker of a feature – and, as usual, we will publish summaries of student research projects in geophysics completed over the past 12 months. All students who have recently completed a thesis in geophysics in Australia are invited to submit a short summary (a couple of paragraphs) together with a short bio (a couple of sentences) and a self-portrait (preferably doing something geophysical) to previeweditor@aseg.org.au. As a bonus, the best student photo will be selected for the cover!

Lisa Worrall
Preview *Editor*
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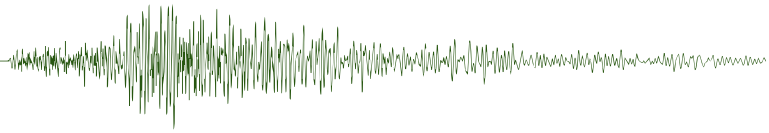

Letter to the Editor

Dear *Preview* Editor

I have always wondered why the ASEG doesn't have its own professional geophysicist accreditation (similar to the AIG's Registered Professional Geoscientist or the AusIMM's Chartered Professional Program) or why it doesn't actively participate in, or promote existing geoscience accreditations (like the AIG's and AusIMM's). From my point of view the ASEG and its Members would benefit from either developing or being part of a professional development program, especially if it was linked to an accreditation and provided clear skill pathways.

Along with benefits to ASEG and its Members, such a program would provide broad benefit to the geophysics community including:

- giving junior geophysicists an official pathway for skill development after university
- providing an incentive for companies to send employees to approved external training, which will also foster stronger relationships across the discipline
- enabling experienced geophysicists (and geoscientists) to develop existing skills and expand knowledge into new areas through officially recognised courses.

Has some form of geophysicist accreditation and/or professional development been looked at within ASEG before?

Shane Mule
shanegmule@gmail.com

Response from the ASEG Federal Executive

The ASEG Federal Executive is often asked about professional accreditation so this opportunity to explain the situation to the whole membership is welcomed.

The ASEG is constituted as a not-for-profit society for the promotion of science, which entitles us to certain tax exemption benefits. However, this status and the associated rules effectively preclude us from granting professional geophysicist accreditation.

The Society is set up as a company and like all companies has a constitution by which it must abide. Part of the constitution describes what the company does (its 'Objects') in legal terms. The ATO and ASIC use the description of a company's Objects to classify a company, and the ASEG falls in the Not-for-Profit sub-category of 'Promotion of Science'. Membership of this sub-category entitles us to tax exemption benefits as long as we adhere to our Objects and comply with a few other ATO applied rules. The resulting conditions placed on ASEG effectively stop us from accrediting geophysicists.

The rule that is relevant to this question is that groups set up for the Promotion of Science cannot actively promote the professional interests of their Members: https://www.ato.gov.au/Non-profit/Your-organisation/Do-you-have-to-pay-income-tax-/Types-of-income-tax-exempt-organisations/Scientific-organisations/.

The AIG and AusIMM were set up as professional organisations and therefore have no limitation on granting accreditation, but they do not enjoy the same semi-automatic tax benefits of the ASEG. We would encourage all professional geoscientists to belong to one of those two groups as well as the ASEG. The choice of professional association is likely to depend on the level of activity each has at your local level, although we note that there is a significant difference in fees between the two. Both of the registered professional categories in AIG and AusIMM require a certain level of Professional Development each year in order to maintain competency. It is worth remembering that the conferences, courses, workshops and even branch meetings that ASEG runs for its Members can count towards meeting those requirements.

In addition, membership of the AIG currently grants competent person (CP) status under JORC and CIM as well as most of the CRIRSCO member authorities. An AusIMM Member is a CP for JORC but needs to be a Chartered Professional in order to be considered a CP for CIM. This will affect anyone working with a TSX based company and having to sign off on NI43-101s. This may change in the future as AIG are discussing a proposal to require anyone writing a public report covering geology, to be a Registered Practising Geoscientist (AIG) or Chartered Professional (AusIMM). That would include all government reports, both by government and to government.

While we cannot accredit our Members we do strongly believe that our role as a society for the Promotion of Science should be led by improving the technical scientific skills of our Members and for this reason we invest in OZStep, our own distinguished lecturer tour, as well as partnering with SEG and EAGE to bring the SEG DISC and DL and EAGE EET lectures to as many of our Members as possible. We are also looking to align our education offerings with tertiary institution requirements in order for increased transferability.

Our local branch meetings also provide a great opportunity to improve your technical knowledge across a wide range of geophysical techniques and problems. The Federal Executive are encouraging the States to make their branch meetings available to more Members by webcasting them. The WA Branch have already done this and hopefully we will see other branches follow suit in the near future.

Kim Frankcombe and Andrew Squelch (on behalf of the ASEG Federal Executive)
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President's piece

Marina Costelloe

I am delighted to announce a new publishing partnership between the Australian Society of Exploration Geophysicists and Taylor & Francis Australasia. We are excited to partner with Taylor & Francis to increase the impact of *Exploration Geophysics* and *Preview* and to take our geoscience, research and career training to a wider audience around the world. *Exploration Geophysics* and *Preview* make excellent additions to Taylor & Francis' existing portfolio of earth sciences titles. Taylor & Francis partners with world-class authors, from leading scientists and researchers, to scholars and professionals operating at the top of their fields. Taylor & Francis publish in all areas of the Medicine, Science, Technology, Social Sciences, Behavioural Sciences, and Humanities sectors. I would like to thank Danny Burns, Ted Tyne and our Publications Committee for steering us through this change task with determination and vision. I look forward to receiving feedback from Members on the change when it comes into effect in January.

As you know, *Exploration Geophysics* is a peer-reviewed forum for scientific papers from members of the ASEG and our partner societies; Society of Exploration Geophysicists of Japan (SEGJ) and Korean Society of Earth and Exploration Geophysicists (KSEG). Our journal publishes ground-breaking research in exploration and applied geophysics, recording the extraordinary growth and achievements in science breakthroughs, innovations, new technologies, practices and discoveries in this field for almost 50 years. *Exploration Geophysics* is led by Managing Editor, Mark Lackie (Macquarie University) and two Co-Editors, Joongmoo Byun (Hanyang University, Korea) and Toshiyuki Yokota (Geological Survey of Japan), and supported by a diverse, international team of more than 30 Associate Editors.

Preview is our highly regarded, recognisable, much loved, ASEG-branded magazine published bi-monthly; it contains the latest news, commentaries, easy-to-read reviews, and case studies for exploration geophysicists around the world. Lisa Worrall (Protean Geoscience) is the Editor of *Preview* and is supported by a team of Associate Editors covering Minerals Geophysics, Petroleum Geophysics, Environmental Geophysics, Technical Standards, Geophysical Data Management and Analysis, Education, Book Reviews, Government, Honours and Awards and the big wide world of the Web.

With AGCC just around the corner I am looking forward to networking with ASEG Members in Adelaide. AGCC will be a great science event, but I am proud to be championing Diversity at the conference. I have been asked to speak at the Women in Earth and Environmental Sciences (WOMEESA) event and want to take this opportunity to thank Beach Energy for sponsoring the Diversity in Geoscience Lunch. The ASEG will have a poster on Diversity at the AGCC. As a Society we are committed to diversity, inclusion and anti-discrimination through respect and appreciation of what makes our membership so varied in terms of age, gender, ethnicity, disability, education and national origin. Members live and work across the world. One of the Society's strengths is in engaging and connecting professionals from geographically remote and isolated areas, which is shown in our membership figures, publication statistics, as well as our social media and online presence statistics. The Society is exceptionally good at linking technology, people and resources. Conferences the Society organises and runs strive to be free from prejudice of any kind and are places where great innovations are uncovered.

AEGC 2019, Data to Discover, is approaching fast. The event will be jointly hosted by the Australian Institute of Geoscientists (AIG), Australian Society of Exploration Geophysicists (ASEG), and Petroleum Exploration Society of Australia (PESA). The AEGC technical program committee has a focus on geology, geophysics, and geochemistry and how these are applied in exploration for both Petroleum and Mineral systems in Australasia and the wider Asia-Pacific region. The conference has major sub-themes encompassing but not limited to: New technologies; New information from old data; Local understanding from regional context; Workflows and methods that reduce cost/turnaround on projects; Cross disciplinary co-ordination; and; Case studies; Interacting and communicating science to the wider community. A vital component of the 2019 conference will be the inclusion of dedicated streams for Australian basins, discovery techniques, mineral mapping, and remote sensing applications.

AEGC 2019 abstract submission is open now, and closes late November 2018. Tim Dean (ASEG) and the Perth organisers have a cracker program being lined up, and are at this stage looking for companies to sponsor the exhibition or book exhibition space, packages are online. Have a look at the updated website: http://2019.aegc.com.au, Perth, 2–5 September 2019. I hope to see you there!

Marina Costelloe
ASEG President
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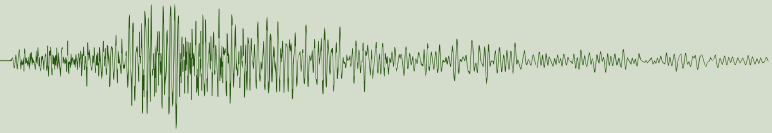

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Executive brief

The Federal Executive of the ASEG (FedEx) is the governing body of the ASEG. It meets once a month, via teleconference, to see to the administration of the Society. This brief reports on the monthly meeting that was held in August. If there is more you would like to read about on a regular basis just get in touch with me (Megan) and I will expand the briefs accordingly.

Finances

The Society's financial position at the end of August 2018:

Year to date income: $376 862

Year to date expenditure: $474 775

Net assets: $1 033 847

Membership

At the time of this report, the Society had 970 Members. This figure is up from the figure of 903 Members as reported in the last Executive brief in August issue of *Preview*. It is down approximately 10% from last year's total (Figure 1).

Numbers are down similarly across the states with the least drop in Members from 2017 being 12.3% in WA, and the most being a 26.6% drop in Tasmania.

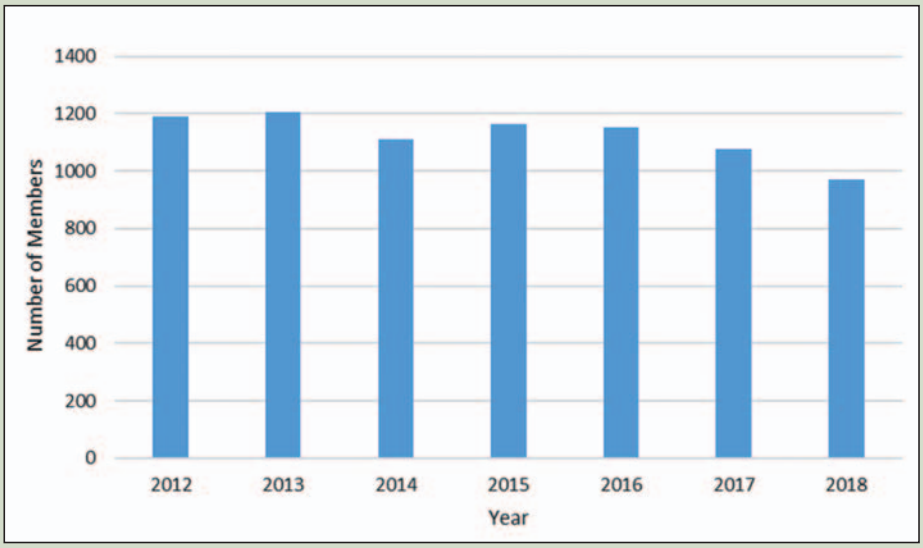

Figure 1. *ASEG membership levels between 2012 and 2018.*

There have been no changes to retired, honorary or corporate membership numbers since August 2018. The increase has mostly been in the Active/Associate membership category, with total numbers now reflecting a reduction from 2017 to 2018 of only 6%. The reduction in student membership numbers is still very high, and now sits at 45% from 2017.

I hope you have had a chance to look at our website, its looking really great thanks to the efforts of the web team. Please take a particular look at the fantastic photos that have been submitted during our photo competition and see who has taken out 1st, 2nd and 3rd prizes.

Don't forget that our website also has an employment section – for Members only! Check out potential employment opportunities or advertise a position if you're an employer seeking the skills of one of our many talented Members.

Megan Nightingale
Secretary
fedsec@aseg.org.au

Welcome to new Members

The ASEG extends a warm welcome to 16 new Members approved by the Federal Executive at its August and September meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Shubham	Agrawal	ANU	ACT	Australia	Student
Walid	Ben Mansour	Macquarie University	NSW	Australia	Associate
Matthew	Cracknell	University of Tasmania	TAS	Australia	Active
Matt	Grant	BHP	QLD	Australia	Active
Josh	Jesse	Coffey	NSW	Australia	Active
Thayyil	Koshy	Independent	WA	Australia	Active
Tara	Martin	CSIRO	TAS	Australia	Active
Sam	Matthews	Macquarie University	NSW	Australia	Student
Dietmar	Muller	The University of Sydney	NSW	Australia	Active
Ndoumba Kelly	Ngaka Litsoung	University of Western Cape	Western Cape	South Africa	Student
Uthman	Oluwole-Raji		VIC	Australia	Associate
James	Regan	Curtin University	WA	Australia	Student
Benjamin	Roberts	University of Queensland	QLD	Australia	Student
Stuart	Stephens	Doray Minerals	WA	Australia	Active
Cameron	Thompson	Curtin University	WA	Australia	Student
Aaron	Tompkins	GBG Australia	NSW	Australia	Active

Update from the ASEG Young Professionals Network

The ASEG Young Professionals are ramping up activity across Australia! There are now mentoring programs running in Victoria and Western Australia. The QLD YPs are currently recruiting mentors and mentees ahead of the program launch on 27 November. If you're interested in participating in the scheme as a mentor or mentee please apply before the cut-off date of 2 November. Application forms can be found on the ASEG website under QLD Branch Events. The South Australian Branch are also actively looking to start a mentoring scheme ahead of a 2019 kick-off.

The Victorian YPs have continued their seminar series with talks on structural geology by Dr Kevin Hill (Melbourne University) and Petroleum Systems Modelling by Dr David Briguglio (3D Oil).

Finally, the Federal ASEG YP and the ASEG WA Branch are jointly sponsoring the first WA GSA Earth Sciences Student Symposium (GESSS-WA) at the University of Western Australia in Perth on 29 November. This symposium builds on the very successful Victorian Universities Earth and Environmental Sciences Conference (VUEESC), which has been held at Monash University in Melbourne for the past 30 years. As GESSS, the concept was extended to Queensland, New South Wales, South Australia and Tasmania in 2017. For more information go to https://gessswesternaustra.wixsite.com/gessswa2018.

Megan Nightingale and Jarrod Dunne
ASEG Young Professionals Network
ypadmin@aseg.org

ASEG Research Foundation 2018 awards

The ASEG Research Foundation has made the following two grants for 2018 for a total value of $30 000.

(1) Curtin University Associate Professor Milovan Urosovic and PhD student Zixing Qin have been awarded $15 000 over 3 years. The project is titled 'The utilisation of a drill-bit seismic source in cross-hole surveys for hard rock mineral exploration.'

Project summary

This project aims to investigate the feasibility and applicability of drill-bit seismic source in cross-hole surveys for hard rock mineral exploration. It will lead to an innovative exploration technique and the technique can be applied to explore numerous hard rock mineral deposits. Moreover, it plays a critical role during mine development in terms of resource estimation, orebody delineation and subsurface geotechnical properties estimation. The proposed research will have a positive and profound impact on hard rock mineral exploration in Australia and world-wide. The expected outcomes are inter-borehole tomographic images and seismic reflection images together with in-situ rock geotechnical information. If successful, the same approach can be expanded to other ambient sources for a multi-well seismic receiver assemblies.

(2) University of Adelaide Associate Professors Simon Holford and Rosalind King and PhD student Matthew Mussolino have been awarded $15 000 over 3 years. The project is titled 'Improving the accuracy of geomechanical predictions in sedimentary basins'.

Project summary

Geomechanical predictions are integral to safe and successful hydrocarbon exploration and development, underpinning drilling strategies and efficient field production. The input data to geomechanical predictions relate to principal stress, fluid pressure and rock strength parameters, but these data are often estimated and subject to natural variation causing uncertainties that are rarely explored. This project will use rich petroleum datasets to define the uncertainties associated with quantification of these parameters, and through Monte Carlo simulations, constrain the impacts on predictions of rock failure. The project will result in new workflows for the improved assessment and application of geomechanical datasets.

The next round of ASEG RF applications for 2019 will open in December 2018 and close at the end of February 2019. The details will be available on the ASEG website.

Doug Roberts
ASEG Research Foundation
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Initial notification for nominations for the 2019 ASEG Honours and Awards

To be presented in conjunction with the AEGC, 2–5 September 2019, Perth, Western Australia

Award categories requiring nominations from ASEG Members prior to the conference include:

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

Lists of previous awardees, award criteria and nomination guidelines can be found on the ASEG website at https://aseg.org.au/honours-and-awards.

For further information, preliminary expressions of potential nominations, and submission of nominations, please contact:

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

ASEG Branch news

Tasmania

The Garry Davidson Symposium, being staged by CODES at the University of Tasmania 22–24 October 2018, will consist of presentations by world-recognised experts on exploration for a range of mineralisation styles. Geophysics is likely to feature strongly in several, particularly **Terry Hoschke**'s 'Geophysical signatures of IOCG deposits' and **Michael Roach**'s 'Tasmanian orogenic and intrusion-related Au-deposits: Relationships to Paleozoic granites'. Other presentation sequences on uranium, sediment-hosted base metal and volcanogenic-hosted massive sulfide deposits will also contain elements of exploration geophysics.

Garry Davidson was a highly respected and versatile geologist who taught generations of students at CODES over nearly three decades. He made significant contributions to our understanding of IOCG, VHMS, sediment-hosted base metal, uranium and orogenic gold deposits, and has been much missed by the Tasmanian geoscientific community since his untimely passing last year. The symposium honours Garry's memory by providing a state of the art appraisal of the characteristics, origins and exploration for these significant mineral resources. Full details including registration can be found via https://bit.ly/2IK2QUN.

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. As always, we encourage Members to also keep an eye on the seminar program at the University of Tasmania/CODES, which routinely includes presentations of a geophysical and computational nature as well as on a broad range of earth sciences topics.

Mark Duffett
taspresident@aseg.org.au

Victoria

The seasonal transition from a Melbourne winter to a Melbourne spring isn't often clear, and one usually has to double-check a calendar to convince oneself that spring has indeed arrived. Following on from the tremendous success of our winter series of 'international' guest presenters, your Branch continued the rage into spring with quite a bang!

In early August, we welcomed Professor **Satish Singh**, who hails from one of France's leading research organisations, the Institut de Physique du Globe de Paris, and is an esteemed member of their marine geosciences division. An enthusiastic gathering of Members attended to hear this year's SPE/AAPG distinguished lecturer give his presentation, titled 'Seismic Full Waveform Inversion for Fundamental Scientific and Industrial Problems'. Members were treated to a lecture describing the past, present and future application of full waveform inversion. Professor Singh discussed the potential applications from exploration in the petroleum industry to practical relevance in seismological and crustal studies.

We concluded our winter program with the annual congregation of PESA, ASEG and SPE Members at the highly-anticipated inter-society Winter Social 2018. As expected, there was a tremendous turnout, despite the bitter Antarctic-like cold on the night. It was certainly a joy to see industry stalwarts and young professionals ascend from hibernation to share a tipple over their common passion for the geosciences. Thank you to everyone that attended the event!

As the sun finally made its long-awaited appearance in mid-September, the melting of the Melbourne permafrost gave way for the first presenter of the Victorian Branch's spring series of meetings. Rio Tinto's Chief Geophysicist, **Theo Aravanis**, was our honoured guest, and his presentation 'When will the UAV revolution arrive for exploration?' drew an extraordinary number of attendees and had your committee members rummaging through the record books! Theo delivered a rather passionate talk about his experiences with using UAVs whilst deeply expressing his disappointment as to why this disruptive technology hasn't revolutionised our industry as yet. That future, he envisaged, should have arrived by now. This assessment quickly stirred a generous volley of dialogue amongst the audience, so it was great to see and hear the different ideas and thoughts from varied specialists in our geoscience community. Thank you, Theo for spawning the imagination of those that attended.

Your committee remains in talks with several potential presenters for the rest of our spring series of technical meetings, so keep an eye out for updates!

Seda Rouxel
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Western Australia

The WA Branch kindly thanks our 2018 sponsors for their ongoing support and assistance with running our monthly Tech Night series.

The Branch hosted two interesting and very well attended technical events in

ASEG WA Branch sponsors.

ASEG news

August. The August 15 Tech Night was a *Petroleum* stream presentation by **Satish Singh** (SEG Distinguished Lecturer) on 'Seismic Full Waveform Inversion for Fundamental Scientific and Industrial Problems'. This event was co-hosted with PESA and we hope to continue working with other professional societies to host more joint technical events in future. The lecture was held in the CGG ground floor function room, and over 60 ASEG and PESA Members from various professional and academic backgrounds attended and socialised over food and beverages.

*WA Branch Members gather for the August *Groundwater* Tech Night presentations.*

ASEG WA president Heather Tompkins, SEG DL Satish Singh, and PESA WA president Helen Debenham.

*Heather Skeen, Karen Gilgallon, and Brendan Ray (Southern Geoscience Consultants) after presenting at the August *Groundwater* Tech night.*

The Tech Night on August 29 included *Groundwater* presentations by 3 geophysicists from Southern Geoscience Consultants (**Karen Gilgallon**, **Brendan Ray**, and **Heather Skeen**) on 'The use of geophysical data for hydrogeology applications in the Exmouth area, Perth Basin, and Nevada, USA'. The Branch also hosted a *Groundwater* Tech Night on September 12 when **Alan Aitken** (UWA) presented on 'Modelling Microgravity for Groundwater Storage', which highlighted possible correlations between atmospheric circulation patterns, ground water storage, and banksia tree deaths in Kings Park, Perth.

The ASEG WA Branch was represented by **Partha Pratime Mandal** (ASEG WA committee member) and **Heather Tompkins** (ASEG WA President) at this year's Hale and St Mary's Career Expo which was held on 17 July at the Hale School memorial hall. It was an excellent opportunity to spread the message of exploration geophysics within the minds of budding young students. We displayed banners, geophysical maps, brochures and took this occasion to share the value of geophysics among various students and family members attending the expo. We engaged with the students by asking them basic questions relating to geoscience, and used candy as a reward when they guessed the right mineral name or rock type. We found the students were interested in geoscience and geophysics as a possible career path in the future. As no other geoscience organization participated in the event, ASEG's engagement with high school students reflects the Society's positive role in the community. Overall it was a great event and very rewarding talking to students interested in STEM fields and geoscience in particular.

Partha Pratime Mandal chatting to students at the Hale & St. Mary school career night.

Upcoming WA events include:

- October 9 – *Young Professionals* – **Vincent Crombez** from CSIRO and **Tasman Gilfeather-Clark** from UWA will present to other young professional members of the ASEG and PESA
- November 21 – *Students/Young Professionals* – annual student Tech Night with presentations by several Curtin and UWA students
- November 28 – *Young Professionals* - Mentoring Program closing session
- December TBC – *AGM* and Christmas Quiz Night

The Tech Night schedule is subject to change due to speaker availability. Please check the website for up-to-date information.

If you would like to provide the Branch with feedback on previous events or share with us ideas for workshops or technical events in 2019, please send us an email (wapresident@aseg.org.au; wasecretary@aseg.org.au).

Heather Tompkins
wapresident@aseg.org.au

Australian Capital Territory

In August, the ACT Branch enjoyed an SEG Distinguished Lecture from **Satish Singh** on 'Seismic Full Waveform Inversion for Fundamental Scientific and Industrial Problems'. The talk looked at how the Full Waveform Inversion method is used to quantify the elastic property of the subsurface and covered its early development and current applications.

Satish Singh presenting to the ACT Branch.

More recently, **Ned Stolz** from the Geological Survey of NSW gave a fantastic presentation highlighting the active program of data acquisition, interpretation and modelling that the survey undertakes to support resource exploration and geological research. These projects include data of immediate use to explorers such as magnetics and gravity, as well as more fundamental data such as regional-scale MT and reflection seismic investigations into the deep crust. Much of these new data feed into regional-based geological interpretation projects and construction of a state-wide 3D model of the geology of NSW. The survey also supports a geophysics R&D program examining petrophysics and palaeomagnetism, especially in their application to geophysical modelling and reconstructing the tectonic evolution of NSW.

Ned Stolz presenting to the ACT Branch.

The ACT Branch is looking forward to these upcoming events:

- October – **Marina Costelloe** (ASEG Federal President): ASEG: How it works and what we are Up To.
- November – Student Award winner presentation (date and venue TBA)
- December – Christmas Party celebration (date and venue TBA)

James Goodwin
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New South Wales

In July, we held our annual dinner. It was held in a restaurant in the city; we ate lots of steak and fish, drank lots of reds and whites, and discussed lots of geophysical and non-geophysical topics. We had a good turnout and a great time was had by all.

In August, **Doug Morrison** from Southlands Geophysical Services presented a talk about measuring terrestrial magnetism from the late 1700s through to the early 1900s. Doug walked us through early measuring methods as well as the first charts showing the changes in magnetism over different parts of the world. Doug linked the measurements to many different investigators and how it developed into what we see as the current magnetic map of the world. Doug bought in some old 'texts' for us to careful look at and it was quite amazing to see what was being done back then. Much discussion followed, with many questions being asked over a few reds. We await Part II.

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 99 on York Club in the Sydney CBD. Meeting notices, addresses and relevant contact details can be found at the NSW Branch website

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Queensland

Since the last issue of *Preview* the Queensland Branch hosted Dr **Satish Singh**, the 2018 SEG/AAPG Distinguished Lecturer, who presented his lecture entitled 'Seismic Full Waveform Inversion for Fundamental Scientific and Industrial Problems'. We enjoyed a great turnout of 19 attendees at Dr Singh's talk, with lots of questions at the end.

The ever popular joint ASEG-PESA Trivia night was held on 14 August. The Trivia Night was well attended, with about 30 players from industry and the universities. The secret question theme revolved around chocolates, with excess chocolates going to the winners. Thanks to everyone involved.

The ASEG trip to Velseis in August included 10 students from QUT and UQ. This visit was hosted by **Karel Driml**, **Troy Peters** and **Shaun Strong** and supported by seismic experts, **Lindsay Horn** and **Nicholas Josephs**. The group toured Velseis' impressive facility, saw the big Univibes and the small Envirovibes, and were able to experience the work of a juggy, by rolling out a spread. Many students took full advantage of the trip by dropping off resumes for fieldwork in the student holidays.

In September **Tariq Rahiman** gave a fascinating talk to the Branch on 'An application of geophysics for marine geohazard assessment: a case study from the Fiji Islands'.

We still have room for technical talks towards the end of the year and encourage volunteers to get in touch. As always, an invitation is extended to interstate and international visitors who happen to be in Brisbane at the time of the meeting. Please get in touch for more information.

Finally, watch this space for the launch of the Queensland Branch mentoring program for early career geophysicists. We'll be looking for both potential mentors and mentees to join the program.

James Alderman
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South Australia & Northern Territory

On Tuesday 7 August the SA/NT ASEG Branch hosted the SEG Distinguished Lecturer, Dr **Satish Singh** for his presentation, 'Seismic Full Waveform Inversion for Fundamental Scientific and Industrial Problems'. We had a great turnout of around 30 attendees, and everyone enjoyed a fantastic evening and a very informative talk by Satish.

To shake it up a bit, in early August we hosted a movie night for National Science

ASEG news

Week. The screening was of a compilation of documentaries on the theme of 'numbers and data' and included some short documentaries and a film on the promising future prospects of the blockchain, the technology that enables BitCoin, amongst other digital currencies. A particularly captivating episode of Catalyst was screened, on the topic of making decisions, and provided a particularly insightful view of how complex science or mathematics can be communicated in a way that everyone understands- a valuable lesson for us all as if no one can understand your science, then what is the point?

This event was marketed to not only ASEG Members but also members of the general public. By advertising widely, the small cinema was almost full (~30 attendees) and we received great feedback from everyone, including the non-scientists. The event was a great success, and we hope to be able to continue this event in the future.

Later in August we hosted our annual Wine Tasting event, where the wine for the annual national ASEG Wine Offer was selected in a blind tasting by a very capable panel of invited guests as a recognition for their current or past contributions to the ASEG. This year, we introduced a new category of sparkling wine, with the NV Adelaide Hills Sparkling K1 by Geoff Hardy taking out the inaugural win. Eden Hall takes all when it came to the reds and whites - with their 2018 Springton Riesling and 2015 Springton Shiraz winning by popular vote. By now you should have received the heavily discounted wine offers to your inbox, or log onto the Members' section of the ASEG website to place your order.

On 24 September we co-hosted a 'Spring Fling' networking event with PESA, SPE and YPP at the Havelock Hotel. The event was a great opportunity for inter-society networking. We also briefly introduced our ideas for a 2019 mentoring program in 2019, with a launch event planned for later this year. If you are interested in this program please email me at sa-ntpresident@aseg.org.au.

Lastly, a reminder to save the date – we have secured the Gallery on Waymouth Street for our annual Melbourne Cup event on Tuesday 6 November this year, so stay tuned for an invite shortly.

If you have any suggestions/comments on the recent events we have hosted, I would love to hear from you. I'm also happy to hear any suggestions for guest speakers or if you have any visitors in town whose work may interest other members.
I would also like to take this opportunity to thank our six sponsors who help make all of our events possible – Beach Energy, Department for Energy and Mining, Minotaur Exploration, Heathgate Resources, Vintage Energy and Zonge Engineering.

Kate Robertson
sa-ntpresident@aseg.org.au

ASEG national calendar: technical meetings, courses and events

Date		Branch	Event	Presenter	Time	Venue
9	Oct	WA	YPN	Vincent Crombez and Tasman Gilfeather-Clark	TBA	TBA
11	Oct	SA-NT	Tech night	Alison Kirkby	1745	Coopers Alehouse, 316 Pulteney Street, Adelaide
17	Oct	NSW	Tech talk	Various	1730	99 on York Club, 99 York Street, Sydney
22–24	Oct	TAS	Garry Davidson Symposium	Various		CODES, University of Tasmania, Hobart
25	Oct	ACT	Student night	Marina Costelloe	1600	Geoscience Australia, Symonston
6	Nov	SA	Melbourne Cup lunch		TBA	Gallery on Waymouth Street, Adelaide
9	Nov	WA	PESA ASEG WA Annual Golf classic		1030	Araluen Golf Resort
13–15	Nov	WA	Asia Pacific Workshop on Fibre-Optic Sensing	Various	TBA	ARRC, Perth
21	Nov	NSW	Tech talk	Paul Harvey	1730	99 on York Club, 99 York Street, Sydney
21	Nov	WA	Tech Night	Various students	TBA	TBA
27	Nov	QLD	Launch YPN Mentoring Program		1730	TBA
28	Nov	WA	YPN	Launch of mentoring Various program	TBA	TBA
29	Nov	WA	GESSS WA	Various	0830	UWA, Perth
	Nov	ACT	Student Award presentation		TBA	Geoscience Australia, Symonston
	Dec	WA	AGM and Christmas Quiz	Various	TBA	TBA
	Dec	ACT	Christmas Party	TBA	TBA	TBA

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

Vale: John Kingsley Newman, Australian geophysical pioneer (1925–2018)

John Newman

One of the pioneers of airborne geophysics in Australia, John Newman, passed away in Rosebud Hospital, Victoria, on 19 May 2018.

John was born in 1925 and educated in Perth. He came from a musical family, including several opera singers, and retained a great love of all kinds of music throughout his life. He was also a keen swimmer and spearfisherman, making his own hand spears, and an enthusiastic follower of science and new developments in technology. He graduated from the University of WA as a BSc Eng in 1947, including three years of physics and pure and applied maths to support a prime interest in thermodynamics of heat engines, particularly steam and gas turbines.

John was an adventurer who was always exploring new ideas. During his younger years he worked as a pearl shell diver around Broome and spent time contract mining blue asbestos in the Hamersley Ranges during 1944 University vacation. He took a break for a year to work in the field in 1946, starting with a mine managed by Lang Hancock in Wittenoom Gorge. This was followed by work with CSIRO Division of Aeronautics in Melbourne, working on a test bench for Australia's first gas turbine.

After graduating as a BSc Eng in 1947, John took on temporary employment as a geophysicist with the Bureau of Mineral Resources (BMR), now known as Geoscience Australia, based in Melbourne. He conducted BMR's first 'survey' for uranium with a Geiger counter in Melbourne, Sydney and Brisbane mining museums. After some time working on various ground geophysical surveys, including an Australia wide absolute gravity survey with pendulums, he joined the BMR's new airborne geophysical survey team about 1950, and became its airborne systems developer.

Initially this involved converting wartime AN/ASQ-1 Magnetic Airborne Submarine Detectors to airborne magnetometer survey tools in the BMR's first DC3 aircraft. These were fluxgate instruments, initially developed by Gulf Oil for airborne magnetic surveys, but then used by the US Navy for submarine detection. After conversion John used these instruments in Australia's first airborne magnetic surveys, and later added gamma ray scintillometers for radiometric measurements.

John left the BMR in 1952 and joined the North Australian Uranium Corporation, exploring for uranium from the air using a Chalk River scintillometer installed in a light wood and fabric Auster aircraft. He did discover uranium at Coronation Hill, near the Alligator River in the Northern Territory using a total field scintillometer. In order to try to discriminate between uranium and potassium (K40) that was always present in the local granites, they flew at very low altitudes (typically 50 ft) and this eventually led to a crash that wrote off the aircraft and left John with crushed vertebrae and four months in a plaster cast.

John returned to BMR in 1954, where he converted an AN/ASQ-8 MAD magnetometer and began development of fluxgate detectors. He also took over management of BMR airborne magnetic and radiometric surveys with the BMR's second DC3. In these days the radiometric measurements were total count only, preceding gamma ray spectrometers. During these years he also developed the BMR's first proton precession magnetometers.

John left BMR again in 1963 to join Barringer Research in Canada, and was involved in Barringer participating in Australian Mining Exploration Geophysics (AMEG) together with Lindsay Ingall. John later became the majority and then sole owner of AMEG, the first Australian owned airborne geophysical exploration company. It operated from 1965 to 1974 with light aircraft and proton precession magnetometers providing commercial surveys to exploration companies. Typically, these surveys provided more detailed data (terrain clearance 150 feet and line separation 500 feet) than the BMR, and navigation was usually achieved by manual picking on photographs. Pilots were usually recruited from the crop spraying industry.

About 1968 AMEG's business was boosted by the development the first successful computer automated data acquisition and processing system for airborne geophysical data. This was developed by Engineering Computer Services (ECS) of NSW. Data was initially captured by photographing side

lit numerical indicators of total magnetic field at one second intervals, and converting these to punch cards and paper tape. The ECS software then converted magnetic profile data to contour maps – a huge step forward at that time. AMEG, working with ECS, was a world leader at that time but eventually was displaced by others. In 1974 AMEG won a large contract to fly a sedimentary basin for BMR but these were recession years and they were unable to finance it. John went to Canada to seek finance but failed and stayed in Toronto working with Barringer Research.

John was always an innovator, he was always eager to grasp new technology and adapt it to geophysical applications. In 1976 he left Barringer to raise capital and support for automated geophysical systems and consulted to several geophysical companies in the Toronto area. He established Interex Geophysics, later to become Interex Computing Systems, in collaboration with several colleagues from the University of Toronto.

Eventually, John returned to Sydney and finally Melbourne, where he settled in Frankston in 1992. He continued his interest in technology and several other business ventures through connections in Australia and North America. He gradually moved out of geophysics, although he remained interested and kept in touch. He retained contact with colleagues in Orbitec who he visited regularly in El Paso.

John remained active and swam regularly at Frankston Beach, in winter, into his 90s. Eventually his health declined, and his physical activity became limited. His mind was sharp, and he put together some notes on his life story and assisted other colleagues in compiling a history of airborne magnetic surveys in Australia. His physical limitations frustrated him, but he kept in touch with many friends and colleagues through email. It was a serious inconvenience to him that death would eventually prevent him from keeping up with developments in technology.

John was an adventurer, innovator and pioneer in Australian geophysics. He is survived by his wife, Ruth, and his daughter, Sheila, who assisted with the compilation of this obituary.

Bob Smith
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AEGC 2019: Call for abstracts announced

The call for abstracts is now open for AEGC 2019, the largest geoscience conference in the southern hemisphere!

Jointly hosted by the Australian Institute of Geosciences, Australian Society of Exploration Geophysicists and the Petroleum Exploration Society of Australia, the AEGC 2019 technical program committee has a focus on geology, geophysics and geochemistry. The call for abstracts is open until 31 August 2018.

Papers are being sought from a wide range of disciplines, including, but not limited to geology, petrophysics, geophysics, petroleum systems, geochemistry, basin modelling, discovery techniques and regolith, conventional oil and gas, mineral mapping, unconventional oil and gas, geometallurgy, CO2 sequestration, ore genesis, coal, mineral systems characteristics, regional deep crustal studies, remote sensing and applications, greenfield exploration case histories, geochronology, brownfield development case histories, project generation and targeting, strategic and industrial minerals, environmental studies, groundwater, hydrothermal applications, palaeontology and archaeology, geotechnical studies, geohistory and geoheritage, high performance computing, mining geology, mathematical methods.

Keep up to date by registering at www.aegc.com.au or by following the LinkedIn page http://www.linkedin.com/company/aegc2019/.

Maud Kay
AEGC 2019 Publicity & Marketing Chair
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Perth to host first Asia Pacific workshop on fibre-optic sensing

The proliferation of fibre-optic cables has resulted in an increased level of interest in their use as sensors. With the employment of appropriate hardware, the cables can be used for both temperature and vibration monitoring. The latter, commonly referred to as Distributed Acoustic Sensing or DAS, is of particular interest to geophysicists as it can enable, for example, a Vertical Seismic Profile to be acquired over the full depth of a well with spatial sampling of under 1 m in a matter of minutes (Figure 1). Attention is also now turning to the use of DAS to quickly and cheaply acquire surface seismic data.

To raise awareness of the uses of fibre-optic sensing Curtin University and the CSIRO are hosting the first Asia Pacific Workshop on Fibre-Optic Sensing in Perth between 13 and 15 November 2018.

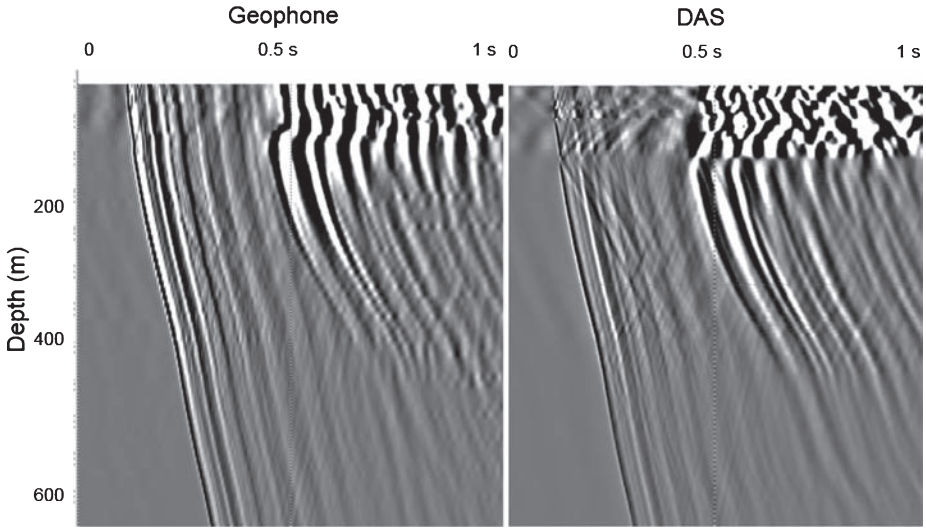

Figure 1. *Comparison of a conventionally acquired (geophone) VSP with one acquired using a DAS system.*

The workshop is divided into three sections:

(1) A Masterclass on fibre-optic sensing by Dr Arthur Hartog. Arthur's research led to the first demonstration of a distributed optical fibre sensor in 1982. Since then he has continued to work on optical sensing and was responsible for the first Raman distributed temperature system. Arthur is the author of the acclaimed book *An introduction to distributed optical fibre sensors*.
(2) Presentations from industry and academia detailing the application of fibre-optic sensing in fields such as mining, oil & gas exploration and production monitoring, pipeline monitoring, security systems, and road and rail monitoring.
(3) Practical demonstrations conducted at Curtin University's dedicated field laboratory.

Registrations are available via the workshop website (www.apwfos.org) and a discounted rate for ASEG Members is available.

Tim Dean
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Update on geophysical survey progress from Geoscience Australia and the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current on 3 October 2018)

Further information on these surveys is available from Dr Yvette Poudjom Djomani at GA via email at Yvette.PoudjomDjomani@ga.gov.au or telephone on (02) 6249 9224.

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
Tasmanian Tiers	MRT	GA	TBA	TBA	Up to an estimated 66 000	200 m 60 m N–S or E–W	11 000	TBA	TBA	TBA	The National Collaborative Framework Agreement between GA and MRT is being updated
Tallaringa N (1A)	GSSA	GA	Thomson Aviation	26 Oct 2017	97 922	200 m 60 m E–W	17 320	26 Mar 2018	TBA	190: Oct 2017 p. 26	TBA
Tallaringa S (1B)	GSSA	GA	Thomson Aviation	26 Sep 2017	145 367	200 m 60 m E–W	26 010	12 May 2018	TBA	190: Oct 2017 p. 26	TBA
Coober Pedy (8A)	GSSA	GA	Thomson Aviation	18 Sep 2017	90 425	200 m 60 m N–S	16 140	21 Dec 2017	TBA	190: Oct 2017 p. 26	TBA
Billa Kalina (8B)	GSSA	GA	MAGSPEC Airborne Surveys	10 Oct 2017	90 353	200 m 60 m N–S	16 140	18 Dec 2017	27 Jul 2018	190: Oct 2017 p. 26	TBA
Childara (9A)	GSSA	GA	MAGSPEC Airborne Surveys	5 Nov 2017	134 801	200 m 60 m N–S	23 910	2 May 2018	TBA	190: Oct 2017 p. 26	TBA
Lake Eyre (10)	GSSA	GA	MAGSPEC Airborne Surveys	2 Oct 2017	91 938	200 m 60 m E–W	16 180	22 Mar 2018	TBA	190: Oct 2017 p. 26	TBA
Streaky Bay (5)	GSSA	GA	GPX Airborne Surveys	21 Jun 2018	90 630	200 m 60 m E–W	15 966	28 Sep 2018	TBA	194: Jun 2018 p. 19	TBA
Gairdner (6A)	GSSA	GA	GPX Airborne Surveys	31 Jul 2018	105 075	200 m 60 m N–S	18 307	TBA	TBA	194: Jun 2018 p. 19	21% complete at 1 Oct 2018
Spencer (7)	GSSA	GA	MAGSPEC Airborne Surveys	11 Jun 2018	50 280	200 m 60 m E–W	8716	6 Aug 2018	TBA	194: Jun 2018 p. 19	TBA
Kingoonya (9B)	GSSA	GA	MAGSPEC Airborne Surveys	5 Aug 2018	150 565	200 m 60 m N–S	26 651	TBA	TBA	194: Jun 2018 p. 19	42.7% complete at 30 Sep 2018
Cloncurry North	GSQ	GSQ	GPX Surveys	Mid-May 2018	101 597	100 m	8687	8 May 2018	8 May 2018	This issue (GSQ section – Figure 1). For more information about this survey please contact geophysics@dnrme.qld.gov.au	31 May 2018
Tanami	NTGS	GA	Thomson Aviation	14 Jul 2018	275 216	100/ 200 m 60 m N–S/E–W	48 267	TBA	TBA	195: Aug 2018 p. 16	63% complete at 2 Oct 2018

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
Kidson Sub-basin	GSWA	GA	CGG Aviation (Australia)	14 Jul 2017	72 933	2500 m line spacing	155 000	3 May 2018	TBA	The survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan 1:250 k standard map sheet areas	TBA
Lawn Hill	GSQ	GA	Atlas Geophysics	21 May 2018	7240	1000 m line spacing	8024	8 Jul 2018	9 Aug 2018	194: Jun 2018 p. 19	13 Sep 2018
Little Sandy Desert W and E Blocks	GSWA	GA	Sander Geophysics	W Block: 27 Apr 2018 E Block: 18 Jul 2018	52 090	2500 m line spacing	129 400	W Block: 3 Jun 2018 E Block: 2 Sep 2018	TBA	195: Aug 2018 p. 17	TBA
Kimberley Basin	GSWA	GA	Sander Geophysics	4 Jun 2018	61 960	2500 m line spacing	153 400	15 Jul 2018	TBA	195: Aug 2018 p. 17	TBA
Warburton-Great Victoria Desert	GSWA	GA	Sander Geophysics	Warb: 14 Jul 2018 GVD: 27 Jul 2018	62 500	2500 m line spacing	153 300	Warb: 31 Jul 2018 GVD: 3 Oct 2018	TBA	195: Aug 2018 p. 17	GVD: 100% complete on 3 Oct 2018

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
East Kimberley	GA	GA	SkyTEM Australia	26 May 2017	13 723	Variable	N/A	24 Aug 2017	Nov 2017	TBA	TBA
AusAEM (Year 1)	GA	GA	CGG	TBA	59 349	20 km with areas of infill	TBA	31 Jul 2018	2 Oct 2018	186: Feb 2017 p. 18	TBA
Surat-Galilee Basins QLD	GA	GA	SkyTEM Australia	2 Jul 2017	4627	Variable	Traverses	23 Jul 2017	Nov 2017	188: Jun 2017 p. 21	TBA
Stuart Corridor, NT	GA	GA	SkyTEM Australia	6 Jul 2017	9832	Variable	Traverses	12 Aug 2017	Nov 2017	188: Jun 2017 p. 22	TBA
Olympic Domain	GSSA	GA	SkyTEM Australia	14 Nov 2017	3181	1.5 & 3 km E–W	33 200	21 Nov 2017	Preliminary final data received by GA 16 Mar 2018	190: Oct 2017 p. 27	Data released via the GA website on 30 Jul 2018
Fowler Domain	GSSA	GA	SkyTEM Australia	Early Dec 2017	3057	5 km NW–SE	15 000	5 Dec 2017	Preliminary final data received by GA 16 Mar 2018	190: Oct 2017 p. 27	Data released via the GA website on 30 Jul 2018

TBA, to be advised.

Table 4. Magnetotelluric (MT) surveys

Location	State	Survey name	Total number of MT stations deployed	Spacing	Technique	Comments
Northern Australia	Qld/NT	Exploring for the Future – AusLAMP	232 stations deployed in 2017–18	50 km	Long period MT	The survey covers the area between Tennant Creek and Mount Isa. The 2018 field season commenced in May 2018.
AusLAMP NSW	NSW	AusLAMP NSW	5034 stations deployed in 2018 to date	50 km	Long period MT	Covering the state of NSW with long period MT stations at approximately 50 km spacing.
Olympic Domain	SA	Olympic Domain	320 total	Varied 1.5 to 10 km	AMT and BBMT	The survey area extends west of Lake Torrens and covers mineral prospects such as Carrapateena, Fremantle Doctor, Red Lake, Punt Hill, Emmie Bluff and Mount Gunson. The survey was completed to Jul 2018.

Table 5 Seismic reflection surveys

Location	State	Survey name	Line km	Geophone interval	VP/SP interval	Record length	Technique	Comments
South East Lachlan	Vic/ NSW	SE Lachlan	Approx. 450	10 m	40 m	20 seconds	2D – Deep crustal seismic reflection	The survey covers the South East Lachlan Orogen crossing the Victorian–New South Wales border. The data acquisition phase of the survey commenced on 5 Mar 2018 near Benalla in Victoria. The survey completed data acquisition south of Eden in NSW on 29 Apr 2018.
Kidson	WA	Kidson Sub-basin	Approx. 900	TBA	TBA	TBA	2D – Deep crustal seismic reflection	Within the Kidson Sub-basin of the Canning Basin extending across the Paterson Orogen and onto the eastern margin of the Pilbara Craton. The survey completed acquisition on 8 Aug 2018.

Editor's note: Murray Richardson, who was a regular and very reliable contributor to *Preview* on behalf of Geoscience Australia, has retired. The *Preview* team will miss him and wish him all the best for the future.

Geological Survey of Victoria: updates on the Stavely Project and the Victorian Gas Program

Stavely Project: A new geological understanding

A new geological understanding for the Cambrian Stavely Arc in western Victoria has been developed as part of the Stavely Project, a pre-competitive collaborative geoscience work program undertaken by the Geological Survey of Victoria (GSV) and Geoscience Australia. The knowledge generated through a systems approach has greatly expanded the mineral exploration search space for arc-related mineral systems in an area of approximately 20 000 km^2. Historical and current mineral prospects for copper and associated metals are known to be associated with Cambrian volcanic belts exposed at surface; however, the majority of the arc, concealed by sedimentary and volcanic rocks, remains untested.

The geoscientific outcomes of the project, with emphasis on their impact on mineral prospectivity and application to mineral exploration, have been summarised in a series of reports published by Geoscience Australia and the Geological Survey of Victoria. The findings were publicly presented at a technical workshop held over two days in Melbourne and at GSV's Werribee Core Library on 27 and 28 June 2018. The workshop was very well attended (Figure 1) with over 150 participants showing great interest in the new regional 3D model demonstration and the examples of the stratigraphic drilling undertaken as part of the project and the mineralised core kindly provided by current explorers for the day – presentations are available online. There was also renewed interest in the Geophysical Signatures of Base Metals in Victoria volume (Willocks et al., 1999), jointly published by GSV and ASEG in 1999!

http://earthresources.vic.gov.au/earth-resources/geology-of-victoria/gsv-projects/the-stavely-project

To download reports, go to the Earth Resources online store at http://earthresources.vic.gov.au/earth-resources/maps-reports-and-data.

Figure 1. *Stavely Project Technical Workshop participants at GSV's Werribee Core Library.*

Victorian Gas Program: Otway Basin Airborne Gravity Survey

The Otway Basin Airborne Gravity Survey covers approximately 16 000 km^2 of southwestern Victoria from the edge of the Otway Ranges to the Victorian/South Australian border. It includes Victorian coastal waters offshore (Figure 2).

CGG Aviation (Australia) Pty Ltd is flying Full Spectrum Falcon® and magnetics at 500 m line spacing and 150 m minimum clearance with the line direction approximately parallel to the coast. Production flights began in August and GSV expects data acquisition to be completed by November 2018. Located data and grids will be publicly released as soon as processing/QC of the survey data is complete.

The new airborne gravity and gravity-gradient data will provide a significant improvement in gravity coverage compared with the existing ground gravity stations on unevenly-spaced detailed lines and at 1.5 km regional spacing onshore and the sparse ship-track gravity offshore.

The Otway Basin Airborne Gravity Survey is a substantial part of the scientific research being carried out as part of the Victorian Gas Program. The results of the survey will support the 2018 Victorian Offshore Acreage Release and help inform GSV's geoscience studies into the potential for further discoveries of onshore conventional gas in the Otway Basin.

http://earthresources.vic.gov.au/earth-resources/victorian-gas-program/airborne-gravity-survey

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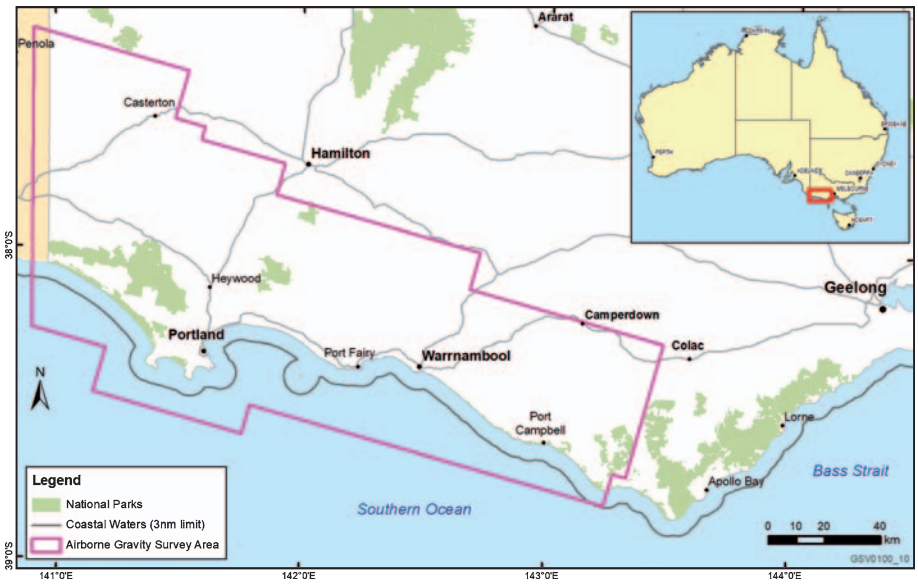

Figure 2. *Otway Basin Airborne Gravity Survey area.*

Reference

Willocks, A. J., Haydon, S. J., Asten, M. W., and Moore, D. H., 1999, Geophysical signatures of base metal deposits in Victoria. Geological Survey of Victoria Report 119 and Australian Society of Exploration Geophysicists Special Publication 11.

Geological Survey of South Australia: New data and upcoming events

First release of enhanced geological structure and depth to magnetic sources from the Gawler Craton Airborne Survey

The Geological Survey of South Australia, in collaboration with CSIRO, have released the first of sixteen data packages that are the result of an ongoing study to enhance the expression of geological structure in geophysical images and derive depth to magnetic sources, at regional scales. The 2017–18 Gawler Craton airborne geophysical survey (GCAS) provides a higher resolution and more consistent mapping of the magnetic field than is available from the previous multi-survey coverage. The advantages of the new survey data are clear on examination of the total magnetic intensity (TMI) data, but it is after enhancement of that TMI data to assist recovery of detailed geological information that the advantages are most clearly expressed.

The result of this study is a collection of images and data products, incorporating studies of the gravity field and magnetic source depths, released to facilitate geological interpretation (Figure 1, Table 1, and Figure 2).

In the source depth study a 'sweet-spot' analysis was used for source depths, which attempts to optimise the precision of individual depth estimates by selecting only the data most appropriate for source depth estimation, and then applying intensive, multi-pass inversions to simultaneously optimise all source parameter estimates from each data selection individually. For Region 2A (Figure 1), 322 source depth solutions were computed. Source depths were compared with known basement drillhole intercepts and a subset of the source depth estimates was used to interpolate basement surfaces (Figure 3).

On 4 December, The Geological Survey of South Australia are holding a GCAS workshop at the Tonsley Drill Core Facility, Adelaide as part of Discovery Week. The workshop will feature presentations from GSSA and CSIRO on the GCAS, all of the available data, case studies and enhancements. You can register your interest by contacting the GCAS Project Leader Laz Katona at Laz.Katona@sa.gov.au.

All available data for the Gawler Craton Airborne Survey, including the data package for GCAS 2A, can be found on the GCAS community information website: http://energymining.sa.gov.au/minerals/gcas.

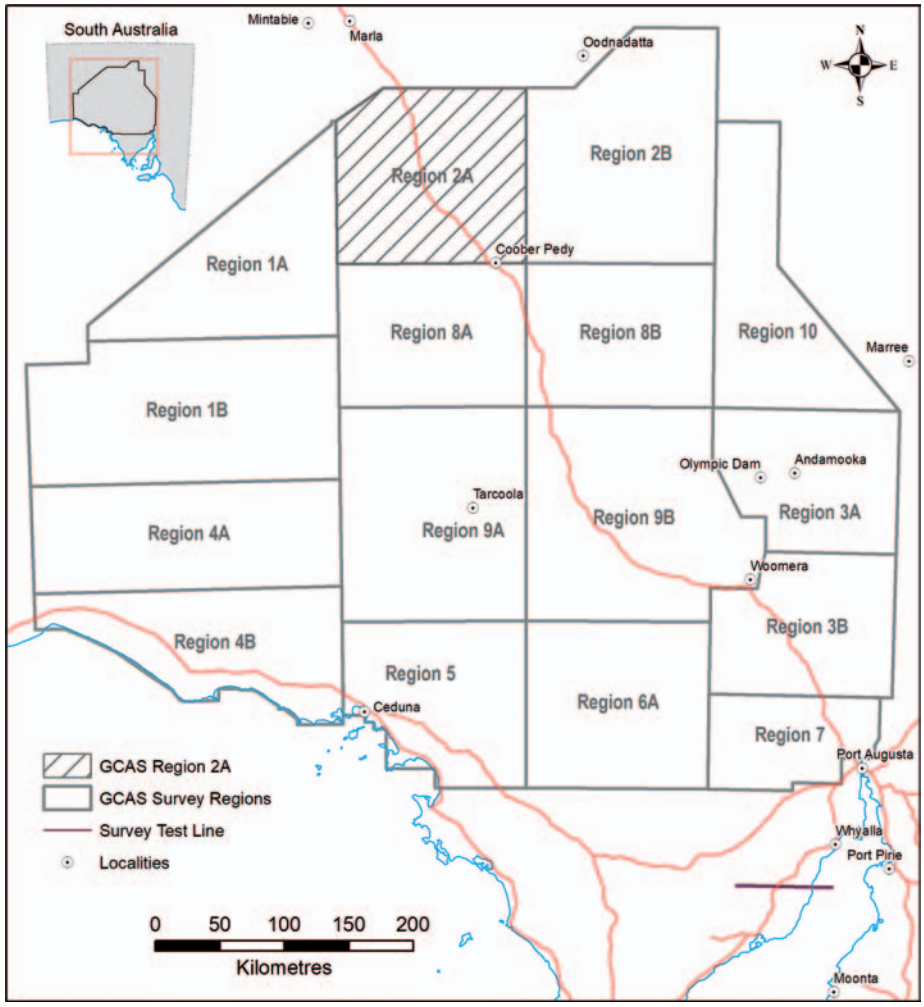

Figure 1. *Detail of the GCAS regions. Region 2A (Murloocoppie) is the first of 16 regions of value added data and magnetic models to be released.*

Table 1. List of enhanced images and depth modelling products released

Enhanced images included in package	Depth modelling products included in package
Bouguer gravity/Vertical Derivative	Basement Elevation
Bouguer gravity pseudo magnetic	Basement intersecting drillholes
Bouguer gravity worms	Cover thickness
TMI Bzz	Magnetic basement surface
TMI Pseudo gravity	Magnetic 3D depth products
TMI RTP/TMI RTP 1VD/ TMI RTP 2VD	Magnetisation models
TMI RTP Tilt	Model sections
TMI total gradient	Model session files (Model Vision)
TMI Trend	Magnetic Source solutions
TMI Trend Consistency	
TMI worms	

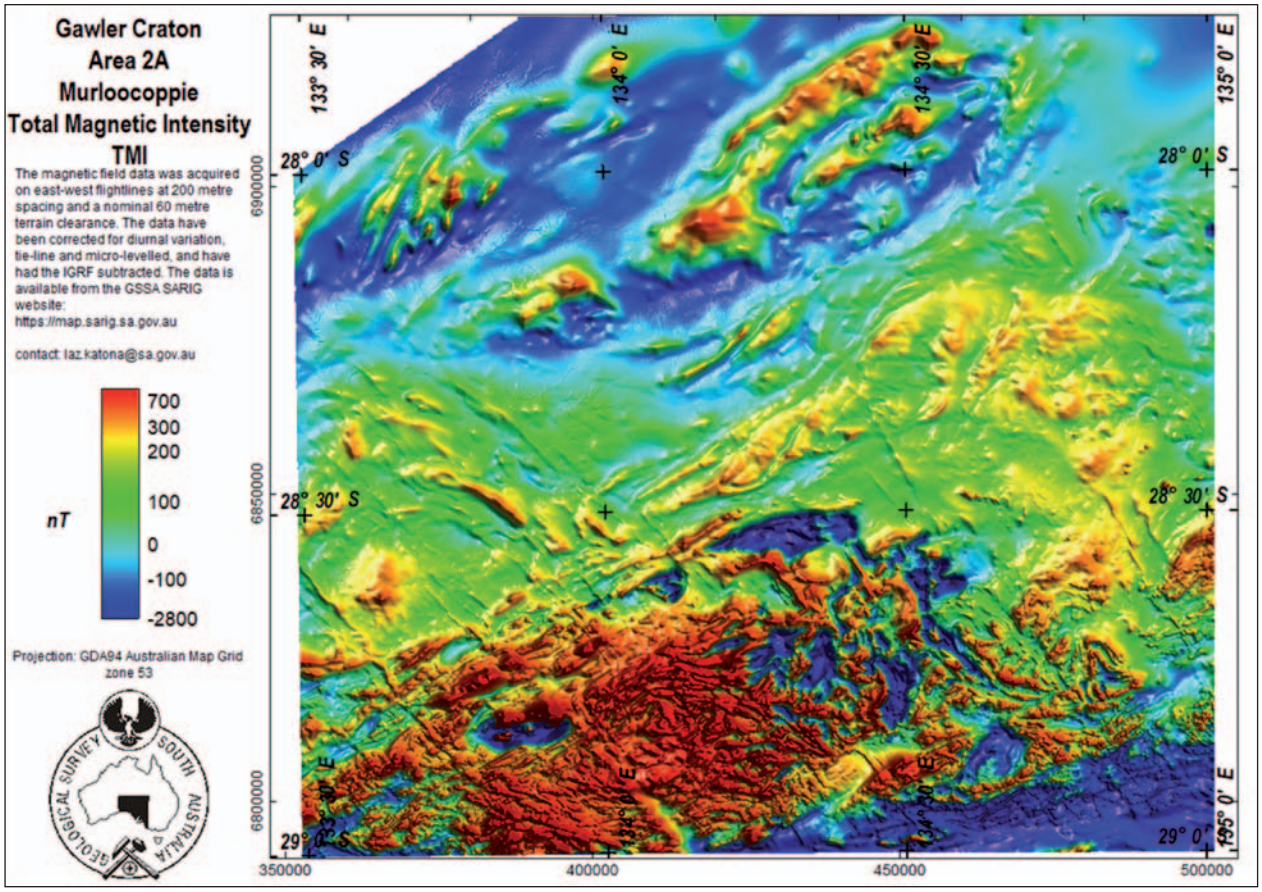

Figure 2. *TMI of GCAS Region 2A.*

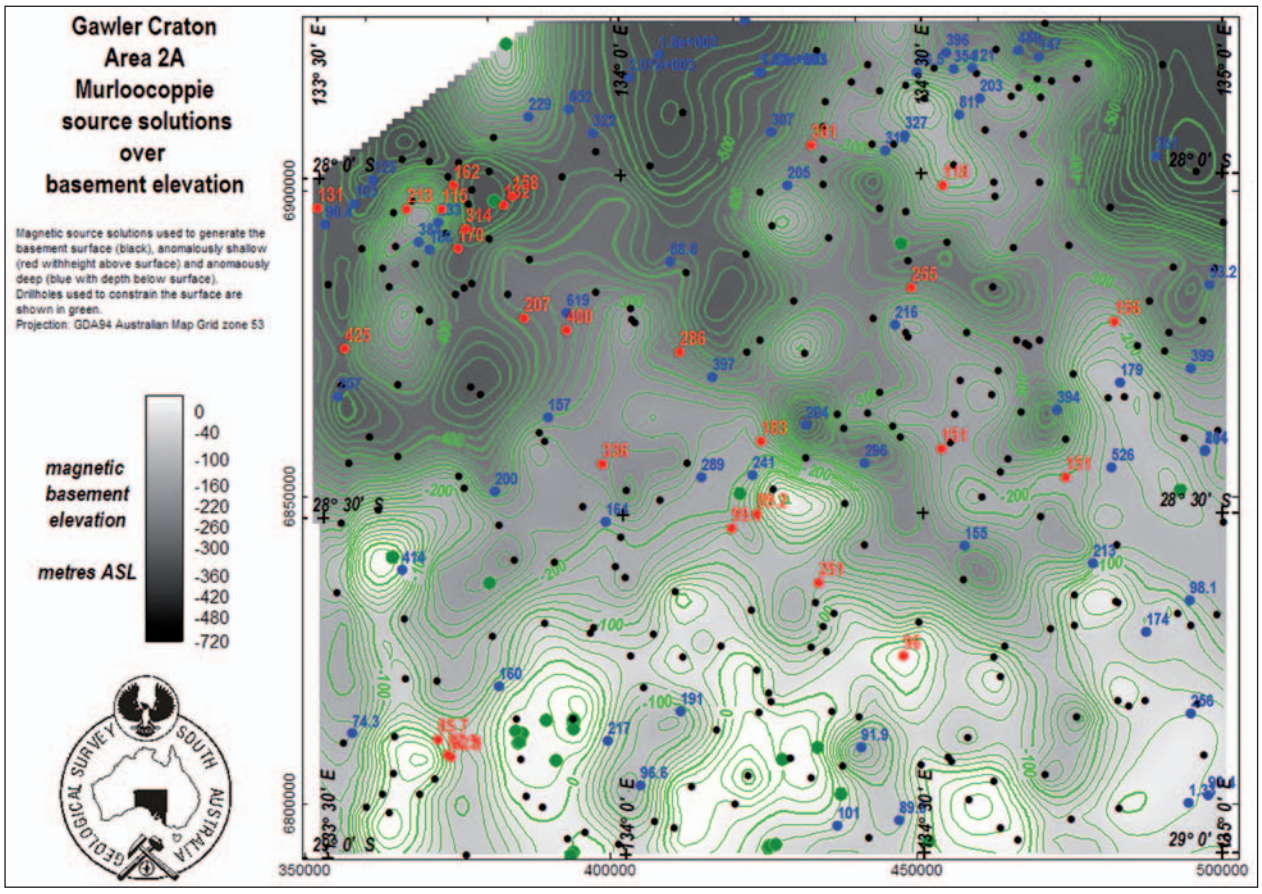

Figure 3. *Basement elevation surface derived from a combination of magnetic source depth solutions and drillhole stratigraphy for GCAS region 2A.*

Other upcoming events in South Australia

Keep your calendar free in early December for a series of workshops and data releases hosted by the Geological Survey of South Australia, followed by the South Australian Exploration and Mining Conference run by the AIG, ASEG, AusIMM and GSA (Table 2).

Gawler Craton Airborne Survey workshop 2018

The aim of this workshop is to demonstrate the utility of the new GCAS datasets and value added products by bringing the principal project participants together with industry and other agencies who have an interest in the project and products to discuss methodologies, interpret the results and deliver the roadmap for the remainder of the GCAS acquisition and data releases.

Attendees will be a mix of GSSA staff, the GCAS team, industry representatives, CSIRO and possibly Geoscience Australia personnel. While still in the early planning stages, we are hoping for contributions from Brian Minty and Clive Foss, and GSSA's GCAS team will deliver a number of presentations. There is scope for an interactive session where some of the new data can be interpreted interactively, in hardcopy.

National MT workshop and AusLAMP SA release day

Magnetotellurics has the capacity to provide an unprecedented insight into the architecture of the Australian continent and its mineral systems. This insight is revolutionising the way in which mineral exploration is conducted. The National UNCOVER strategy identified the collection of a national network of magnetotelluric data as one of the highest priorities for the Australian geoscientific community. The Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP) is a collaborative national magnetotelluric (MT) project focused on acquiring long-period MT data at approximately 2800 sites across Australia at approximately 50 km spacing.

The aim of this workshop is to celebrate the success of AusLAMP by bringing the MT community of Australia together with all interested in understanding the lithospheric architecture of the continent, to discuss the methodology, the interpretation and future progress of this important geophysical method and associated data sets. The workshop will also celebrate the completion of the South Australian portion of AusLAMP and the release of this new MT data.

Discovery Day

Themed 'Discover: New Data, New Technology, New Insights', the South Australian Government's Geological Survey of South Australia (GSSA) Discovery Day will showcase the latest innovative work of the GSSA staff and key collaborators and deliver new insights and opportunities for mineral exploration and discovery in South Australia. Online registration here prior to the event is mandatory to gain entry. Catering will be included in your free registration.

Kate Robertson, Stephan Thiel, Laszlo Katona, Philip Heath
Geological Survey of South Australia, Department of Energy and Mining

Table 2. Upcoming events in South Australia

Event	Date	Location	Cost	More information
Gawler Craton Airborne Survey Workshop 2018	Tuesday 4 December	SA Drill Core Reference Library, Tonsley	Free	Laz Katona Laz.katona@sa.gov.au
National MT Workshop and AusLAMP SA Release Day	Wednesday 5 December	SA Drill Core Reference Library, Tonsley	Free	Stephan Thiel Stephan.Thiel@sa.gov.au
Discovery Day	Thursday 5 December	Adelaide Convention Centre	Free- register here	See the website for more information, or email: resources.customerservices@sa.gov.au
South Australian Exploration and Mining Conference	Friday 6 December	Adelaide Convention Centre	Registration $200, students $50 here	http://www.saexplorers.com.au/ info@saexplorers.com.au

Geological Survey of New South Wales: Palaeomagnetism and magnetic petrophysics – oroclines and arcs

Bob Musgrave, Senior Research Geophysicist, manages the Geological Survey of NSW (GSNSW) PALM Lab (for Palaeo- Archaeo- Litho-Magnetic Laboratory). This palaeomagnetic/magnetic petrophysics facility is based at the University of Newcastle and operates in collaboration with the Centre for Geoscience in the Newcastle Institute for Energy and Resources (NIER). First set up in 2012, the lab has grown from a basic facility supporting 'classic' palaeomagnetic studies of tectonics, to embrace a diverse range of research, ranging from magnetostratigraphy and magnetic petrophysics studies of volcanosedimentary sequences, to tracking the accumulation and migration of gas hydrates in marine sediments. The lab also provides fundamental support to the NSW petrophysics database, by providing measurements of saturated density, high precision magnetic susceptibility, the Königsberger ratio, and remanence polarity and direction (for oriented samples). The equipment and capabilities of the PALM Lab are summarised in Figure 1 and Table 1.

Following a recent upgrade involving the purchase of a high-sensitivity spinner magnetometer (AGICO JR-6A), refurbishment of the vibrating sample magnetometer, and the installation of a purpose-built parallel diamond saw, the lab is now engaged in a palaeomagnetic test of the Lachlan orocline hypothesis (Cayley, 2015; Musgrave, 2015), a new model for the late Ordovician to early Devonian tectonic evolution of eastern Australia (Figure 2). The project, which forms part of GSNSW's contribution to the ARC Linkage project 'Ore deposits and tectonic evolution of the Lachlan Orogen, SE Australia', involves PhD students Umer Habib and Tom Schaap from the University of Tasmania.

In a nutshell, the Lachlan orocline hypothesis explains the apparent repetition of terranes in the Lachlan Orogen in Victoria as the result of a pair of oroclines – vertical-axis folds penetrating through the lithosphere and extending laterally for hundreds of kilometres. The driving mechanism for the folding is thought to be rapid south-eastward retreat of the palaeo-Pacific subduction zone due to roll-back of the slab after its southern end was pinned by the arrival of the continental

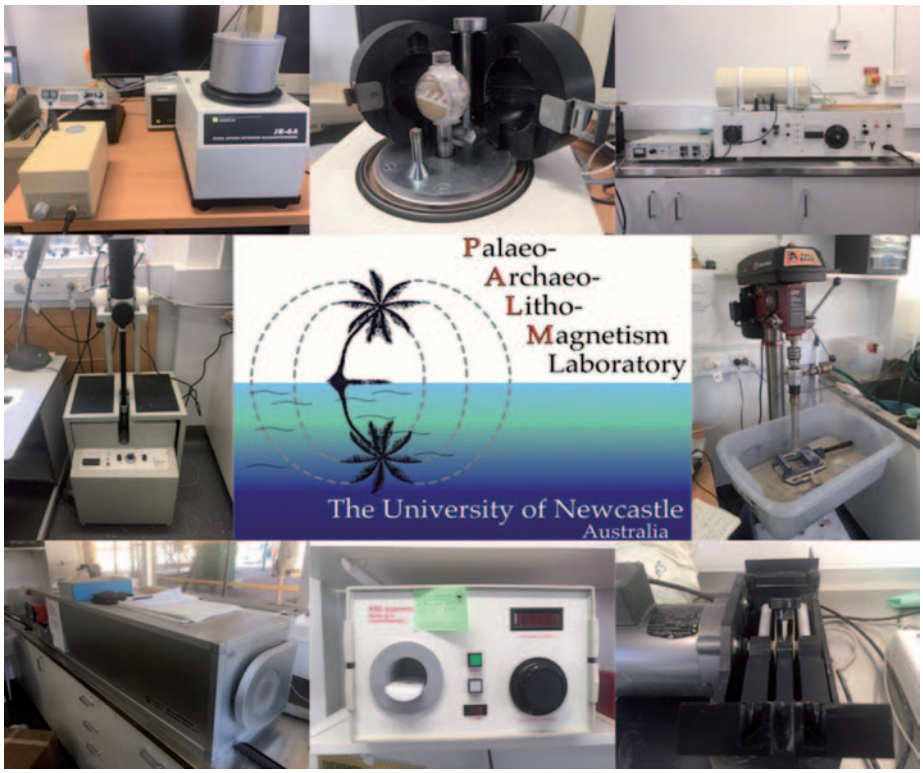

Figure 1. *Montage of PALM lab equipment. Clockwise from top left: magnetic susceptibility well sensor and AGICO spinner magnetometer; inside the AGICO, showing automated specimen holder; alternating field demagnetiser; diamond drill; parallel-blade specimen saw; pulse magnetiser; thermal demagnetiser; vibrating sample magnetometer.*

Table 1. Equipment at the PALM Lab

Instrument	Function
AGICO JR-6A high-sensitivity spinner magnetometer	Remanence direction and intensity: range 2.4 μA/m to 12.5 kA/m
Molspin spinner magnetometer	Remanence direction and intensity: range 100 μA/m to 2.5 A/m
Magnetic Measurements thermal demagnetiser	Stepwise thermal demagnetisation: imposition of controlled partial thermal remanent magnetisation
Molspin alternating field demagnetiser, with partial anhysteretic remanent magnetisation add-on box	Stepwise alternating field demagnetisation: imposition of controlled partial anhysteretic remanent magnetisation
IM-10 pulse magnetiser	Isothermal remanence acquisition and DC demagnetisation
Molspin Nuvo vibrating sample magnetometer	Magnetic hysteresis analysis
Bartington MS-2 magnetic susceptibility, with well and stratigraphic sensors	High sensitivity, accurately calibrated magnetic susceptibility
Fluxgate and Hall-effect magnetometers	Low- and high-field test equipment
Mu-metal cans	Low-field specimen storage
Degaussing 'wand'	Degaussing of magnetic shields
Archimedes scale and vacuum saturator	Saturated density and specimen volume
Water-cooled diamond bit on drill press mount	Preparation of palaeomagnetic and petrophysics samples
Parallel blade diamond saw	Preparation of palaeomagnetic and petrophysics samples
Freezer for marine sediment storage	Storage of marine sediment samples, to minimise alteration of iron sulfides

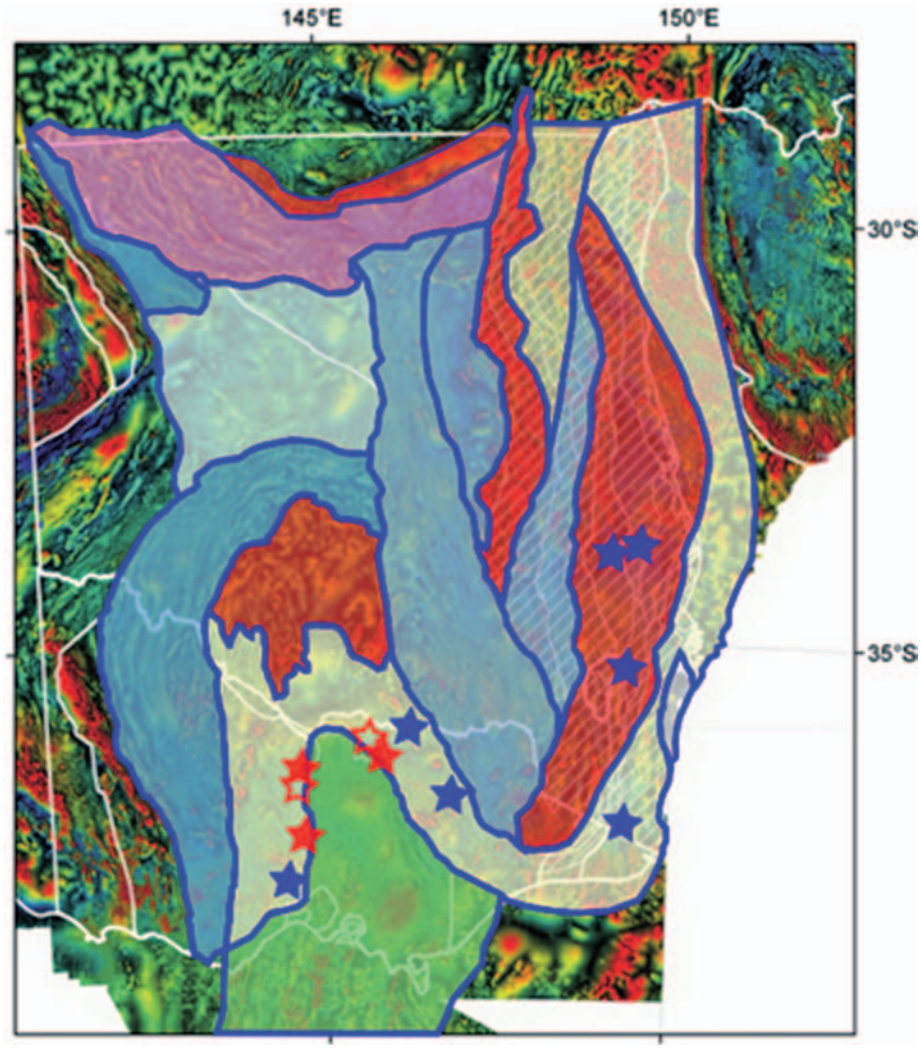

Figure 2. *Sample localities (stars) on a map showing elements of the Lachlan orocline hypothesis superimposed on a tilt-filtered total magnetic intensity image of eastern Australia. Each locality comprises multiple sites. Blue stars = late Ordovician–Silurian, red stars = Cambrian. Open symbols are localities from an earlier study (Tetley et al., 2014).*

Selwyn Block, which extends Tasmanian crust under the Melbourne Zone in Victoria (Moresi et al., 2014). Rotation of palaeomagnetic declination in sympathy with an oroclinal fold has been employed to validate similar structures in Europe (Van der Voo, 2004).

A proof-of-concept study using the PALM Lab of a related orocline hypothesis for the origin of curvature of the Dundas–Fossey in Tasmania was recently completed as a BSc Honours project by University of Tasmania student Kat Job (Job and Musgrave, 2018). Bob and Umer have recently returned from a reconnaissance sampling survey around the Lachlan Orocline, collecting over 180 oriented cores from 34 sites (Figure 3).

Other work at the PALM Lab is currently focussed on assembling and measuring a representative suite of rock specimens from the highly prospective Macquarie Arc, to supplement the existing rather patchy dataset of field- and core-based measurements. The specimens, all standardised in dimensions (2.5 cm diameter, 2.2. cm long) to fit the range of instruments in the lab, will be archived for any future additional studies.

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Van der Voo, R., 2004, 2004 Presidential address: paleomagnetism, oroclines, and growth of the continental crust. *GSA Today* **14**(12), 4. doi:10.1130/1052-5173(2004)014<4:poagot>2.0.co;2

Figure 3. *PhD student Umer Habib coring siltstone in the Rockley Volcanics.*

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The Resources 2030 Taskforce report

Summary

The Resources 2030 Taskforce has provided the government with 29 recommendations aimed at ensuring the Australian resources sector is strong, competitive and sustainable both now and in the future.

The Minister, Matt Canavan, and the Chair of the 2030 Taskforce, Andrew Cripps, should be pleased with the report. As the Minister stated, this is just the first step in developing a hopefully, by-partisan 'White Paper'. Like many important issues, the devil is going to be the detail. There may be tension between the States and the Federal Government. There will be issues with who is going to be responsible for implementation, how much will it cost and who is going to pay for it.

For example, there is a simple recommendation (R10) that 'the federal government should amend the Australian Bureau of Statistics' data collection categories to better capture and quantify greenfield exploration expenditure'.

That should be straightforward, but the ABS has been starved of funds from years of efficiency dividend cuts and without more resources it may not be able to comply with this request. Consequently, do the States provide the funding or can the federal government be persuaded to realise the value of good data? In any case, why didn't the Taskforce approach the ABS to discuss the issue?

The process

The Resources 2030 Taskforce was established by the Resources Minister Matt Canavan on 28 March 2018 and was tasked to advise the government on how to ensure that the resource sector's competitiveness and sustainability is maintained to 2030 and beyond.

Its report was delivered to the Minister in August, as requested, and the Minister made it public on 21 September – an impressive performance.

In the six-month period the Taskforce interacted with over 100 people in both the mineral and petroleum resource industries, received 32 submissions, and was supported by 14 officers from the Department of Industry, Innovation and Science. See: https://www.industry.gov.au/strategies-for-the-future/resources-2030-taskforce for a very comprehensive account of the process and the report to the Minister.

It is interesting reading the submissions. All the main lobby groups and professional associations such as AMEC, AusIMM, APPEA and the MCA contributed – and they mostly complained about red-tape, land access and the complexity of environmental compliance. Rio Tinto was the only company in the top 200 of the ASX that made a submission, and it pulled no punches: reduce corporate tax; change the GST framework, which penalises those who contribute the most; maintain the fuel tax credits; develop an energy policy that meets Australia's emissions target; build trust with China and ensure that anti-Chinese sentiment does not take hold; reduce red tape and develop a climate change policy. The Australian Nuclear Association made a case for nuclear energy and Geoscience Australia and CSIRO argued for more research and better access to data.

Surprisingly, the mineral resources industry is doing reasonably well at the moment. It's the petroleum sector's investment that has declined dramatically and is of concern, and yet it did not appear to receive any special attention.

The recommendations

The key recommendations within the six main themes are summarised below. You have to go to the report to see them all.

1. Positioning the sector for the future

2. A strategic ministerial advisory group should be established to drive reform and promote the long-term national interests of the resources sector. The group would work in collaboration with industry, states and territories, communities, research bodies and the federal government towards the 2030 ambition of being the most advanced and successful resources sector in the world.
3. Resources ministers on the Council of Australian Governments Energy Council should agree and lead a strategic national reform agenda for the resources sector that is informed by the strategic ministerial advisory group and the National Resources Statement.

Comment: The gists of these recommendations are commendable, but how will such a diverse group of people and agencies work together in practice? And how would success be measured?

2. Attracting investment by promoting Australia's world-class strengths

7. Governments and industry should collaborate on a strategy to better promote Australia's world-class strengths as a destination for inbound investment in the resources sector,
8. Governments and industry should better promote Australia's resource export capabilities, with a focus on its strengths in environmental management and restoration economy, the resources equipment, technology and services sector and higher education.

Comment: It is not clear what could be done better than at present; how much more should be spent and how the effort would be managed?

3. Finding and developing new resources

9. Governments and industry should develop a Resources Data Strategy to advance collaboration on data collection and analysis. The strategy would cover ways to improve:

a. the scope and curation of geoscience, environmental and heritage data;
b. data access and discoverability.

11. Governments should support and develop a mechanism to attract and deploy co-funding for UNCOVER initiatives, to harness research and make a step change in exploration success rates in under-cover terrains and provide high-quality resources for future generations of Australians.
12. Governments and industry should determine which body will drive the implementation of UNCOVER initiatives.
13. The federal government should expand the Exploring for the Future program to make it a national initiative, both onshore and offshore.
15. Governments should develop strategies to facilitate value-adding for prospective battery and critical minerals domestically.

Comment: These recommendations are very relevant for the ASEG. All highly commendable, how they can be implemented in practice and how much will they cost are the key unknowns.

4. Building strong communities

16. Building on existing materials, governments, industry and communities should develop a comprehensive set of credible best-practice guidelines and standards for community engagement.

Comment: This is only part of R16. This recommendation, together with Rs 17–19, are very important. Too often the perception in local communities is that miners come to the local area, profit from the mineral extraction and then leave. This view must be changed for the resource industry to succeed in the future.

5. Improving environmental performance

20. Governments should develop an environmental management economy to further bolster Australia's competitive advantage in this area. This should include developing nationally consistent approaches and methodologies for continuous life-of-mine rehabilitation, offshore operations decommissioning, early closure planning and legacy site management.

Comment: R 20 and R21–24 are very important. As resource extraction is going to impact on more and more people it is essential that environmental performances are acceptable both in Australia and overseas.

6. Workforce and skills

R25 and R26. Governments and industry should map the skills needs of the resources sector for 2030 and beyond, and should better coordinate earth sciences and other resources-focused curricula at university and VET levels that target the longer-term needs of the sector, as informed by the skills map.

Comment: Recommendations 25–29 are also very important. Themes 4–6 should have been numbered 1–3 because without high quality staff and good people interaction on these issues, the future could be bleak. It is good to see a recommendation that more females be employed in the resource industries and that the local custodians of the land are increasingly engaged and employed.

Let's just hope we get good outcomes after the good work done by the Taskforce.

Global demand for oil will remain firm, according to the IEA and BP, and emissions will not decline

Oil Information 2018 (https://www.iea.org/oil2018/) is the latest edition of a publication that has been produced annually by the International Energy Agency since 1989. It was released to journalists in September and indicates, together with the *BP Energy Outlook 2018* (https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html), that the use of oil as an energy and chemical commodity will continue to remain firm until at least 2040. In 2016 demand for oil was estimated to be 4736 Mtoe and in 2017 the estimate increased slightly to 4746 Mtoe.

The United States was once again the world's top producer (620 Mtoe) followed by Saudi Arabia (560 Mtoe), the Russian Federation (548 Mtoe), Canada (242 Mtoe), and Iran (229 Mtoe). The latter overtook Iraq as the world's fifth largest producer in 2017. However, Donald Trump will upset these numbers if the sanctions on Iranian oil restrict its production.

What happens to renewables?

The BP report makes some interesting forecasts on the future global energy mix (see Figure 1). There are three points to make about the forecast. The first is that global energy demand will continue to increase for the foreseeable future *en route* to an annual consumption of about 20 billion toe. The second is that by 2040 the sources of energy will be almost equally distributed between oil, gas, coal and non-fossil sources. Oil and coal will decline as a percentage, but actual production rates will remain relatively constant and non-fossil sources and gas will increase both as a percentage and in actual production.

The third point is that, if the BP transition scenario is anywhere near correct, then it is most unlikely that global warming will be limited to 2 degrees. That's because the fossil fuel burn in 2040 of 13 billion toe is about one third higher than the 2010 level of 10 billion toe. The CO_2 emission will continue to increase relentlessly. So, sell your sea-side mansion now – while you can still drive there at the weekends!

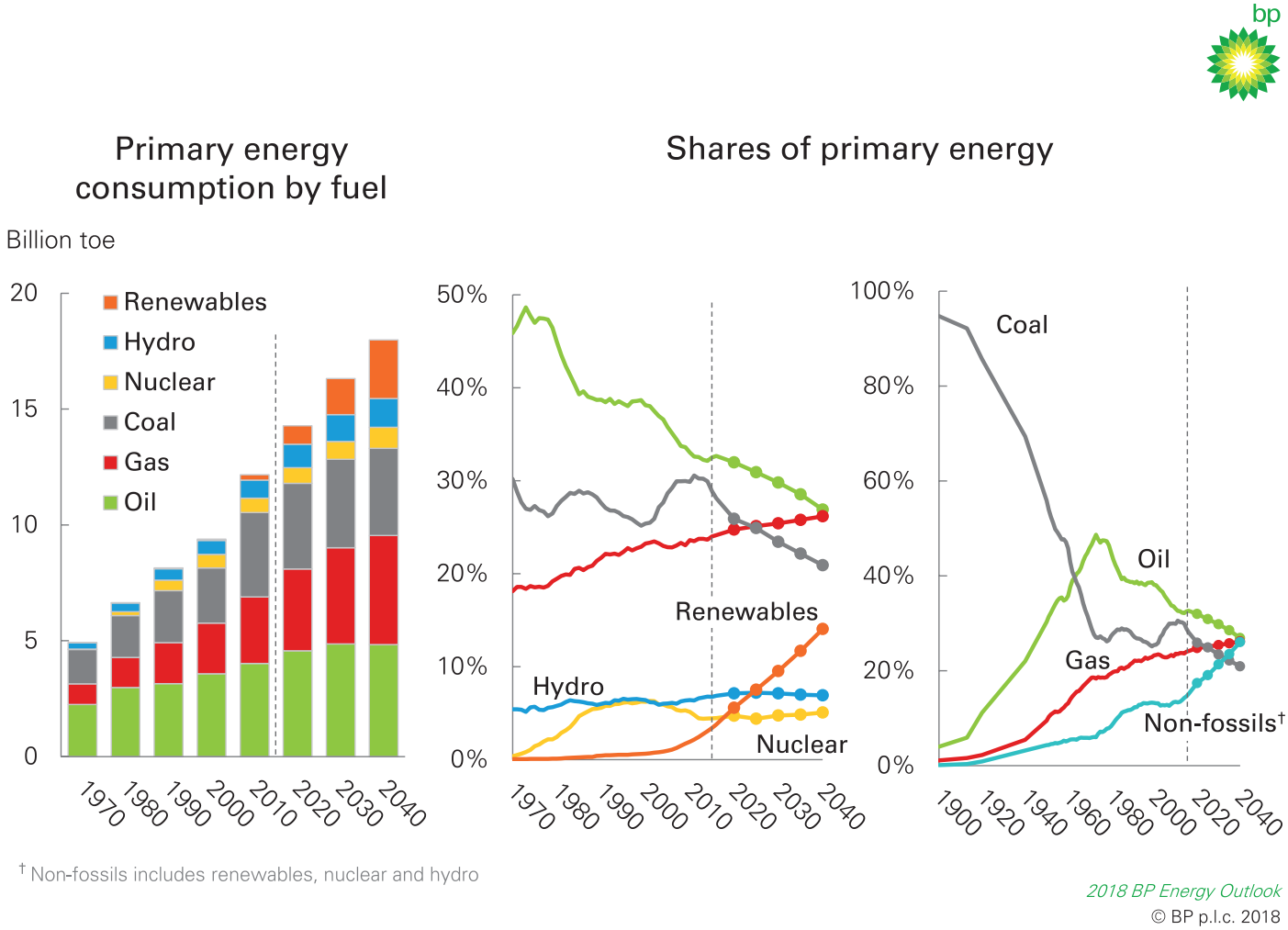

Figure 1. *Future global energy mix as forecast by BP. Source: BP Energy Outlook 2018 (https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html).*

Exploration investment increases for both minerals and petroleum

Investment in mineral exploration continues to increase, and for petroleum the worst may be over, according to the Mineral and Petroleum Exploration data for the June quarter of 2018, released on 3 September 2018 by the Australian Bureau of Statistics (http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8412.0Main+Features1Jun%202018?OpenDocument).

Minerals

The trend estimate for total mineral exploration expenditure increased by 6.8% to $547m in the June quarter 2018. The largest contribution to the increase was in Western Australia. Investment there increased by 7.0%, to $341m, the highest it has been in that state since the September quarter 2013. The national trend has been increasing steadily over the past two years, as shown in Figure 1, where the seasonally adjusted and the trend estimates from 2010–2018 are plotted.

In original terms, mineral exploration expenditure rose 28.4% to $563.4m. Exploration on areas of new deposits rose 37.1% ($54.0m) and expenditure on areas of existing deposits rose 24.1% ($70.7m).

In terms of commodities, gold continues to dwarf all others and the estimated $223m invested to hunt for gold in the June 2018 quarter amounted to approximately 40% of the total amount devoted to minerals exploration (see Figure 2).

At first glance it might appear strange that the investment in gold exploration has increased, when the price of gold this year has dropped from US$1350/oz at the start of 2018 to $1200/oz in September 2018, a fall of 11%. However, while the price of gold was falling, the value of the A$ against the US$ was keeping pace. It declined in value by about 12% from US$0.80 to US$0.70 over the same period. Furthermore, the tariff trade war initiated by President Trump contributed to the uncertainty in the global economy, and gold seems to benefit from uncertainty.

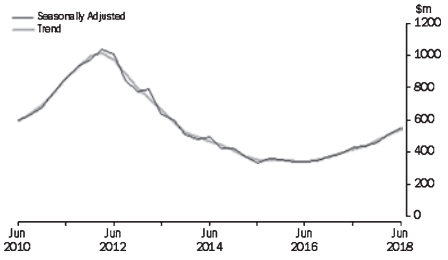

Figure 1. *Seasonally adjusted and trend estimates for Australian mineral exploration investment June 2010–June 2018 – courtesy Australian Bureau of Statistics. The numbers have not been corrected for inflation.*

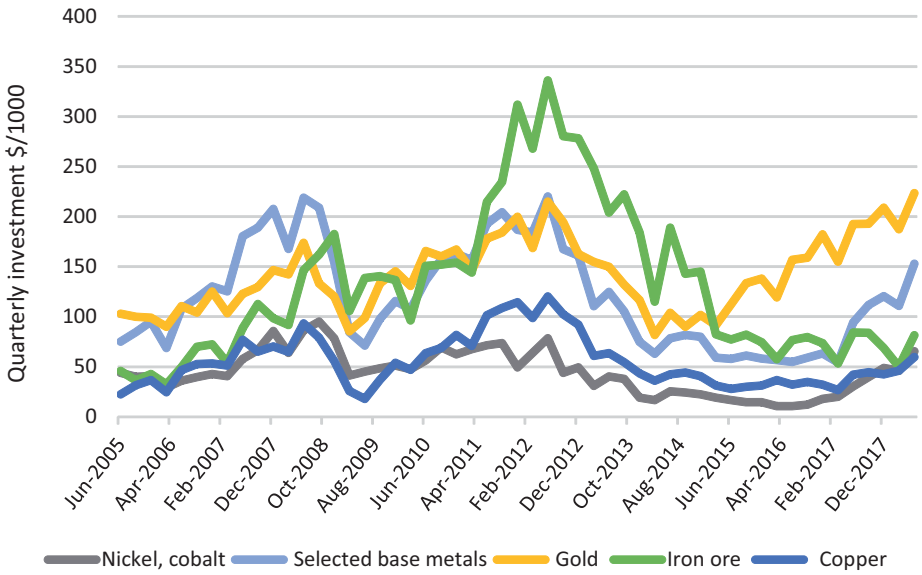

Figure 2. *Quarterly investment in selected commodities, CPI adjusted to 2018 dollars, for the period 2005–2018. The total investment for the June 2018 quarter was estimated as $563m.*

Notice that the investment in the hunt for iron ore has dropped to approximately a quarter of what it was in 2012; probably because of the slowdown in China's growth rate.

Petroleum

Although the trend estimate for total petroleum exploration expenditure rose 10.6% to $262.9m in the June quarter 2018, the total level of investment is very disappointing (see Figure 3). The total actual investment of $327m is still well below the peak of over $1.5 billion in the 2014 June quarter.

Exploration expenditure on production leases rose 0.6% and exploration expenditure on all other areas rose 13.0% ($24.4m). The seasonally adjusted estimate for total petroleum exploration expenditure rose 84.8% to $326.6m in the June quarter 2018. Exploration expenditure on production leases fell 4.2% and exploration expenditure on all other areas rose 122.2% to $152.2m.

The largest contributor to the increase in the trend estimate was Western Australia (up 19.8%, to a seasonally adjusted estimate of $214m, approximately 65 percent of the national total of $327m.

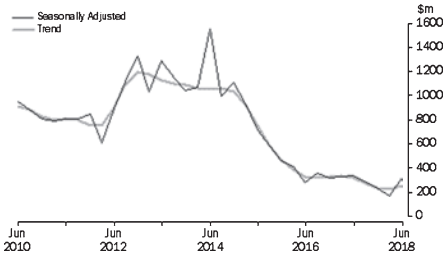

Figure 3. *Quarterly petroleum exploration investment (onshore + offshore), seasonally adjusted and trend 2010–2018, courtesy Australian Bureau of Statistics. The numbers have not been corrected for inflation.*

It's not obvious what the government can do to improve the levels of investment. The political situation in the Middle East is clearly a major factor, and with the US sanctions on Iranian oil starting to take effect, and the price of crude oil gradually increasing, there may be opportunities to attract more explorers. Only time will tell.

The 2018 Offshore Petroleum Exploration Acreage release*

The Australian Government's annual Offshore Petroleum Exploration Acreage release is a key part of its strategy to promote petroleum exploration in Australia's offshore waters.

The media release states:

'All release areas have been nominated by industry, assessed and considered by government, publicly consulted, and selected to offer the petroleum exploration industry a variety of investment opportunities. The acreage release provides the petroleum industry with access to comprehensive pre-competitive geological and geophysical datasets and ensures the provision of quality information on third party issues that may impact on successful applicants when conducting exploration work programs.

The 2018 acreage release, which was publicised on 6 July 2018, comprises 21 areas located across six sedimentary basins in Commonwealth waters offshore of Western Australia, South Australia, Victoria and the Ashmore and Cartier Islands. 16 areas are available for work program bidding and five areas for cash bidding. The areas are located in water depths of 15 to 4534 metres, vary in size from 80 km² to 12 128 km², and vary in level of existing geological knowledge. All areas are supported by pre-competitive geological and geophysical data and analysis undertaken by Geoscience Australia.'

Figure 1 shows the locations of the 26 areas available in this round of releases and Table 1 lists each of the areas.

For further information on any of the areas and their respective closing dates, please visit the 2018 acreage release website at www.petroleum-acreage.gov.au.

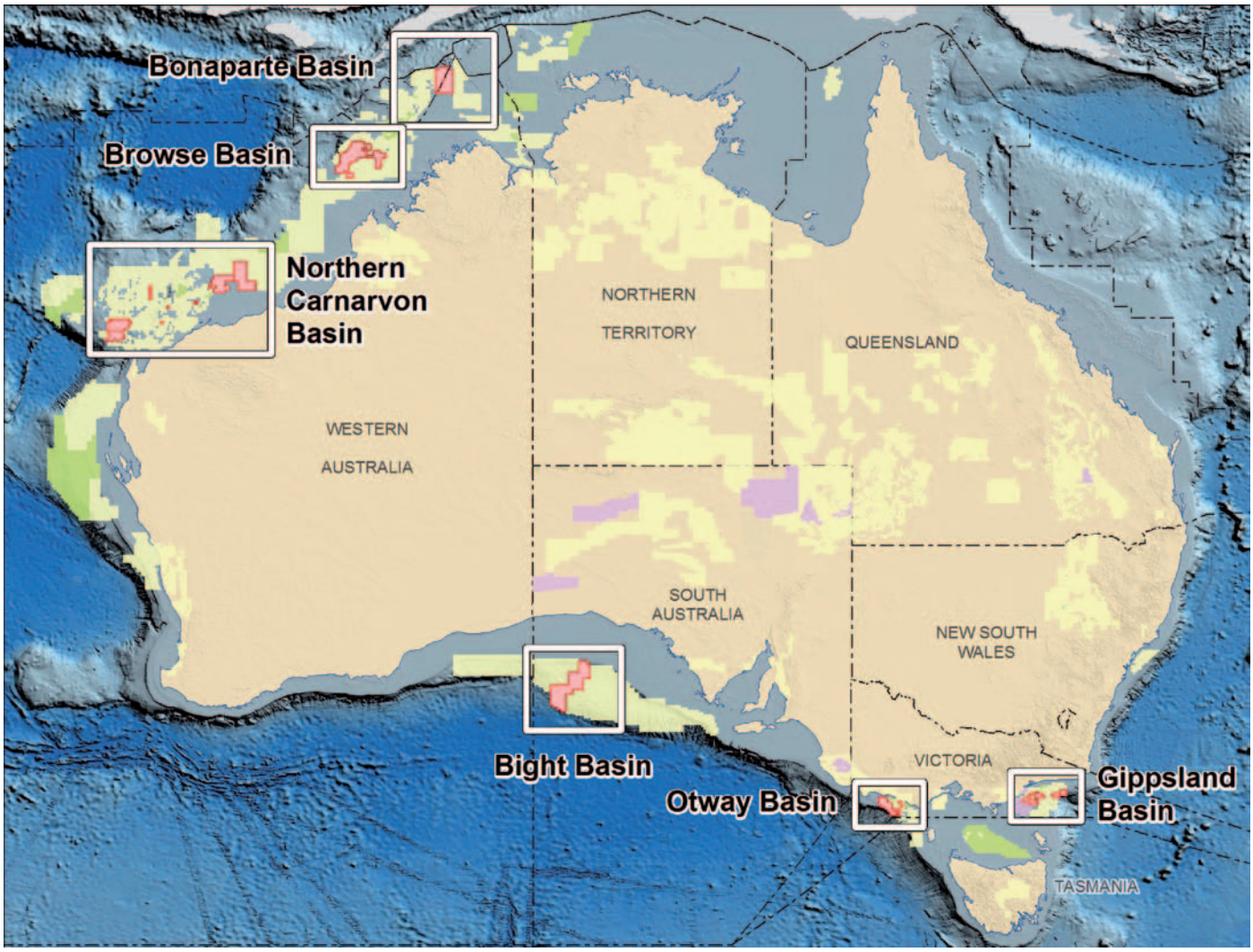

Figure 1. *Location of areas listed in the 2018 Offshore Petroleum Exploration Acreage release.*

Table 1. List of areas in the 2018 Offshore Petroleum Exploration Acreage release showing the closing date for bids

Round	Release areas	Closing date for bids
Round One – work program	AC18-1, W18-1, W18-9, W18-11, W18-12, V18-1, V18-2, V18-4, V18-5	18 Oct 2018
Cash bid prequalification	W18-6, W18-7, W18-8, W18-10, V18-3	4 Oct 2018
Cash bid auction	W18-6, W18-7, W18-8, W18-10, V18-3	7 Feb 2019
Round Two – work program	W18-2, W18-3, W18-4, W18-5, S18-1, V18-6, V18-7	21 Mar 2019

* This piece was heldover from the August issue of *Preview*.

Education matters

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Call for summaries of student theses completed in 2018

As you complete your thesis and plan your future, please ensure you provide a summary of your thesis (a couple of paragraphs), a short bio (a couple of sentences) and a self-portrait (preferably doing something geophysical) to *Preview* (previeweditor@aseg.org.au). Every December *Preview* publishes summaries of student work completed in the preceding year (cf http://www.publish.csiro.au/PV/issue/8532/). Not only is this a marvellous opportunity to publicise your work, it is also your chance to catch the eye of some future employer – in industry or government, national and internationally!

An industry-student day for seismic exploration

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Velseis Pty Ltd recently hosted a half-day tour of their facilities for students from the Queensland University of Technology (QUT) and the University of Queensland (UQ). On 20 August, a group of 10 geophysics and geology students, along with representatives from the Queensland ASEG Branch Lindsay Horn and Nick Josephs, travelled to their office at Sumner Park, Brisbane.

The success of several geophysics student field trips over the past few years prompted this industry-student collaboration. This was organised by representatives of the QUT Natural Resource Society (Alan Pearse), the UQ Geosociety (Harrison Button), the Qld Branch of ASEG (Nick Josephs) and the staff at Velseis (Karel Driml).

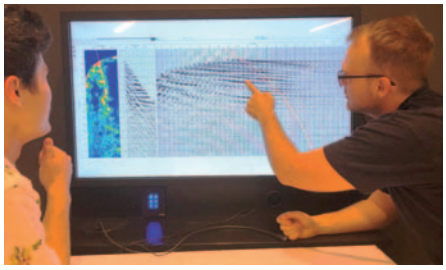
Troy Peters, geophysical services manager, greeted the group and, after a brief introduction and review of site safety, gave an introductory lecture on seismic geophysics and its use in industry. Troy presented an overview and history of Velseis and took the students through a typical onshore seismic survey; from planning through to interpretation. Several pertinent questions from the keen students were answered by Troy and Lindsay. Troy described recent projects consisting of thousands of channels being deployed for 3D surveys, and Lindsay provided historical perspective for the group by recollecting a 2D acquisition he was involved in, which contained a humble twelve channels. Their insights of where seismic has come from and where it is heading resonated well with the students and more questions surfaced from their curious minds. After more discussion the group went for a tour of the facility.

Shaun Strong, a previous graduate from UQ, led the group and explained the use of the different types of equipment. Shaun introduced the students to the Velseis workshop and showed the innards of their cabled systems and geophones. Most were in awe at the sheer scale of equipment and logistics required for the operations both in Australia and around the world.

The group moved outside to view the UNIVIB 26 000 lb and the large Renegade 80 000 lb vibrators! Always a winner with students, they climbed in and around them, but unfortunately too many of the Velseis crew were in the field and they couldn't be demonstrated. Some students, however, were heartened by the fact that the company and parts of the industry were so busy.

The next stop on the Velseis tour was to the large warehouse down the road where the students were shown the inside of the dogbox, some rudimentary field shot data and were introduced to the daily jobs of a Field Observer. Then the group moved outside and were tasked with laying cable spread out along some pegged points. Here they received a glimpse of the Juggie's work day and quickly realised how tough it can get and how nice the dogbox was in comparison. Geophones were stomped in and cable unwound and connected by volunteers. Upon packing up everyone pitched in to tidy up and felt the weight of those cables and geophones.

Lastly the students reconvened in the presentation room and were met with food and drinks to close out the field trip. Informal discussions were had and everyone left on a good note.



QUT students Alan Pearse and Max Millen review an example of calculating residual statics on raw seismic data acquired by Velseis.

The 2018 geophysics seismic field trip was educational and effectively communicated the scope and application of seismic and was well received by the students and well orchestrated by staff. For the geophysics honours students, the use of data for interpretation was new and refreshing.

While the day was pitched at a level for those just beginning their geophysics studies, the overview and machinery provided stimulation for the students by illustrating multiple avenues for them to follow up, including vacation work, focussing future studies and even providing a vision for possible careers.

Many thanks to Velseis and staff, Lindsay Horn and the ASEG for their organisation and supervision of the excursion.

The 80 000 lb Renegade seismic vibrator with the eager group of students. Back row: Nick Josephs (Energeo), Egerton Macpherson, Anthony Caracella, Ben Roberts, Honor Wilson, Max Millen, Callum Kowalski, Shaun Strong (Velseis), Harrison Button, Troy Peters (Velseis), Lindsay Horn (Geophysical Acquisition Services), Karel Driml (Velseis). Front row: Adam Wright, Alan Pearse and Dale Harpley.

Australian student wins gold medal at Earth Science world games

Rebecca Whittle, a Year 11 student from Abbotsleigh High School in Sydney, won a gold medal at the International Earth Science Olympiad in Thailand, securing Australia's best gold medal performance at the UNESCO-sanctioned International Science Olympiads since 2009.

Rebecca competed against more than 140 students from 38 countries to win gold, finishing in the top 10 per cent of Earth Science students in the world. Her medal is the second gold for Australia at this year's International Science Olympiads, following a gold-medal performance by Sydney Grammar School student Hugo McCahon-Boersma at the International Physics Olympiad in July.

Rebecca was part of a four-member team representing Australia at the International Earth Science Olympiad. The three other students won silver medals, putting them in the top 20 per cent of students and delivering Australia's best overall performance at the competition since Australia began sending a national team in 2015.

The International Earth Science Olympiad competition involved two theory exams and four practical tests covering all aspects of Earth systems science and planetary astronomy. Topics included the geology of planetary bodies, the formation of rocks, rock and mineral identification, sea-level rise processes and the geochemistry of groundwater.

Rose Zhang from Narrabundah College in Canberra was also part of a team awarded a silver medal in the International Team Field Investigation that she completed with students from other countries. This part of the competition emphasises international collaboration and teamwork.

The Australian students spent a year in exams and intensive training before competing on the international stage. They outperformed 6000 other students from more than 280 schools in the qualifying exams, making a shortlist of 91 to attend a two-week summer school at the Australian National University in preparation for the International Science Olympiad competitions.

The Australian Science Olympiad program is run by Australian Science Innovations www.asi.edu.au and is funded through the Australian Government's National Innovation and Science Agenda, with support from various organisations including the AGC.

Environmental geophysics

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Explaining what we do

Welcome readers to this issue's column on geophysics applied to the environment. This month's column isn't so much about environmental applications of geophysics, but is about something that I think about pretty often (and is as pertinent to environmental geophysics as much as to any other branch of our science). How do you explain what we do to civilians, i.e. to people not immersed in our dark art/science?

In the following paragraphs I present a few of the explanations that I have tried in the past. My apologies if any of this sounds condescending, but I think what we do is really kind of weird, even to the electrical engineers that I have spoken to: at least they have some background in electricity (sorry to my not-electrically oriented friends – you will just have to think in parallel for the rest of this column). The point though is that I think that it is important as scientists, specialising in geosciences, and then specialising further into geophysics, that we make what we do accessible, especially to kids. You never know what will get a young person interested – in a career that they never knew existed.

Many years ago I was running a survey on the River Murray using shallow TEM to map the sediments (and accompanying salinity) from the surface of the river to a depth of about 20 m (by the way most of water in the river is about 20 ohm-m), dragging the EM antenna behind a small houseboat. The skipper of the houseboat decided on a Sunday morning that I should talk to Macca on ABC radio and tell him about the good work that we were doing (the project was mostly about mapping the proximity of saline groundwater to the base of the river in order to help with evaluating the effectiveness of salinity reducing schemes on the river and floodplains). Anyway, Macca gave me lots of stick for having such a strong American accent after living in Oz for so long (at that time I'd been in the country >15 years). Once we got past that he did want to know what we were doing and how it worked… And then I gave some variation of the explanation that I give to whoever is asking (usually in more detail than they are interested in).

Well you know, it's a little like seismic (for some reason most people have some understanding of seismic surveys), where they set off small explosions on the surface and you get an idea of what's down there by how fast the sound waves go through the earth and the layering that they bounce off of, but instead you use electricity. We put a little (sometimes a lot of) electricity into the ground to kind of light up the parts of the ground that are more or less conductive than other parts of the ground. Sometimes it's the geometry of the setup that helps you determine depth, and sometimes it's some property of the electricity itself. Sometimes I talk about the frequency and that high frequencies see shallow and low see deep; if someone looks really interested (chuckling at my desk thinking of some poor innocent listening to my crazy rants) you can do TEM loops and smoke rings descending into the Earth. And then something about treating the Earth as a big electronic engineering problem with the ground acting like masses of resistors and conductors, mix in few inductor and capacitors, etc. and you get the picture. I kind of got the point across I think. Geez I hope I didn't go through all of that for poor Macca.

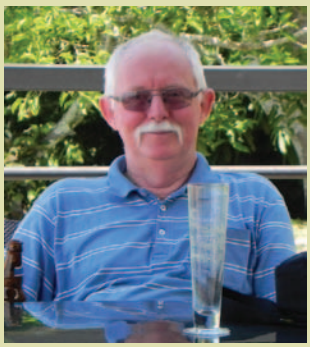
Anyway, I got some calls and emails over the next few days about that interview from friends in the biz, saying that my explanation mostly worked. LOL. So that's kind of my spin on how I explain to most people what I do.

And then there is nuclear magnetic resonance – NMR. I have no idea how to describe NMR to 'normal' people. It's weird enough to me that NMR is a kind of a strange combination of quantum physics (protons have a quantum property called spin, an even number of protons in the nucleus of a given molecule = no net spin in that proton while an odd number of protons = net spin) and classical physics. We can mostly align molecules with net spin (molecules with odd number of protons…) with another bigger magnet, and then can bang them away from that alignment by using an alternating magnetic field at just the right frequency, and then turn the AC source off and the darn little magnets take some time to realign with the big magnet. And what do you get when you move magnets? An E-field, detectable using – classical, old-fashioned, based-on-Maxwell's-Equations physics (i.e. a magnetic sensing coil). By coincidence hydrogen is pretty ubiquitous in the crust (think water) and by another amazing coincidence has just one proton (the first odd number), so has a magnetic spin that can be aligned, and measured. So we can detect water in the crust if we are able to align those hydrogens in the water to an external static magnetic field (the Earth's magnetic field is usually sufficient) and a loop on the surface that we can energise at that right frequency.

Turn this logic around slightly and fill a portable 'cavity' with something like petrol (i.e. hydrocarbons that have more hydrogen than water) and you've got a proton precession magnetometer. Build really really big magnetics and set them up in a frame so they can be rotated around a test material and you have – an MRI (yes to a large extent MRI's work by mapping the variable water content in your body). Etc. Still, hard to explain.

So the upshot is that I am curious if anyone out there deals with this on a regular basis – and if so, feel free to let me know how you describe what we do. If I get enough responses I'll combine them into another column sometime out there in the future.

Minerals geophysics



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Geophysical inversions – finding a Volkswagen in a cubic mile of rock

In the early days of mineral exploration geophysics the emphasis was pretty much limited to finding anomalies. Geophysical techniques were in their infancy, instrumentation was often quite crude, and the supporting mathematical theory was relatively basic. There just wasn't the measuring precision, nor the mathematical tools and the processing hardware.

Geophysical instrumentation dramatically improved with the advent of semiconductors and digital recording. Similarly, geophysical processing advanced with improved mathematical techniques and the ability to efficiently process the much larger amounts of data that was afforded by ongoing increases in computing power.

These improvements advanced the scope of mineral exploration geophysics beyond basic anomaly finding. Improved mathematical capabilities (both software and hardware) led to better geophysical modelling. Visual matching of these models to more accurate field results led to estimations of the dimensions and properties of source bodies. With more sophisticated data processing and presentation capabilities, systematic mapping of rock types distinguished by pertinent physical property contrasts also became possible.

Once we had the means to accurately model the geophysical response from a physical property distribution, and the necessary computing power, we had the tools to undertake geophysical inversion. This is the iterative process combining theoretical modelling and comparison with field results to recover a model of the causative physical property distribution. As mathematical tools and computing capacity further advanced, inversion capability improved. Inversion progressed from 1D (e.g. early SIROEX GRENDL layered earth inversions) to 2D (e.g. early ZONGE DOS resistivity and IP geo-electric section inversions), to the 3D inversion tools (e.g. UBC potential field 3D model inversions) in routine use today. We now have capacity to recover an estimation of the 3D distribution of the physical property that generated the anomaly pattern in the first place.

Inversions changed the way we interpreted geophysics, and made geophysics more accessible to other geo-scientists, nowhere more so than in electrical geophysics. Compare the IP pseudosection and the resulting inversion in Figure 1. I know which one I'd rather show the exploration manager as a drill target!

But inversion goes beyond this. Hand-in-hand with developments in inversion tools came the means to manipulate the controls within the inversion process. Basic inversions typically generate a smooth model, which isn't necessarily replicating the sharp boundaries we often see in geology. The ability to sharpen up boundaries, and alter horizontal and vertical sensitivities in response to the geological setting were early variations. However, some care was needed. I had a presentation that caused consternation within the exploration team. I called it 'dial-a-depth', and it illustrated the dramatic changes in the apparent depth of burial of a modelled IP-anomalous target that could be induced merely by changing the vertical settings of a 2D IP-resistivity inversion.

With improved user interfaces, this quite simplistic manipulation of the inversion process advanced to the much more elaborate and specific limitations imposed in a constrained inversion. In this process, an inversion is forced to fit physical boundary conditions and property ranges derived from a known or pre-conceived geological model. In its simplest form, this could simply be restricting an inversion to, say, having the modelled source body lie beneath a known depth of cover. In its full form, a constrained inversion must fit within a very detailed 3D model. But a word of caution – given the wide range of possible solutions, particularly with potential field inversions, the final model may appear to fit the pre-conceived geology but this is no guarantee of the model's validity. The resulting inversion may be more of what you want, rather than what's really down there.

In a further advance, co-inversion using two or more geophysical techniques offers even more control and constitutes another powerful tool. However, the assumption that there are sympathetic variations in different physical properties isn't always right – magnetic properties may distinguish two different rock types, but density or electrical property contrasts may be elsewhere. Like any subjective process, it should be applied with careful thought.

Despite all these advances in instrumentation and mathematical processes we don't yet have sufficiently powerful and sensitive geophysical techniques, nor the appropriate inversion processes, to detect and characterise a Volkswagen buried within a cubic mile of rock as has been claimed, but we've come a long way from geophysics' basic beginnings. And the advances continue.

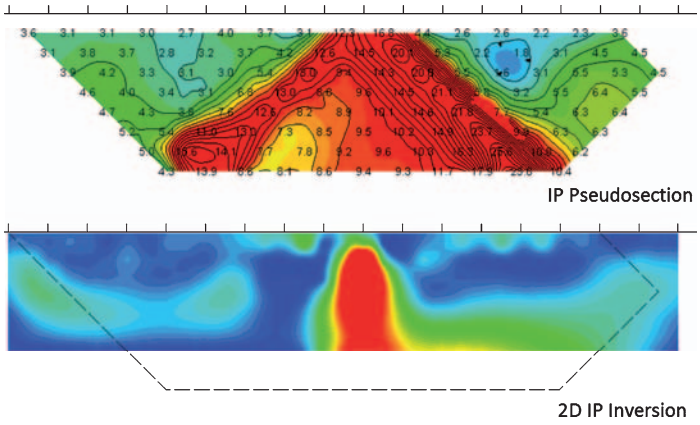

Figure 1. *IP Pseudosection and 2D IP Inversion.*

Seismic window

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Time to depth conversion

One of the arts of geophysics is converting seismic times to depth, and dealing with the uncertainty. Today we can convert entire datasets to depth using 'seismic velocities' and co-krigging with well depths. It was not always so easy. To calculate the depth to various objectives in a well, a number of hand calculations were required. The easiest step in this process was selecting the velocity functions nearest the well location because they were printed at the top of the section (Figure 1). Today velocities come as separate files and there are a number of versions – migration velocities, smoothed velocities, velocities in depth or time, velocities corrected for anisotropy etc. But, the 'velocity boxes' had a choice of only two types of velocity – average and interval. Although the average velocities were easier to use, it was the interval velocities that gave the best results. Figure 2 shows the supplied velocity information on the left, and the series of calculations that led to depth estimates on the right. The far right column is the calculated average velocity and it differs from the average velocity supplied on the section.

Depth prognoses are special cases and require more care than simply converting a map from time to depth. To produce depth maps there is a variety of methods and techniques that can be employed ranging from a single time-depth formula from a well to quite complex 3D functions. One technique I have used is the Vo-K method. Unfortunately I have rarely had much luck with Vo-K and I'm not a fan. My preference is to analyse the available data for trends and identify a time – depth relationship. For example, I had good success in the Exmouth sub-basin using the 'Dempsey formula', where the primary objective in three exploration wells was found to be in error by just –1, 0 and 1 m. This method used a simple formula (Figure 3) derived from well control to estimate the depth to the top Barrow Group, and contained two terms – a water layer term and a rock

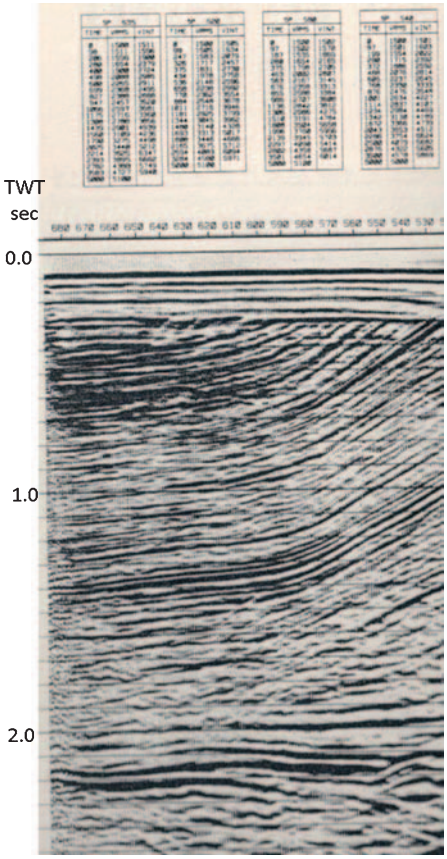

Figure 1. *Seismic section with 'velocity boxes' in the header. Details of the second from the left are reproduced in Figure 2.*

TWT (ms)	Vav (m/s)	Vint (m/s)	TWT interval	OWT interval	Thickness (m)	Depth (m)	Vav * (m/s)
0	1500	1505	99	50	74	0	
99	1505	1634	148	74	121	74	1505
247	1583	2079	79	40	82	195	1582
326	1717	2457	49	25	60	278	1703
375	1831	2730	59	30	81	338	1801
434	1978	2758	102	51	141	418	1927
536	2148	2596	122	61	158	559	2086
658	2258	2992	112	56	168	717	2180
770	2362	3554	114	57	203	885	2298
884	2518	3678	127	64	234	1087	2460
1011	2716	3946	170	85	335	1321	2613
1181	2925	3799	163	82	310	1656	2805
1344	3045	3962	136	68	269	1966	2926
1480	3140	4320	213	107	460	2235	3021
1693	3313	5017	115	58	288	2695	3184
1808	3446	4666	357	179	833	2984	3301
2165	3575	5712	429	215	1225	3817	3526
2594	4203	6094	690	345	2102	5042	3887
3284	4500	5971				7144	4351

Figure 2. *Example of calculations used to prognose depths from stacking velocities. The three left hand columns are taken from the seismic section shown in Figure 1. A hand calculator was used to calculate the depth to each velocity point. Note how the average velocity in the right hand column differs from the value printed on the section.*

"Dempsey Formula" for Water Bottom (WB) to Top Barrow (IH) Depth Conversion
$Thickness_{WB\text{-}IH} = TWT_{WB\text{-}IH}/2000*(2698-1017.8*(TWT_{WB}/2000+0.5*(TWT_{WB\text{-}IH}/2000)))$

Figure 3. *A simple formula used to calculate depth to the Top Barrow Group in the Exmouth Basin. This formula, developed by Craig Dempsey of BHP, calculates the thickness of sediments below the water bottom.*

layer term. When broken down this formula has some aspects of the Vo-K method.

Variations in water depth can distort the actual structural configuration below, and hide prospective structures. A visual technique I commonly use to apply a rudimentary correction to minimise the effects of a varying water depth is to flatten seismic sections on a surface equal to 0.6 times the water depth (Figure 4). This is basically a static correction.

No matter which method is used, it is unlikely to tie to the available well control so a depth adjustment map is created by contouring or gridding the error values at wells. Creating a depth adjustment map is where the art sneaks into depth conversion, but it is a requirement to produce maps that tie to well control.

It seems we haven't progressed far. Where we once used interval velocities and tied to wells with an adjustment map, we now use detailed seismic velocities co-krigged with well data. Overall the only difference seems to be the speed of the calculations.

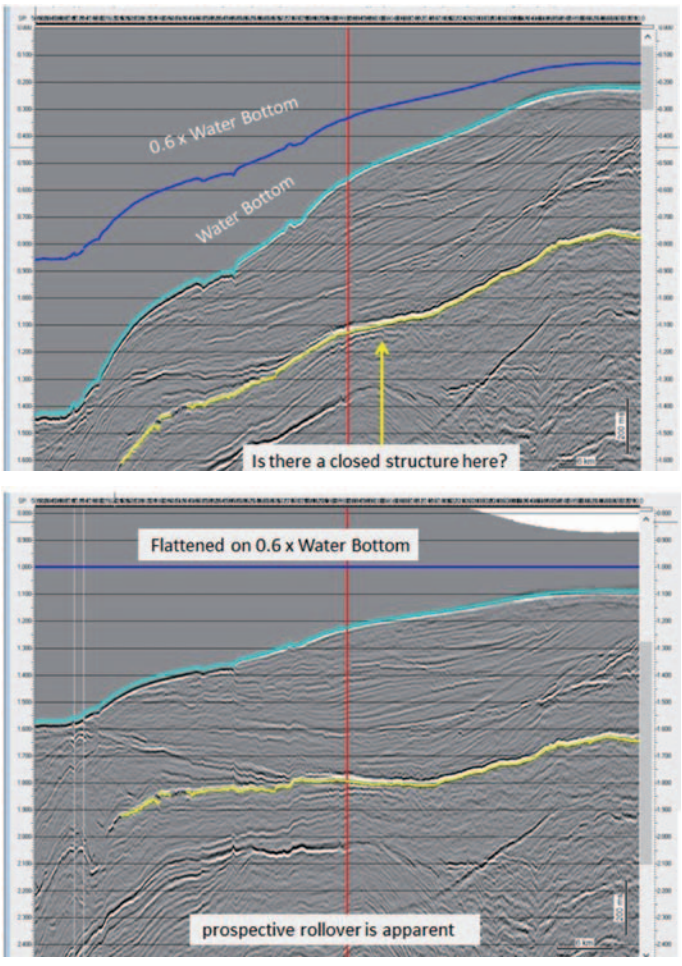

Figure 4. *Example of quick approximation to remove distortion of structure beneath a varying water depth. The yellow horizon has no rollover in the time section (top). After flattening on 0.6 × water bottom a rollover can be seen (bottom).*

Webwaves

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State of the Union

August 2018 is the second anniversary of the launch of the current (ninth) incarnation of the ASEG's website (www.aseg.org.au). *Preview* **190** marked the first anniversary by reviewing site use over the preceding year, and it now seems appropriate to examine how the website has been used over the subsequent year. This *Webwaves*, therefore, will focus on use of the ASEG's website between August 2017 and 2018.

Figure 1 plots internet traffic to the site over the past year, in conjunction with regular events such as editions of *Exploration Geophysics* and *Preview*. New for 2018 is the monthly newsletter. The Christmas and New Year break is evident, as is the Australia Day return to work. Perhaps an indication of the success of the AEGC conference is the below-average traffic in March.

Editor's note: Email alerts currently direct Members to access *Exploration Geophysics* and *Preview* via the CSIRO Publishing website.

Figure 2 shows where site visitors were domiciled. Figure 2*a* shows the number of users from each country visiting the site between 1 August 2016 and 31 August 2017 (the first year of site operation), while Figure 2*b* shows visits per country between 1 August 2016 and 31 August 2018. The second year of operation saw around 19 000 visitors, which was slightly lower than the 21 501 visitors in the first year. As might be expected, most site traffic originates from Australia and the USA. However, there is an increase in globally distributed traffic.

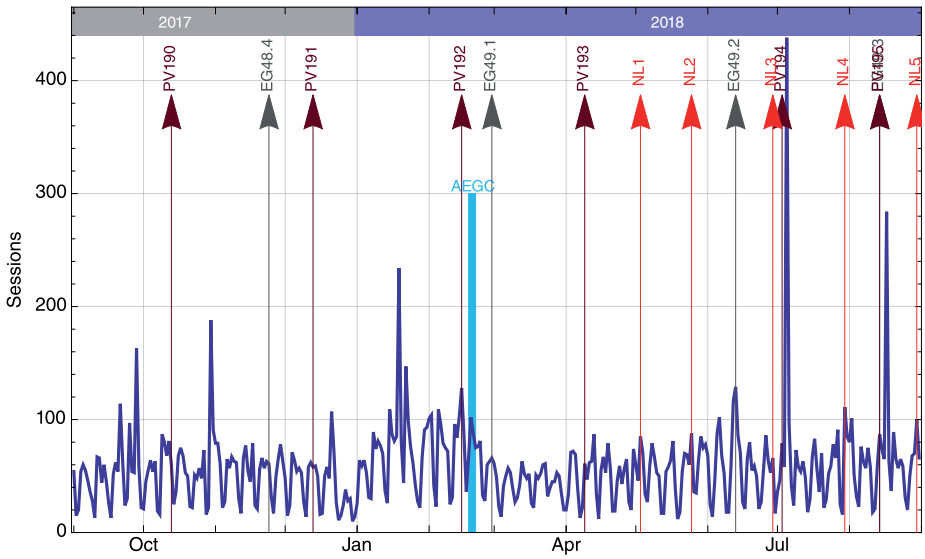


Figure 1. *Internet traffic to the ASEG website between August 2017 and September 2018.*

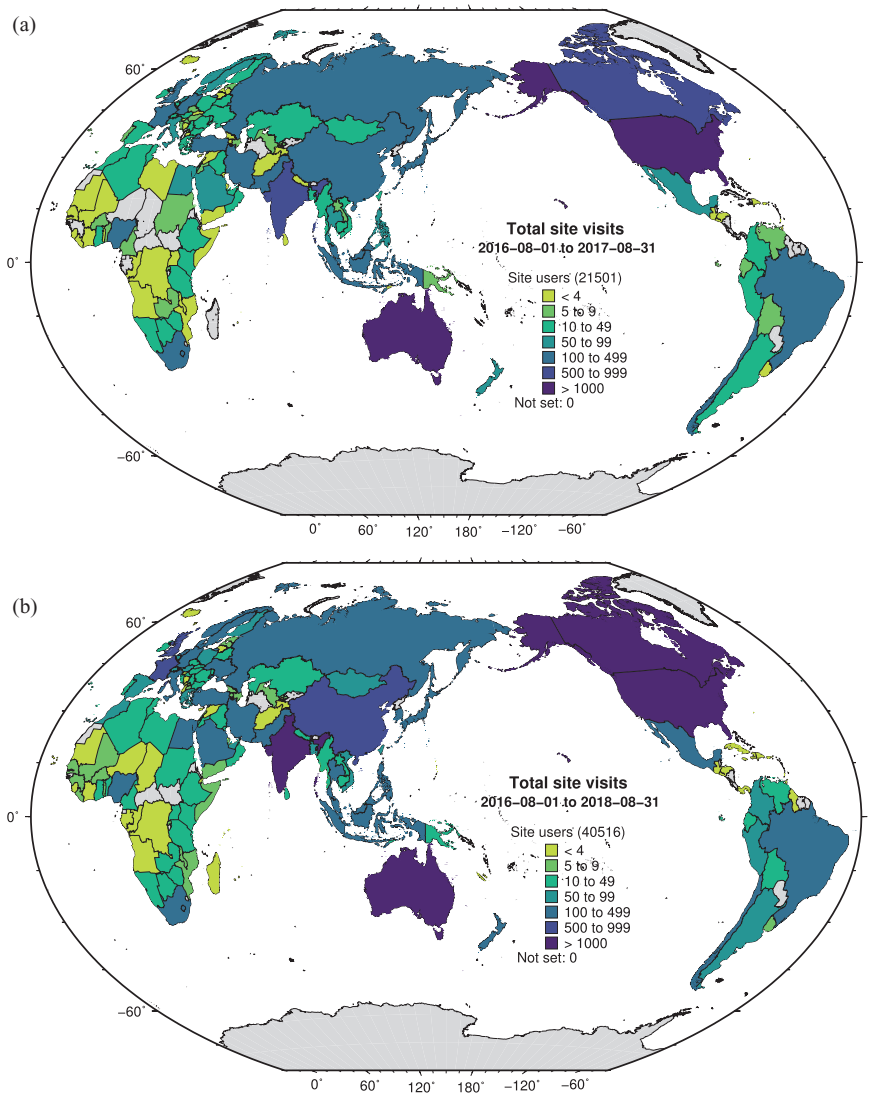


Figure 2. *(a) Visits per country between 1 August 2016 and 31 August 2017. (b) Visits per country between 1 August 2016 and 31 August 2018.*

Figure 3 shows cities that hosted more than 50 visitors to the ASEG website over the past year. Despite a significant number of visitors not indicating a city of origin, it is clear from the 19 international cities listed that while the ASEG remains focused on Australia, its international relevance is increasing.

Figure 4 shows referrals to the ASEG website from the various social media platforms. Site referrals are dominated by Facebook and LinkedIn, and there is a strong contribution from Reddit. Not shown, is the subtle shift in users accessing the site from desktops to those accessing the site from mobile phones and tablets.

Figure 5 lists the top 50 pages visited. Much of the interest is in events, including the 2018 AEGC conference, publications and news. The SA/NT Branch's annual wine offer is popular, as are the employment-related pages. Another popular addition is the ability to purchase Isles and Rankin's (2013) text as an encrypted PDF.

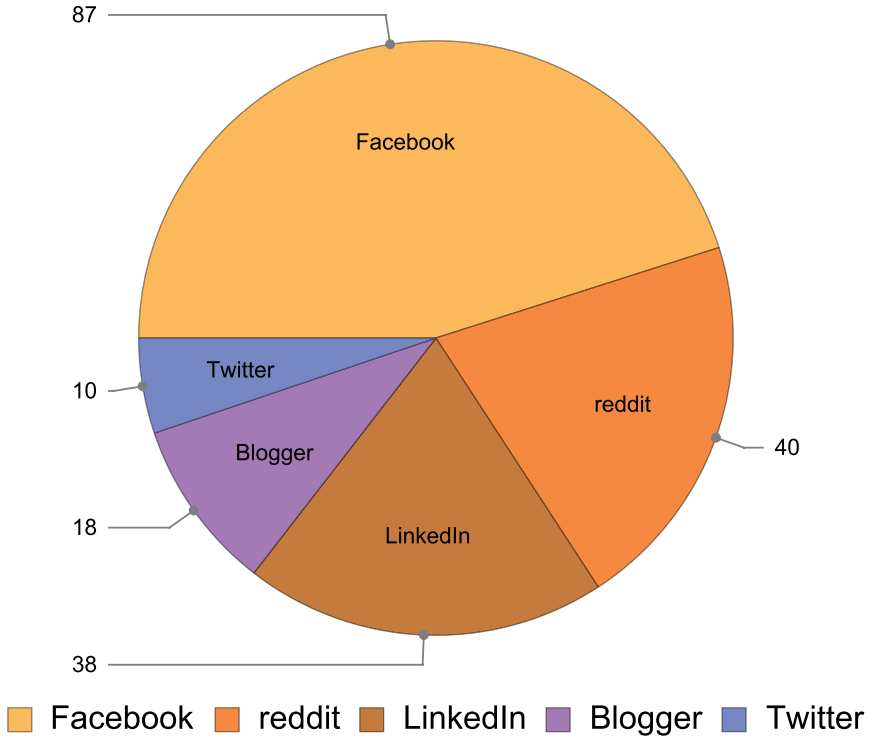


Figure 4. *Referrals to the ASEG website from various social media platforms.*

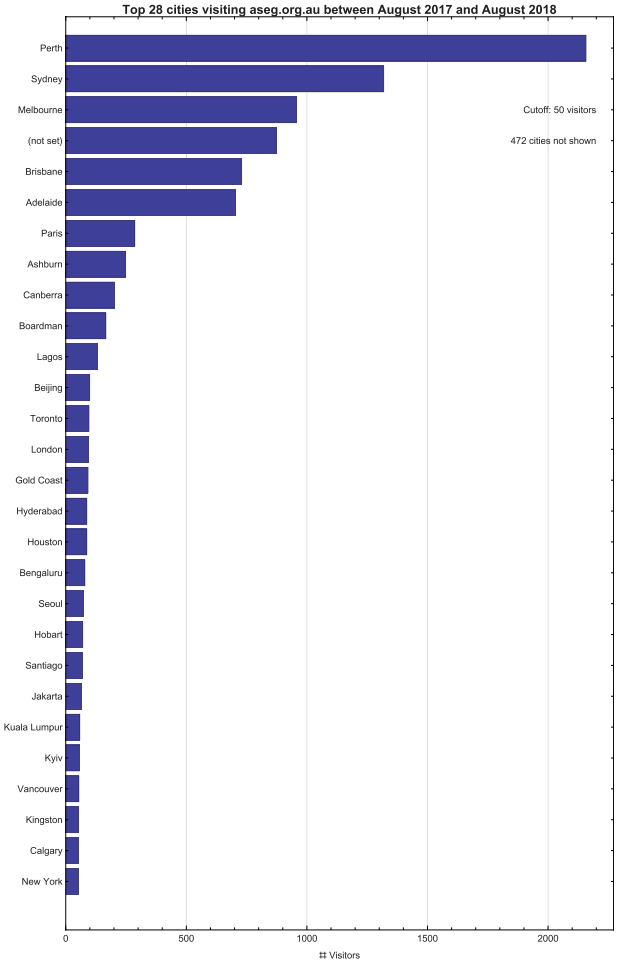


Figure 3. *Top 28 cities hosting visitors to the ASEG website between August 2017 and August 2018.*

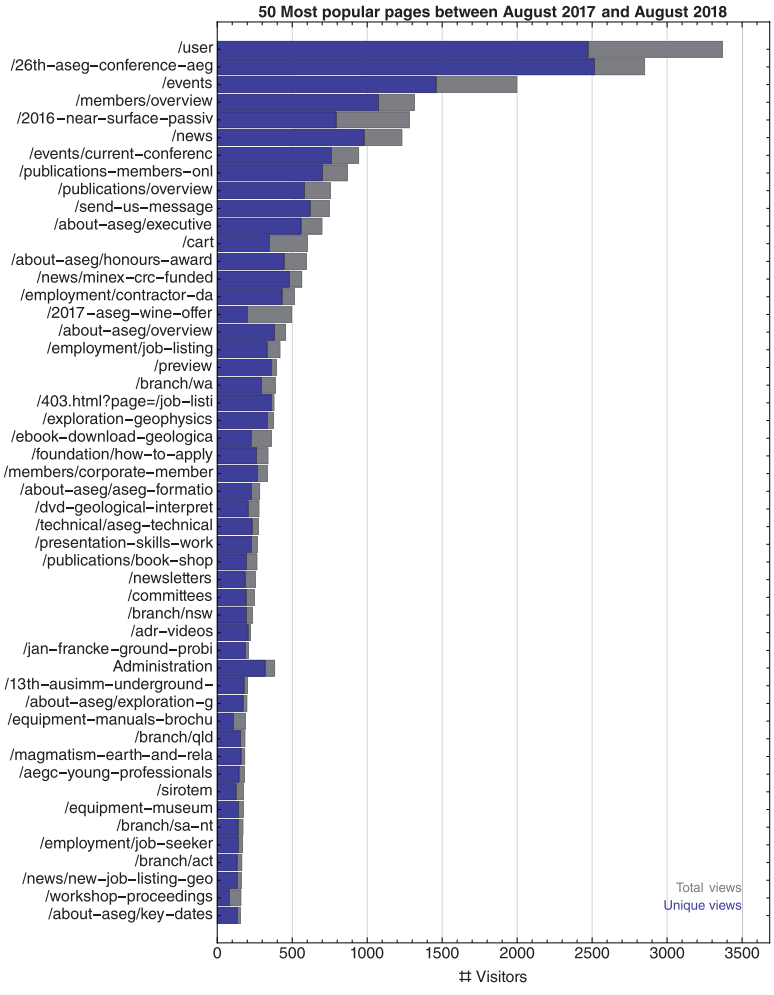


Figure 5. *Top 50 pages visited on the ASEG website.*

The usefulness of the ASEG's website is indicated by the comparison of Figure 2 with Figure 6, which shows the worldwide distribution of ASEG Members. Despite limited membership in central Africa, central America, eastern Europe, central Asia and the middle east, with a few exceptions, the website shows reasonable traffic from all these regions and that such traffic has increased over the past year.

Over the next year, www.aseg.org.au is expected to undergo quiet evolution. Additions are planned in education and technical-standards pages. Most of the material included in the hardcopy membership directory has been moved to the website. The contractors' database remains outstanding, but is nearing completion.

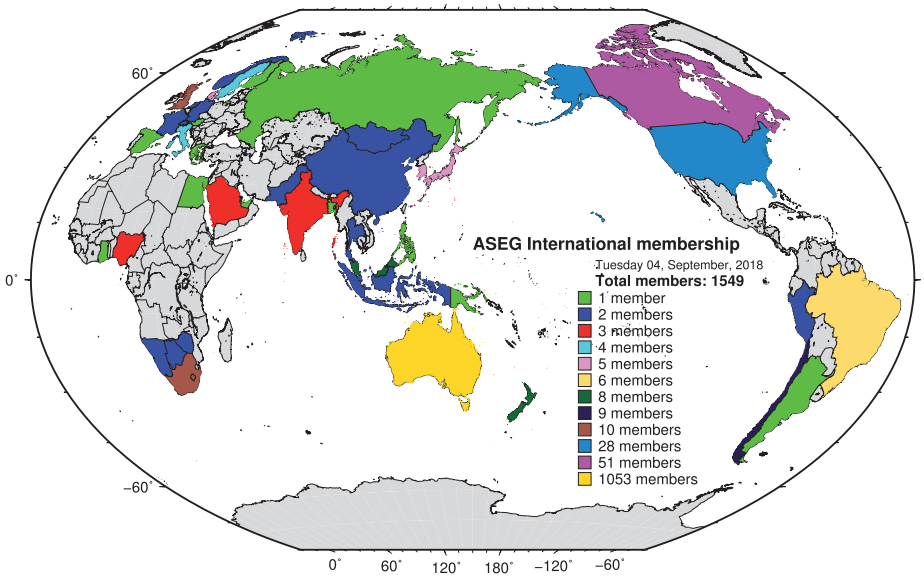
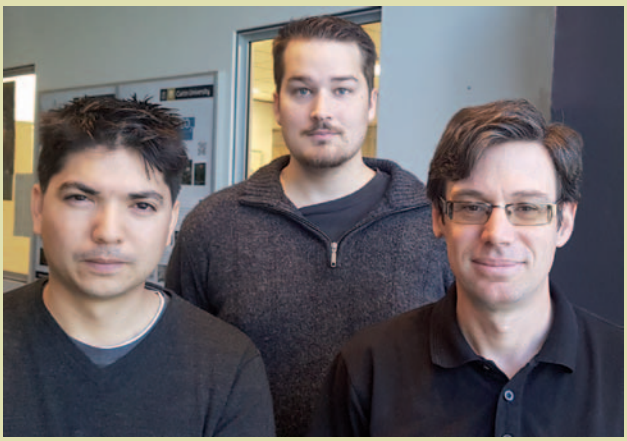


Figure 6. *Distribution of ASEG Members worldwide.*

Reference

Isles, D. J., and Rankin, L. R., 2013, Geological interpretation of aeromagnetic data. ASEG.

Perth's lost guns: a geophysical case study



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Introduction

The fear of a Japanese invasion of Australia grew significantly during the first months of 1942. The recent capture of Singapore (15 February) and the bombing of Darwin (19 February), resulting in over 234 deaths, and other air raids across northern Australia, suggested that an attack could be imminent. The port of Fremantle, just south of Perth in Western Australia, was an important naval base throughout this period; housing one of the largest submarine fleets in the southern hemisphere.

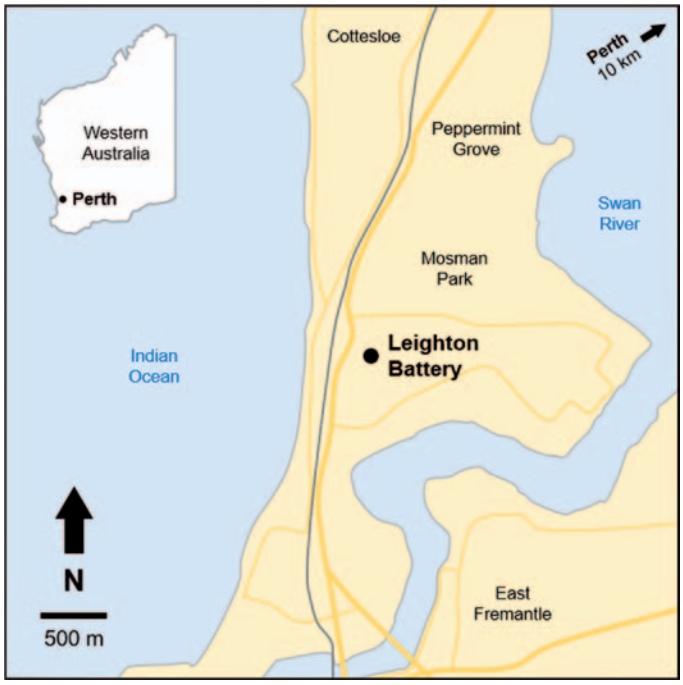

Figure 1. *Location of the Leighton Battery relative to Fremantle, Perth, and the Swan River inlet.*

A series of coastal defences, including large-calibre naval gun emplacements, were therefore constructed to defend the port. Buckland Hill, approximately 3 km northeast of the harbour (Figure 1) is one of the highest topographic sites near the port and was chosen as the site for the Leighton Battery of 6-inch guns in 1942. It is currently the only coastal defence installation in Perth that remains accessible to the public.

Construction began at the end of 1942 (Figure 2) with the battery becoming operational in February 1943. It consisted of two 6-inch guns (Figure 3 left panel) along with several 3.7-inch anti-aircraft guns (Figure 3 right panel). As well as the guns, over 300 m of tunnels were constructed. These tunnels are up to 10 m below the surface, and provided storage, communications, rest areas, and observation posts.

Before the end of World War 2, three additional 5.25-inch guns were installed at the site. These guns could be used in both coastal defence and anti-aircraft roles (Figure 4). Three specially constructed emplacements hosted the guns. These were located adjacent to, but disconnected from, the existing tunnel complex (Figure 5). 1947 saw the completion of this work, and the site was manned until 1963 when coastal artillery was declared obsolete. The site then became a base for a transport unit, until the army finally vacated it in the mid-1980s.

Following the abandonment of the site, the state government sold the land for housing. The area immediately surrounding the battery, however, was retained as a park. The guns themselves were sold for scrap, and two of the three 5.25 inch gun emplacements were backfilled and revegetated (sites 2 and 3

Figure 2. *Photograph of Buckland Hill during construction of the Leighton Battery. The North Mole of Fremantle harbour can be seen in the background.*

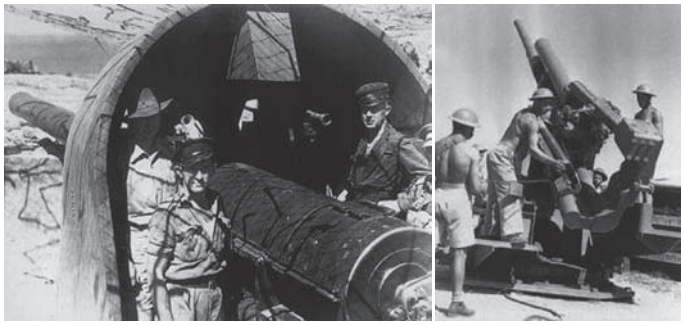

Figure 3. *Left: 6-inch gun. Right: 3.7 inch anti-aircraft gun.*

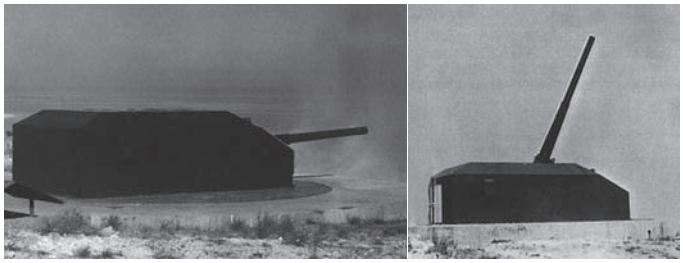

Figure 4. *The 5.25-inch guns fired in (left) coastal defence and (right) anti-aircraft roles.*

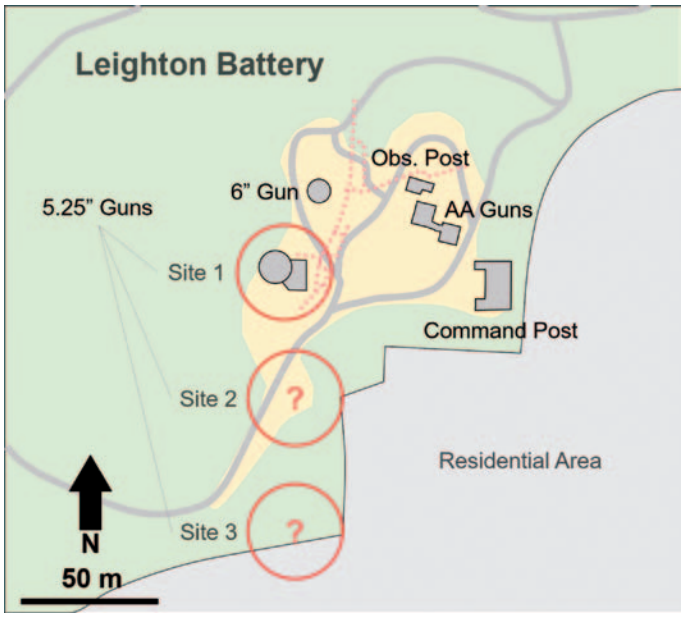

Figure 5. *Location map of the 5.25-inch gun emplacements (site 1, 2, and 3) relative to what is now a residential area. The location of the tunnels are shown by the dashed red lines. The blue line is the 2D seismic line.*

in Figure 5). In 1990, the Royal Australian Artillery Historical Society of Western Australia (RAAHSWA) were given permissive occupancy to develop the site as a military museum, which opened to the public in late 1997.

As part of their continuing restoration, the RAAHSWA is in the process of obtaining funding to restore the exposed 5.25-inch gun emplacement (site 1 in Figure 5). They then aim to excavate the two remaining (buried) gun positions. The exact position of these emplacements is unknown, and in one case, even its existence is uncertain (Figure 6). To this end, the Department of Exploration Geophysics at Curtin University conducted a series of near surface geophysical surveys at the site. The paper begins with a short description of the methods we employed in the area. We then give an overview of the current results and identify areas for future work.

Method

The gun emplacement consists of a ring of reinforced concrete within which the gun was mounted along with three adjacent rooms (Figure 7). By comparing the current topography of the site to historical maps, we expect the second emplacement to be buried at a depth of about 1 m. On this basis, we acquired the following data around its suspected position:

- Ground penetrating radar (GPR).
- 3D electrical resistivity imaging (ERI).

Figure 6. *Current photo of the suspected site of the second gun emplacement. Compare this with Figure 2.*

- 2D seismic.
- EM31 – frequency domain electromagnetics (EM).

Results

Ground penetrating radar (GPR)

GPR is a high-frequency electromagnetic method commonly used for near-surface investigations. It is employed to image contrasts in dielectric permittivity, which is the degree of electrical polarization that occurs under the influence of an electric field. Water, for example, is extremely polarizable resulting in strong reflections where the transition from dry to saturated layers exist. In addition, subsurface conductivity can strongly affect the propagation of GPR signal. Highly conductive media, such as saline water, can rapidly and completely attenuate any GPR signals.

In a first-pass survey, GPR is useful to discriminate changes in both the presence of reflectors (e.g. ground disturbances) as well as their relative strength. Targets can be further analysed with tightly spaced grids to identify their shape and extent.

Figure 8 shows a radargram from the 670 MHz antenna, which intersects a potential gun emplacement site. This particular image also covers part of the ERI grid. The chaotic reflection signature of the porous and dry local Tamala Limestone is present at both edges; however, a distinct change in the

Figure 7. *Photograph of the currently exposed gun position.*

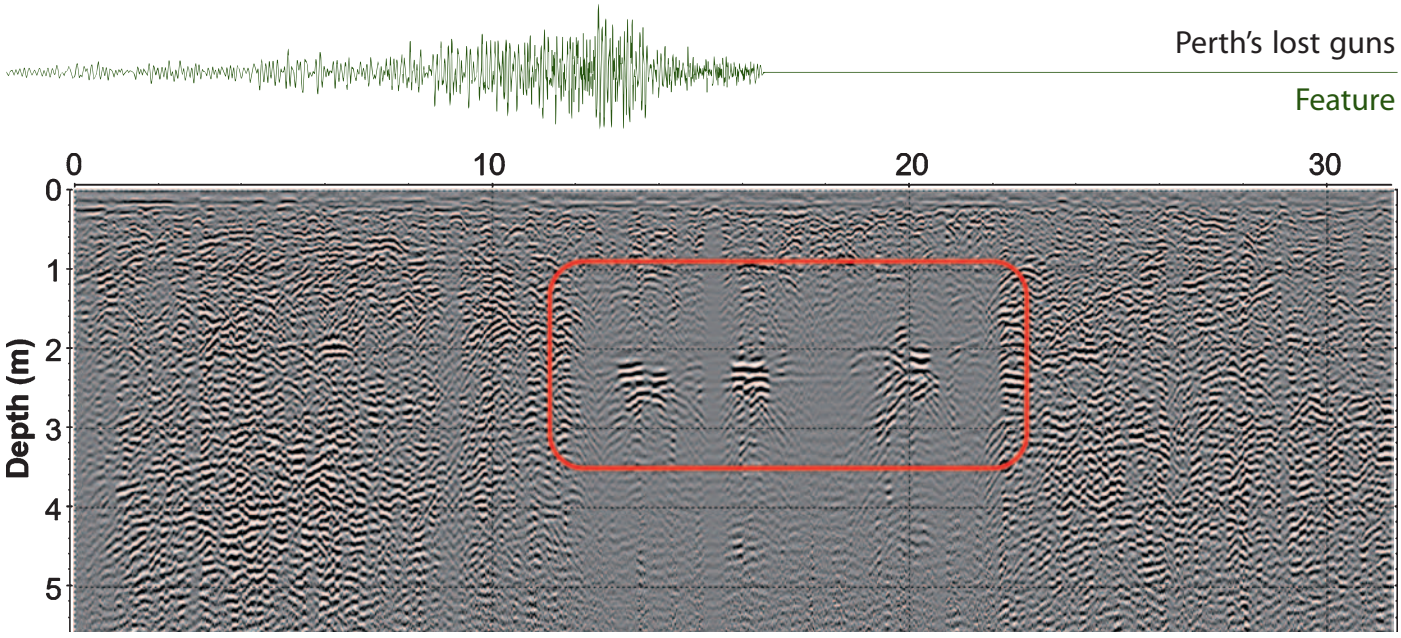

Figure 8. *GPR profile showing the likely location of the gun emplacement. The red box highlights strong horizontal reflectors at a depth of approximately 2 m.*

reflection characteristics exists at the centre of the profile. Here, a set of strong horizontal reflectors can be seen approximately 2 m below ground level. Given the abrupt change in reflection characteristics and abnormal reflectors within otherwise-plain earth, we believe the highlighted area is likely to be the position of the gun emplacement.

3D electrical resistivity imaging (ERI)

ERI is a geophysical method that images the conductivity distribution of the near subsurface. An electric field is created by injecting a current across two electrodes, which is measured as a voltage by one or more pairs of electrodes in a different location. The conductivity distribution of the ground is then recovered through numerical inversion.

The 3D ERI survey was located over the approximate location of the buried gun emplacement (site 2 on Figure 5), identified from the GPR survey. The grid consisted of 2 m spaced stainless-steel electrodes in a 12 × 6 rectangular grid. Resistivity-imaging data was collected using a set of dipole-dipole electrode sequences, including cross-diagonal measurements. The data was inverted using the 3D finite-element inversion algorithm, BERT (Günther et al., 2006).

Figure 9 shows the inverted 3D dataset. An extremely conductive (<1 Ω m) body in the centre of the grid is interpreted as the gun pit. The conductive body is clearly not geological, the Tamala Limestone is approximately 1000–3000 Ω m when dry, and local elevation eliminates the possibility of seawater intrusion. We suggest it may be the reinforced concrete, or the material used to backfill the gun emplacement. An extremely resistive region exists on the north eastern end of the grid. Such high resistivity values are usually associated with dry concrete or air-filled cavities, consistent with the underground rooms located next to the gun pit.

2D seismic

The seismic data was acquired using a single line of 48 10 Hz geophones with 1 m spacing. A sledgehammer source was employed at 1 m intervals. The line was positioned so that one end was located over the suspected gun pit position (the blue line on Figure 5).

Figure 10 shows two records taken at the western and eastern ends of the 2D line. The likely position of the gun emplacement is outlined in red. The effect of the much higher velocity of the concrete can be seen by comparing the first arrivals of the near-

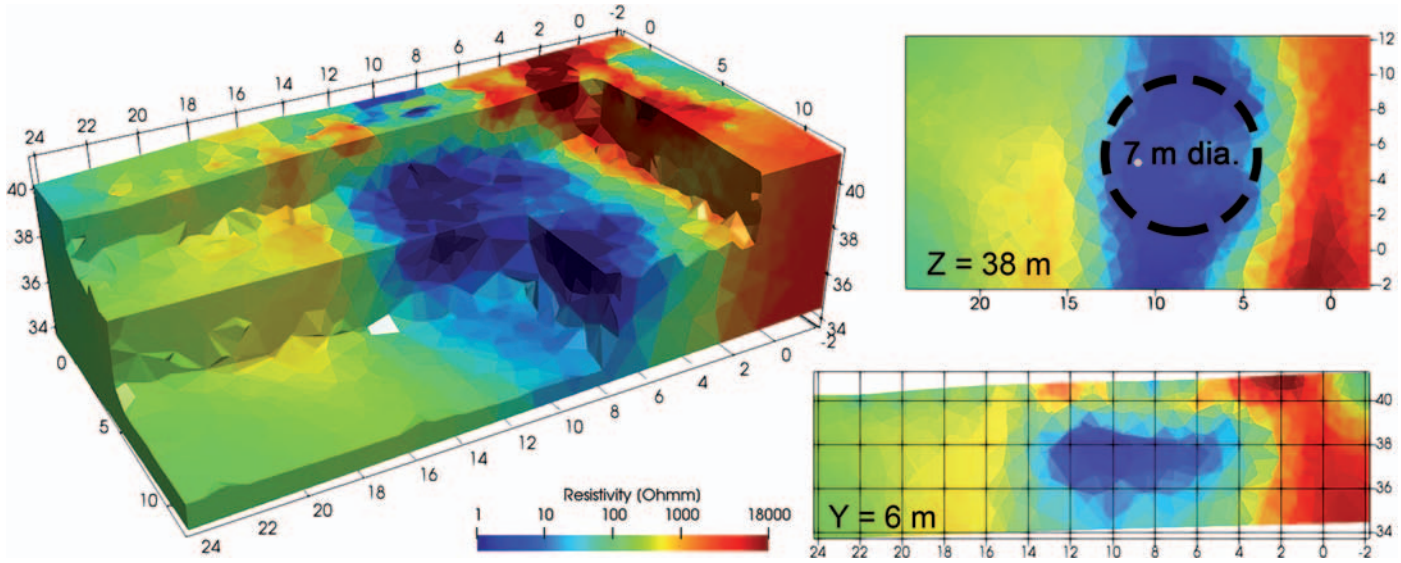

Figure 9. *3D image visualising the inverted ERI electrical resistivities over the approximate gun pit location. The cube is clipped to highlight the conductive body in the centre of the grid.*

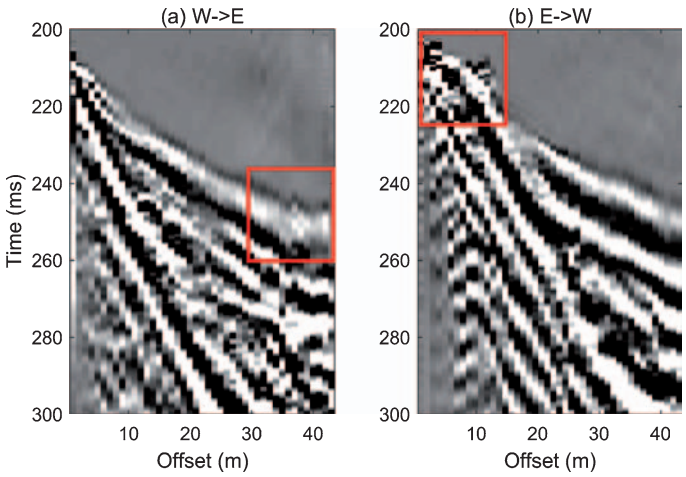

Figure 10. *Seismic data plots acquired with the source at (a) the western end of the line and (b) the eastern end of the line. The order of the traces has been reversed in (b) to enable a direct comparison. The position of the gun emplacement is outlined by the red boxes.*

offsets in Figure 10*b* with those in Figure 10*a*. Similarly the arrival times at the far offsets in Figure 10a differ from those in Figure 10*b*.

EM31

The Geonics EM31 frequency domain EM survey was co-located with the 3D ERI survey. The EM31 system detects subtle variations in magnetic susceptibility and bulk electrical conductivity. The survey involved collecting in-phase and out-of-phase data on a dense 1 m grid. The EM31 was operated with vertical magnetic Tx-Rx dipoles in a horizontal coplanar configuration.

A significant circular-shaped electrical conductor in the resistive host was detected (Figure 11). The anomaly has similar lateral dimensions to the known gun emplacement — both having an inner diameter of approximately 6 m (Figure 11 compares the EM31 response with the dimensions of the existing gun emplacement; a faint dotted circular line has been added to assist the comparison).

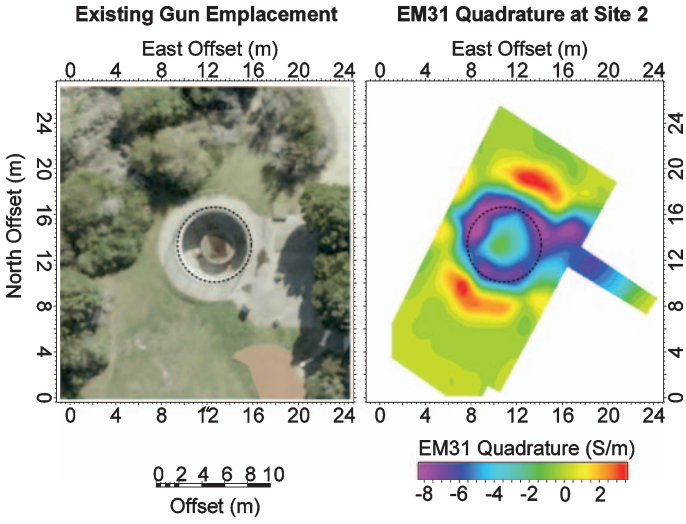

Figure 11. *Left: Aerial imagery of the existing gun-emplacement. Right: the recorded EM31 quadrature apparent conductivity response over the area with the suspected buried gun-emplacement.*

According to McNeil (2016) a time lag in the received secondary field is caused by 'soil magnetic viscosity'. This may occur in areas of high concentrations of ferromagnetic minerals. The highly negative (<–7000 mS/m) out-of-phase component is most likely a cultural artefact produced by the steel in the reinforced concrete of the original gun-emplacement. For reference, the typical background quadrature component value recorded over the shallow sands and Tamala limestone ranged between 15 and 30 mS/m (note that the scale in Figure 12 is in S/m so the anomalous values are several orders of magnitude higher than the surrounding electrically resistive earth).

Discussion and future work

Not only did this survey aid the historical society in helping pinpoint the location of the missing gun emplacement, it also gained considerable media coverage with stories on multiple radio stations and the local news (Figure 12).

Figure 12. *Screenshot of a story on the survey broadcast on Channel 10 news. The full story can be viewed at tinyurl.com/ybvg7rzt.*

In terms of the data already acquired, the co-located GPR and FDEM data offer further inversion opportunities; which would incorporate structural constraints and tailored seed-models to direct the inversion process.

Future work is also currently being undertaken to locate the third gun position (which is likely to intrude into a local backyard, 'site 3' on Figure 5) and a reputed tunnel that goes from the battery to an observation post on the other side of Stirling Highway.

Acknowledgements

The authors thank Dominic 'Legend' Howman, Brett Harris and Curtin students for helping acquire the data and the Royal Australian Artillery Historical Society of Western Australia for allowing access to the site.

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McNeil, J. D., 2013, The magnetic susceptibility of soils is definitely complex: Technical Note TN-36, Geonics Limited.

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Please note that this is a non-profit activity carried out by the ASEG SA/NT Branch committee only for ASEG members. The prices have been specially negotiated with the wineries and are not available through commercial outlets. Compare prices if you wish but you must not disclose them to commercial outlets.

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ASEG PRICE $135/dozen (RRP $240)

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2015 was a cracking vintage in pace, yield, and above all quality and is likely to surpass the 2002 vintage in greatness.The 2015 Eden Hall Springton Shiraz is deep crimson-red, with savoury spice and black pepper on the nose. Ripe black fruit and lifted raspberry and prunes give way to fine, dusty tannins that linger seductively and make you want for more. Let go, drink some more now, but can be cellared with confidence if you must.

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International calendar of events 2018–20

October	**2018**		
1–3	Future Energy Africa 2018: Conference and Exhibition https://www.futureenergyafrica.com/	Capetown	South Africa
3–5	5th International Workshop on Induced Polarization https://ncas.rutgers.edu/academics-admissions/academic-departments/earth-environmental-science/research-initiatives/near-surface-geophysics/5th-international-workshop-induced-polarization	Newark	USA
10–11	EAGE Australasian Workshop on Continuous Improvement in 4D Seismic https://events.eage.org/en/2018/eage-australasian-workshop-on-continuous-improvement-in-4d-seismic	Perth	Australia
14–18	AGC Convention http://www.agc.org.au	Adelaide	Australia
14–19	SEG Annual Meeting https://seg.org/Annual-Meeting-2018	Anaheim	USA
22–26	Digital Disruption in Exploration: A Symposium on Disruptive Innovation in Resource Exploration http://cess-dde.com/	Perth	Australia
23–25	SPE Asia Pacific Oil & Gas Conference and Exhibition (APOGCE)	Brisbane	Australia
29–30	Asia Geoscience Student Conference & Exhibition https://www.agsce.org/	Perak	Malaysia
November	**2018**		
4–7	2018 GSA Annual Meeting https://www.geosociety.org/GSA/Events/Annual_Meeting/GSA/Events/gsa2018.asp	Indianapolis	USA
4–7	AAPG International Conference & Exhibition 2018 http://capetown2018.iceevent.org/	Capetown	South Africa
12–14	13th SEGJ International Symposium http://www.segj.org/is/13th/	Tokyo	Japan
13–15	First Asia Pacific Workshop on Fibre-Optic Sensing www.apwfos.org	Perth	Australia
13–15	Fourth AAPG/EAGE/MGS Myanmar Oil & Gas Conference	Yangon	Myanmar
December	**2018**		
6	South Australian Exploration and Mining Conference www.saexplorers.com.au/	Adelaide	Australia
10–14	AGU Fall Conference https://fallmeeting.agu.org/2018/	Washington, DC	USA
April	**2019**		
23–36	5th International Workshop on Rock Physics http://sgpnus.org/5iwrp.html		Hong Kong
23–26	EAGE-GSM 2nd Asia Pacific Meeting on Near Surface Geoscience & Engineering https://events.eage.org/en/2019/eage-gsm-nsge-2019/	Kuala Lumpur	Malaysia
May	**2019**		
6–9	Offshore Technology Conference http://2019.otcnet.org/welcome	Houston	USA
19–22	GEM 2019 Xi'an https://seg.org/Events/Events-Calendar/GEM-2019-Xian	Xi'an	China
June	**2019**		
11–13	AGU/SEG Airborne Geophysics Workshop	Golden	USA
September	**2019**		
2–5	AEGC 2019: Data to Discovery http://2019.aegc.com.au/	Perth	Australia
15–20	SEG International Exposition and 89th Annual Meeting	San Antonio	USA
October	**2020**		
11–16	SEG International Exposition and 90th Annual Meeting	Houston	USA

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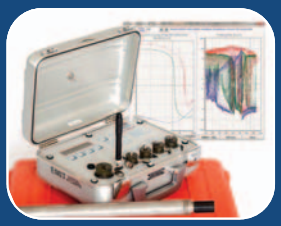

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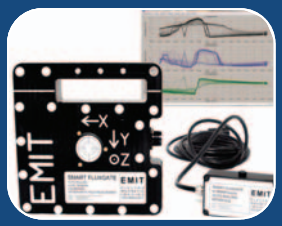

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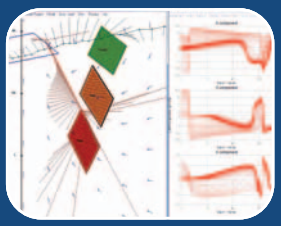

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