Australian Society of
Exploration Geophysicists

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PREVIEW

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FRONT COVER

Professor David Boyd, the ASEG 2016 Gold Medal winner, at Kata Tjuta in July 2016. Professor Boyd died in November 2016 and his obituary appears in this issue of *Preview*.

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Editor's desk

This issue of *Preview* features Brian Spies' account of the arrival in Australia of time domain EM (*Time domain EM comes to Australia: The early history of the MPPO-1*). No-one is better placed to write this story than Brian – who received the MPPO-1 on behalf of the Bureau of Mineral Resources Geology and Geophysics in Canberra in 1972. His account of the instrument's reception and deployment made me reflect, once again, on how much we owe the BMR. The contribution that BMR scientists and technicians made to geophysical data acquisition and interpretation underpins our knowledge and understanding of the geology and geological history of the Australian continent – and still shapes the development of our exploration strategies.

In this issue we also pay tribute to Professor David Boyd – the 2016 ASEG Gold Medal award winner who died last November. Professor Boyd was active right up until the last days of his life, as his obituary – and our cover photo – testify. In that regard he has, once again, set an example for us all!

There are also treats in store from our regular commentators. David Denham (*Canberra observed*) excites us with more good news about increases in mineral exploration expenditure, but disappoints us with the latest figures on petroleum exploration expenditure. Michael Asten (*Education matter*s) reports on the new UNCOVER field school for student geophysicists. Mike Hatch (*Environmental geophysics*) gets an old friend talking about the challenges of working as a consultant and having to focus geophysical data acquisition on client needs. Mick Micenko (*Seismic window*) ponders semantics in seismic data acquisition – to resolve or to detect, that is the question! And Terry Harvey (*Mineral geophysics*) and Guy Holmes (*Data trends*) challenge us, once again, to rethink the way we do business.

Speaking of how we do business and, in particular, of how we package ourselves, in late March I attended Science in the Surveys 2017, which was a one-day programme of presentations from the state and federal geological surveys (with the notable absence of NTGS). There were also a number of presentations from various research consortiums such as UNCOVER. The buzz word for the day was 'de-risking'. Data acquisition is technically de-risking exploration, co-funded drilling programmes are financially de-risking exploration, and proactive engagement with the community is de-risking the social environment for exploration. The GSV, for example, is de-risking the social environment for exploration by actively consulting with landholders about survey activities and by following through with customised 'explanatory' notes. Rumour also has it that in SA consideration is being given to state royalties being shared with landholders – now that would be a game-changer! In the meantime it is clear, if you want to catch the attention of those holding the purse strings you have to be 'de-risking' something – it doesn't really matter what!

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

President's piece

Katherine McKenna (ASEG President) with Keeva Vozoff at the recent NSW ASEG Branch Meeting.

I find it difficult to believe that it is already April 2017. Since the last (February) issue of *Preview* appeared I have had the honour of giving a presentation to the ASEG's NSW Branch. I have called it as I experienced it – a true honour. First, it was the first meeting for the NSW Branch at their new 'digs' in York Street. Worth a visit, as the room has large floor to ceiling glass windows that look up York Street, with views of the Queen Victoria building and the Town Hall. The ASEG NSW Branch meetings, for as long as I have been going to ASEG meetings (which is since I graduated), have been held at the Rugby Club on the third Wednesday of the month. You never had to think about when or where, just who was talking. So, I was pleased to be a part of some sort of history by being present at the first meeting in the new venue. The second reason that I was honoured by the occasion was that I was in my home town, surrounded by so many good friends. People that I have worked with or alongside, people who have taught me (Keeva Vozoff was my lecturer at Macquarie University), mentored me, people with whom I have drunk far too many reds and, sometimes, all of the above. After writing my column in the last issue of *Preview* about the importance of mentoring, it was such a buzz to be presenting to a group of people that have been such role models and have had such an influence on me.

The other great thing that came out of the meeting was that I got to catch up with some of the organising committee for the next ASEG conference. This is going to be a great conference from all accounts so far. The conference will be held in Sydney in February 2018, less than a year away. It is being called the Australasian Exploration Geoscience Conference (AEGC). It sees the ASEG collaborating with PESA and the AIG to deliver a high-quality geoscience programme with the theme of exploration, innovation and integration. Mark Lackie, one of the co-chairs (who is also the president of ASEG's NSW branch) talked up the new venue and interest that has been generated so far. There has already been a call for abstracts, which will close in May.

My last soapbox session as President, is titled 'The Importance of Volunteers and Volunteering'. The ASEG is an association run by volunteers, as most people are aware. One of the ASEG's greatest strengths is the volunteers that serve on the committees, the state branches, and the federal executive. The association would not survive if these Members did not give up some of their time to help. So, I would like to take this opportunity to thank everyone that has been a part of the ASEG this year. There are far too many to mention, some you would see at Branch meetings, but many are also working behind the scenes on various committees. If there is anyone interested in volunteering there is plenty of opportunity on numerous committees, state branches and the federal executive. Just let throw your hand up at a state branch meeting or contact someone on any of the committees and let them know you are interested.

I have had a great opportunity to work with the Federal Executive during the past year. There have been various projects that have been completed and items that are being put into place to see the advancement of the ASEG in the future. A report will be presented at the AGM in Brisbane in April and reproduced in the June issue of *Preview*. We are, however, losing a few members of the Federal Executive. One person who is leaving us is Tania Dhu, who has done a fantastic job, as Chair of the State Branch Committee, in getting the communication between the state committees and the Federal Executive running smoothly. This can only benefit our Members, as there is now real communication flow and needs and issues are heard and resolved quickly. Also, one of the longer standing members of the Federal Executive, Koya Suto, is stepping down. Koya's achievements on behalf of the ASEG are manifold. He has been the long-standing Chair of a number of committees, a past President and, most recently, Chair of the International Committee. He has worked tirelessly on forming relationships with geophysical societies in other countries. He has been rewarded with formal agreements between the ASEG, the Society of Exploration Geophysicists of Japan (SEGJ) and the Korean Society of Earth and Exploration Geophysicists (KSEG), and has formed good working relationships with societies in numerous other countries. Koya's happy attitude, endless energy and enthusiastic work ethics will be missed.

I would also like to thank members of the Federal Executive for their tireless efforts over the past year. It is their work that makes the ASEG operate and improves things for our Members. I know Andrea Rutley, as the new President, will have everyone's support and I am looking forward to the future under her leadership.

I will sign off here, as there are hills to cycle and work to be done. I look forward to catching up with everyone at the ASEG conference in February 2018 in Sydney.

manete placeidi, facere geophysics

(keep calm, do geophysics)

Katherine McKenna
ASEG President
president@aseg.org.au

Welcome to new Members

The ASEG extends a warm welcome to 19 new Members approved by the Federal Executive at its February and March meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Rebecca	Abel	Curtin University	WA	Australia	Student
Adeel	Ahsan	Bahria University	Islamabad	Pakistan	Student
Andrew	Buchel		NSW	Australia	Associate
Franklin	Froget	QGC	QLD	Australia	Active
Joshua	Grover	University of Melbourne	VIC	Australia	Student
Nicholas	Leong	Fender Geophysics	NSW	Australia	Active
Yong	Ling	Queensland University of Technology	QLD	Australia	Student
Zac	McCarrey	Curtin University	WA	Australia	Student
Mark	Murphy	Consultant	QLD	Australia	Active
Gerard	O'Halloran	BHP Billiton Petroleum	WA	Australia	Associate
Theophilus	Okoror	Ambrose Alli University	Edo State	Nigeria	Student
Lena	O'Toole	University of Sydney	NSW	Australia	Student
Rosine	Riera	The University of Western Australia	WA	Australia	Student
Taimoor	Sohail	Australian National University	ACT	Australia	Student
Hammad	Tariq	Weatherford	Punjab	Pakistan	Associate
Mark	Taylor		WA	Australia	Associate
Alexander	Tetreault	Curtin University	WA	Australia	Student
Andrew	Wilson	The University of Melbourne	VIC	Australia	Student
Matthew	Wilson	Flinders University	SA	Australia	Student

ASEG Federal Executive 2015–16

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Email: president@aseg.org.au

Andrea Rutley: President Elect (Promotions Committee Chair)
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Email: presidentelect@aseg.org.au

Marina Costelloe: Secretary
Tel: (02) 6249 9347
Email: fedsec@aseg.org.au

Danny Burns: Treasurer (Finance Committee Chair)
Tel: (08) 8338 2833
Email: treasurer@aseg.org.au

Phil Schmidt: Past President (Honours and Awards Committee)
Tel: 0410 456 495
Email: pastpresident@aseg.org.au

Koya Suto: (International Affairs Committee Chair, Research Foundation)
Tel: (07) 3876 3848
Email: vicepresident@aseg.org.au

Kim Frankcombe (AGC Representative, Conference Advisory Committee and Technical Standards Committee)
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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 last monthly meeting, which was held in February. We hope you are finding these reports interesting and informative. If there is more you would like to read about on a regular basis just get in touch with me (Marina) and I will expand the 2017 briefs accordingly. Anyone who would like to see the full minutes of the monthly meetings should add their name to the mailing list maintained by the Secretariat. FedEx also holds planning meetings twice a year.

Society finances

The Society's financial position at the end of January 2017:

Year to date income $66 456.84

Year to date expenditure $8 846.64

Net assets $1 178 890.34

Membership

Membership renewal numbers at the end of February 2017 was 76%, up from 73% at the same time in 2016. It's not too late to renew your membership. To everyone who has renewed for 2017 – congratulations and a very big thank you!

Welcome to the new student Members, student membership is up, students please like our facebook page – search for Australian Society of Exploration Geophysics. Remember early and mid-career Members can join the ASEG Young Professionals Network https://www.aseg.org.au/about-aseg/aseg-young-professionals.

2017 Membership survey

We will be running a survey again in 2017 to gain feedback about what Members want from the ASEG. If you have any questions that you would like included in the survey please email me before 9 April 2017.

ASEG policies

An updated travel policy will be available to read in mid-April, if you are interested please email me. The most significant change to the policy is for students travelling on ASEG sponsored scholarships, proof of personal insurance will now be required.

The ASEG will be developing a new policy to cover volunteering, in line with an updated society code of ethics, in 2018. Work has commenced on this policy and if you would like to assist please let me know.

New website

I hope you have had a chance to look at our new website, its looking really great. Take a look at all the events that can now be found on the website. You will also notice the 26th ASEG conference is now being advertised – get your abstracts in soon and visit www.aegc2018.com.au.

AGM

I hope to see at least some of you at the ASEG AGM in Brisbane. It will be held at the XXXX Brewery at 1800 on Monday 10 April. Brisbane Local, Koya Suto, will be giving a talk entitled 'Near-Surface geophysics; geophysics for human life, geophysics in the life of a human'.

A very big thank you to the 2016 Federal Executive committee and a very big thank you to the local State Branch committees for all of your hard work during 2016.

Cheers!

Marina Costelloe
Honorary Secretary
fedsec@aseg.org.au

Koya Suto, a long-standing member of the ASEG Federal Executive, is retiring from the Executive at the 2017 AGM. In the words of the current ASEG President, Katherine McKenna, 'Koya's achievements on behalf of the ASEG are manifold. He has been the long-standing Chair of a number of committees, a past President and, most recently, Chair of the International Committee. He has worked tirelessly on forming relationships with geophysical societies in other countries. Koya's happy attitude, endless energy and enthusiastic work ethics will be missed.'

News from the ASEG Young Professionals Network

Hi everyone, I just want to inform you that the next President of the ASEG Young Professionals Network is Megan Nightingale. You may have had the pleasure of working with Megan in her role as the Secretary of the QLD ASEG Branch, or as a member of the ASEG Education and Communications Committees. She is an intelligent, capable geophysicist (who also likes to ride bikes!). I have had the pleasure of Megan's support for the ASEG Young Professionals for the last couple of years and she has proved to be an invaluable asset bridging the gap between students and professionals in Queensland and engaging them in our network.

Her intelligence coupled with her leadership will be of tremendous value for the ASEG Young Professionals Network and in return provide benefits the ASEG community.

I hope you are as excited as I am to see where the ASEG Young Professionals Network will go under Megan's Leadership.

Millicent Crowe
Millicent.Crowe@ga.gov.au

Introducing Megan Nightingale

Megan Nightingale

Hi, my name is Megan Nightingale, I was born and raised in Brisbane and attended the University of Queensland. I started my studies in an Engineering Degree before seeing the light and transferring across to Earth Sciences. I obtained a Bachelor's degree in Geology and completed Honours in Exploration Geophysics in 2010. I've been working as a seismic interpreter in Brisbane for Energeo since 2011. I signed up as an ASEG Member whilst I was at university and have been a Member ever since. I've been actively involved in the ASEG since becoming the Qld Branch Secretary in 2013. I am a member of both the Education and Communications/ Promotions Committees.

I am very excited to be taking on the role of President of the ASEG Young Professionals Network. I have some big shoes to fill replacing Millicent Crowe, who's done an amazing job getting this group off the ground. Millicent was responsible for the running of some fantastic courses at the conference last year. Not to mention setting up the Young Professionals booth, which provided a friendly comfortable environment for Young Professionals to gather and to grow their own networks. I'm sure we all remember how daunting our first conference experience was, walking around unknown in a sea of brilliant and experienced geophysicists who are all reminiscing about antics at previous year's conferences.

It is my intention to continue on in this vein, providing similar facilities/ opportunities at future conferences as well as increasing interaction with our sister societies, including AIG and PESA. I'm hoping you've all taken heed of the wise words of our current ASEG President, Katherine McKenna, and if you do have any ideas or are willing to assist in mentoring of new graduates and young professionals please get in touch. I'd also love to hear from other young professionals who'd like to actively participate in the running of this group – please contact ypadmin@aseg.org.

Megan Nightingale
ASEG Young Professionals Network President
ypadmin@aseg.org

Notice of Annual General Meeting (AGM)

The 2017 AGM of the Australian Society of Exploration Geophysicists (ASEG) will be held at the XXXX Brewery, Black Street and Paten Street, Milton, Brisbane, on 10 April. The meeting will be hosted by the Queensland Branch. Drinks will be available from 6:00 pm and the meeting will begin at 6:30 pm.

The business of the Annual General Meeting will be:

- To confirm the minutes of the last preceding general meeting;
- To receive from the Federal Executive reports on the activities of the Society during the last preceding financial year;
- To receive and consider the financial accounts and audit reports that are required to be submitted to Members pursuant to the Constitution and to law;
- To consider and if agreed approve any changes to the ASEG Constitution;
- To report the ballot results for the election of the new office holders for the Federal Executive;
- To confirm the appointment of auditors for 2017.

After the AGM, Brisbane local, Koya Suto, will be giving a talk entitled 'Near-Surface geophysics; geophysics for human life, geophysics in the life of a human'.

Invitation for candidates for the Federal Executive

Members of the Federal Executive serve in an honorary capacity. They are all volunteers and Members are encouraged to consider volunteering for a position on the Executive or on one of its committees. Current members are listed in *Preview*; please contact one of them if you want to know more about volunteering for your society.

In accordance with Article 8.2 of the ASEG Constitution '…The elected members of the Federal Executive are designated as Directors of the Society for the purposes of the [Corporations] Act.'

The Federal Executive comprises up to 12 members, and includes the following four elected members:-

(i) a President,
(ii) a President Elect,
(iii) a Secretary, and
(iv) a Treasurer.

These officers are elected annually by a general ballot of Members. Andrea Rutley was elected as President-Elect in 2016 and as such will stand for the position of President.

The following offices are also recognised:

(i) Vice President,
(ii) the Immediate Past President (unless otherwise a member of the Federal Executive),
(iii) the Chair of the Publications Committee,
(iv) the Chair of the Membership Committee,
(v) the Chair of the State Branch Committees, and
(vi) up to three others to be determined by the Federal Executive.

These officers are appointed by the Federal Executive from the volunteers wishing to serve the Society.

Nominations for all positions (except Past President) are very welcome. The name of the nominated candidate and the position nominating for, along with the names of two Members who are eligible to vote (as Proposers), should have already been forwarded to the Secretary:

Marina Costelloe
ASEG Secretary
Care of the ASEG Secretariat
PO Box 576
Crows Nest
NSW, 1585
Tel: (02) 9431 8622
Fax: (02) 9431 8677
Email: fedsec@aseg.org.au

Nominations must have been received via post, fax or email no later than COB Tuesday 7 March 2017. Positions for which there are multiple nominations will then be determined by ballot of Members and results declared at the Annual General Meeting.

Proxy forms and further details of the meeting will be sent to Members prior to the meeting by email and made available to Members on the Society's website.

ASEG Branch news

Queensland

The Queensland Branch has had a great start to the year with the first local Branch meeting drawing record crowds. Approximately 50 Queensland Members filled the XXXX Brewery Cinema to hear **David Close** and **Tony Hallam** of Origin Energy shed light on the dark art that is AVO and quantitative interpretation. It was great to see many Queensland Members renewing in 2017 and we also welcomed several fresh new faces with a strong student contingent from QUT and UQ in attendance.

March's meeting doubled as the Queensland Branch AGM and was held on Tuesday 21 March, again at the XXXX Brewery. All Branch positions were up for nomination – **Fiona Duncan** (President), **Megan Nightingale** (Secretary) and **Henk van Paridon** (Treasurer) were all re-elected un-opposed. The technical talk was given by **Tariq Rahiman**, Principal Geophysicist of Golder Associates in Brisbane. Tariq discussed the increasing use of geophysics in engineering site investigations and provided examples from recent projects around Australia.

The Federal AGM will be held in Brisbane on Monday 10 April at the usual venue – the XXXX Brewery. Koya Suto will also present a short technical talk entitled 'Near-Surface geophysics; geophysics for human life, geophysics in the life of a human'.

An invitation to attend the Queensland Branch meetings is extended to all ASEG Members and interested parties. Details of all upcoming Queensland events can be found on the Qld Events tab on the ASEG website. We are still looking for speakers for the rest of the year, if you'd like to volunteer a talk please contact qldpresident@aseg.org.au or qldsecretary@aseg.org.au.

Megan Nightingale (Qld Branch Secretary)
qldsecretary@aseg.org.au

South Australia & Northern Territory

The SA/NT Branch had a relatively relaxed start to 2017, with only one event since taking a break after the Christmas Party and Honours Student night rounded off 2016. We started the year with our AGM, where a new committee was voted in to take the lead for 2017. **Josh Sage** will stay on as President, **Adam Davey** and **Mike Hatch** will remain Secretary and Treasurer respectively for another year, and the majority of last year's general members have agreed to continue on, as well as a few newcomers. Thanks to all the people who have volunteered to help out in 2017.

Following our AGM, we were joined by **Dr Graham Heinson** from the University of Adelaide, who gave the Branch a review of the first year of the National Exploration Undercover School (NExUS) initiative. NExUS is an advanced training course for the best and brightest geoscience students from around Australia, with three one week modules held in Adelaide, the Adelaide Hills region and Yorke Peninsula. The programme is broken up into classroom lectures, laboratory and drill core practicals and two field trips, as well as evening networking opportunities. Response from the inaugural class was overwhelmingly positive, and the experience was highly valued both by all who attended and all those who were involved organising and running the programme. Given the success of the initiative, NExUS will be opening up again in 2017. I thank Graham for his presentation and wish him and the course all the best going forward. For any more information on NExUS, please visit the website http://www.nexus.org.au/.

Our technical meetings are made possible by our very generous group of sponsors, which in 2016 included the Department of State Development, Beach Energy, Minotaur Exploration, Borehole Wireline and Zonge. We will be in touch shortly hoping they will return in 2017. Of course, if you or your company are not in that list and would like to offer your support, please get in touch at the email below.

As usual, further technical meetings will be held monthly, at the Coopers Alehouse on Hurtle Square in the early evening. We invite all Members, both SA/NT and interstate to attend, and, of course, any new Members or interested persons are also very welcome to join us. For any further information or event details, please check the ASEG website under SA/NT Branch events and please do not hesitate to get in touch at joshua.sage@beachenergy.com.au, the email listed below, or on (08) 8338 2833.

Josh Sage (SA/NT Branch President)
sa-ntpresident@aseg.org.au

Tasmania

The Tasmanian branch hosted **Marina Costelloe**, Section Leader, Geophysical Networks at Geoscience Australia (and federal ASEG Honorary Secretary) at a meeting held on March 3 in the CODES Conference Room, on the Sandy Bay campus of the University of Tasmania. Marina graciously took the opportunity to address ASEG Tasmania Members following maintenance visits to GA Geophysical Network sites in Tasmania. She talked about these, as well as other

Marina Costelloe speaking to the Tasmania Branch (Photo: Steve Calladine).

The ASEG Tasmania Branch AGM (Photo: Steve Kuhn).

geophysical data receiving stations in Australia and its territories, and brought home the significance of their role in monitoring seismic, tsunami, geomagnetic and weapons testing activity. An audience that nearly packed out the venue was very appreciative.

A very brief Annual General Meeting of ASEG Tasmania Members followed immediately after Marina's talk. All incumbents were returned including yours truly. Thanks to **Steve Kuhn** (Secretary) and **Anya Reading** (Treasurer) for their ongoing assistance, and to all Members who participated in the AGM.

A few days later, several ASEG Tasmania Members also availed themselves of the chance to see **Dr Andi Pfaffhuber** of the Norwegian Geotechnical Institute's Perth office present a talk entitled 'Geosurveys innovation' – how geophysical methods such as airborne EM, SAR and LiDAR are being used to deliver geotechnical efficiency in geohazards, tunnelling, soil characterisation and other infrastructure development assessment'. This presentation also took place at UTas' Sandy Bay campus, in the Engineering lecture theatre. Thanks to the Tasmania Chapter of the Australian Geomechanics Society for extending the invitation to ASEG Members.

The previously announced presentation by **Anton Rada** on his UAV magnetic surveying developments has been postponed. Look for news of a reschedule in the next edition of *Preview*.

An invitation to attend Tasmanian Branch meetings is extended to all ASEG Members and interested parties. Meetings are usually held in the CODES Conference Room, University of Tasmania, Hobart. Meeting notices, details about venues and relevant contact details can be found on the Tasmanian Branch page on the ASEG website. Interested Members and other parties should also keep an eye on the seminar programme of the University of Tasmania's School of Earth Sciences, which regularly delivers presentations of geophysical as well as general earth science interest. Please contact ASEG Tasmania Branch President **Mark Duffett** with any queries.

Mark Duffett
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Victoria

The ASEG Victoria Branch started the year in February with a very well attended first technical night. We had the pleasure of welcoming **Jovan Silic** from Jovan Silic and Associates. His talk entitled 'Recent case studies using Airborne Electro-magnetic methods for ground water and minerals exploration - the case for using 2.5D inversion and discarding noise' presented a new AEM inversion algorithm, developed in joint venture with Intrepid Geophysics.

A week later we caught up with familiar faces from PESA and SPE at the 'Summer Social', which was held at Henry and the Fox. The event was well attended and gave Members the opportunity for some much needed networking while enjoying a cold drink under an absolutely delightful summer evening in Melbourne (yes, we do have lovely weather here…sometimes).

Our next technical meeting was held on March 16. We welcomed **Warren Gray**, technical director for SeisIntel, who gave a talk entitled 'Three years in the marine exploration world', which reviewed the evolution of seismic exploration over these last three difficult years. The talk was followed by the Victorian Branch Annual General Meeting. **Seda Rouxel** (President), **Thong Huynh** (Secretary) and **Greg Walker** (Treasurer) were all elected un-opposed.

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Western Australia

The WA Branch has been very active with Tech night presentations over the first few months of 2017. In February the Branch hosted **Juerg Hauser** from CSIRO who presented on 'A Pragmatic Bayesian Perspective on Exploration Using Airborne EM Data'. This presentation was followed in March by **Shane Evans** from Moombarriga Geoscience who presented on magnetotellurics for regional and local exploration, citing various case studies. In April the Branch is hosting SEG Distinguished Lecturer **Paul Hatchell** who will be presenting on 'Getting more for less: Frequent low-cost seismic monitoring solutions for deepwater fields'.

The WA Branch's Tech Nights are sponsored by the following companies: Globe Claritas (Platinum), Resource Potentials, Western Geco, CGG, Atlas Geophysics, First Quantum Minerals Inc, GPX Surveys, Paradigm (Gold), Geosoft, ExploreGeo, and Southern Geoscience (Silver). The Branch could not put together its wide range of technical activities without the support of our Platinum, Gold and Silver sponsors, and we look forward to a long standing partnership with these companies. Sponsorships are due for renewal in May so if you are interested in sponsoring the Branch please contact the Branch President on wapresident@aseg.org.au.

The calendar for 2017 is filling up. Our Tech night programme has presenters lined up through to August with the following presenters:

- May – **Andreas Pfaffhuber** (NGI) presenting 'Geophysics, the disruptive innovation for the geotechnical industry';
- June – **Darren Hunt** (Teck) presenting on the use of seismic reflection at the Teena deposit;

ASEG news

- July – **Tim Munday** (CSIRO) presenting on the use of airborne EM to target groundwater resources in the Murchison region of WA.

The schedule is subject to change due to speaker availability. Please check the website for up-to-date information. We are excited about the programme of events planned for 2017 and look forward to catching up with our fellow Members.

Kathlene Oliver
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Australian Capital Territory

By the time you read this the ACT Branch will have held its AGM and my term as Branch President will have come to an end. My sincere thanks to the committee members who have supported me in the role, in particular **James Goodwin**, **Adam Kroll** (Secretaries) and **Philip Wynne** (Events organiser). Best of luck to the new President – there are already some exciting events in the pipeline for the local Members in 2017.

Congratulations are also due to our 2016 Student Scholarship award winner, **Rhys Hawkins**, who has recently had part of his PhD work published in *Exploration Geophysics*. Look out for his upcoming paper (with co-authors **Malcolm Sambridge** and **Ross Brodie**) called 'Trans-dimensional Bayesian inversion of airborne electromagnetic data for 2D conductivity profiles', which explores a novel trans-dimensional sampling approach to a time domain airborne electromagnetic (AEM) inverse problem. The ACT Branch is currently accepting applications for the 2017 Student Scholarship and Student Travel awards.

The Branch kicked off its programme for 2017 with a technical presentation at its February meeting by **Kevin Dodds**, himself a former ASEG Federal President. Kevin is now R&D manager at Australian National Low Emissions Coal Research and Development (ANLEC R&D). ANLEC R&D has a comprehensive suite of projects to support implementation of low emissions coal technology including carbon capture and transportation, assessment and monitoring of storage sites and coal gasification. They are also involved in the demonstration projects at CarbonNet (Gippsland Basin, Victoria) and SW Hub (southern Perth Basin).

Kevin Dodds presenting to the ACT Branch.

The AGM is scheduled for 30 March and Members will enjoy a talk on the Lord Howe Rise by **Ron Hackney**. In May we are anticipating a visit from current ASEG President, **Katherine McKenna**, who will tell us about all the to hear all the good things FedEx is up to, and in June–July we are hoping to host SEG Distinguished Instructor **Doug Oldenburg** for a DISC on EM methods.

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New South Wales

In February, we held our AGM and three of the usual suspects (myself, **Ben Patterson** and **Sherwyn Lye**) were elected to the roles of President, Treasurer and Secretary. This was also the first meeting at the new venue and we voted it a success as well.

Our speaker for the evening was our current ASEG Federal President, **Katherine McKenna**. For the first part of her talk, Katherine gave us an update from the Federal Executive discussing where the Society was at and where it would like to be heading. For the second part of her talk Katherine spoke about the different airborne datasets that are available in our neighbouring Asia-Pacific countries. Her talk wandered through PNG, Indonesia and quite a few other countries, where the types of surveys and the reasons for obtaining those surveys was presented. Quite a few interesting images were shown, and I felt the audience certainly learnt a bit about the geology and geophysics of our neighbours. Much discussion followed, with more questions being asked over a few reds.

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.

Mark Lackie
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ASEG national calendar: technical meetings, courses and events

Date	Branch	Event	Presenter	Time	Venue
10 Apr	QLD	ASEG AGM	Various	1830–2030	XXXX Brewery, corner of Black Street and Paten Street, Milton
May	ACT	Tech night	Katherine McKenna	1600	Scrivener Room, Geoscience Australia, Symonston, ACT
10 May	WA	Tech night	Andreas Pfaffhuber	1730–2000	City West, 45 Plaistowe Mews, West Perth
04 Jun	WA	Tech night	Darren Hunt	1730–1900	TBA
Jul	ACT	SEG DISC	Doug Oldenburg	TBA	TBA
12 Jul	WA	Tech night	Tim Munday	1730–1900	TBA
09 Aug	WA	Tech night	TBA	1730–1900	TBA
11 Oct	WA	Tech night	Bill Peters	1730–1900	TBA

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

Vale: Professor David Boyd (26 June 1926 – 2 November 2016)

Professor Boyd at the Archimedes office, 2011.

Family, friends and colleagues of Professor David Boyd were deeply saddened by his passing in early November last year, but also gladdened by the impact that he had on geophysics, science and many other facets of life.

We happily celebrated Prof's 90th birthday at the Adelaide ASEG Conference last August[1,2] – he was energetic, humble, inspiring (as always) and 'engaged'. He attended the entire conference – not to collect his ASEG Gold Medal, nor to receive the accolades at the two social functions that his ex-students arranged for the occasion – he was actively chasing new and different ideas and ever keen to engage with bright young geos, taking the early steps in their careers. The enduring recollection of Prof at the August ASEG is immediately post the award presentations, of course led by his own Gold Medal. A young lady by the name of Camilla Sorensen had received the Shanti Rajagopalan Medal for the best paper published in *Exploration Geophysics* by a student in the period leading up to the conference. Prof shunned the back-slapping for his own award and made a bee-line to Camilla to congratulate her and, no doubt, to encourage her to follow in Shanti's footsteps. David had many outstanding students but; after Shanti's untimely death from illness in 2007, he intimated that Shanti was 'a special student'[3,4]. The achievements of his students were his driver, and the way he inspired and guided them to achieve is a lesson for all those who teach.

Prof's student list is long[5], and many of those students have become industry leaders – in mineral exploration and mining, in oil exploration and production, in advanced research (both minerals and oil & gas) and in corporate life. His legacy will last well beyond this obituary. His quest to bring overseas students into the Australian geophysical community had its most satisfying moment when Shanti Rajagopalan (from India), Zhiqun Shi (from China) and Irena Kivior (from Poland) met with him at the ASEG conference in 1989, comparing notes on their respective PhD projects and the applications of their work in both minerals and oil & gas exploration.

Shanti, Irena and Zhiqun – the Prof's PhD graduates from India, Poland and China.

A key facet of the Prof's teaching success was his collaboration with complementary technical specialists. At Adelaide Uni, he brought in Peter Brooker to lecture in high-level mathematics, geo-statistics and computing. Those of us who endured a Dr Brooker lecture, comprising reams of partial differential equations and/or mind-bending matrix inversions, could look forward to the next Prof Boyd lecture, knowing it would feature stories of geophysical adventures in darkest Africa or other exotic places worldwide[6]. The challenging Brooker lessons were made easier to absorb by Prof's inspiring stories. His collaboration with Bob Smith was very similar. David gave Bob credit for initiating the AMF course 'Geophysics for Geologists', although the Prof seemed to retain the top billing. The first day or so of the five-day course comprised David telling his stories and stressing the simple, mainly qualitative and dominantly geological methodology for interpreting aeromagnetics (and other geophysical methods). Bob followed through with much more heavy-duty offerings, particularly on the intricacies of electrical and electromagnetic methods. The 600-plus geologists who attended the course learned much from both Bob and David and in many ways the course changed the culture of Australian exploration, creating much better integration of the geological and geophysical disciplines.

David was born and bred in Dalmuir, near Clydebank in Glasgow, but evacuated to rural locations when Clydebank was bombed during WWII. He entered Glasgow University at age 17 in 1943 and, as a late applicant, he was unable to get into the Chemistry class. This proved a lucky break because he chose Geology, loved it and graduated in 1947 with a double honours degree in Natural Philosophy (Physics) and Geology. This was a first for Glasgow University, and it led to a nine-year lecturing position in the new science of geophysics. This period included field surveys on Jan Mayen Island in the northern Arctic Ocean, the Lake Albert Rift Valley in Uganda, as well as various locations in the UK. Much of this field work was for petroleum and mineral exploration companies, thereby initiating David's knack for creating collaboration between industry and academia. He then spent four years with mining engineers John Taylor and Sons, working on mine sites, mainly on the west coast of the

Field work on Campsie Hills, 1949.

[1]https://www.aseg.org.au/sites/default/files/ProfDavidBoyd90celebrations.pdf
[2]https://spaces.hightail.com/receive/cyUau
[3]https://spaces.hightail.com/receive/tRyFv
[4]http://www.trevorrow.com/shanti-tribute.pdf
[5]https://www.aseg.org.au/events/professor-david-boyd-90th-celebrations
[6]https://spaces.hightail.com/receive/G720h

UK, but also in Cyprus during the EOKA guerrilla activity.

When metal prices dropped, David seized the opportunity to join Hunting Geology and Geophysics. In David's words:

'I worked with them for twelve happy years until the end of 1968 and in the course of the job travelled over Africa, Southern Asia, Australia, parts of Europe and visited North America. During this period I think it reasonable to consider myself to be among the top two or three people in the world interpreting airborne magnetic surveys. They were great years. I usually spent about half the year based in Elstree and half on the job somewhere overseas in a great variety of jobs which offered a great intellectual challenge. I developed the methods which are used throughout the world to interpret mineral surveys over a series of jobs in Ghana, Uganda, Cyprus, Angola and Kenya and Tanzania. The method was developed in Ghana matching the magnetic patterns with the available geological maps including the field maps which in Ghana were very good, and improved in Uganda where I could work with the geologists who were in the process of mapping the area. After that it was a matter of refinement.'

David's work at Huntings was dominated by UNDP jobs and the new 'geological' methodology which benefited greatly from the group's multi-disciplinary team and established skills in aerial photo interpretation. This integrated approach became not only a model for future projects but became a stimulus for aeromagnetic surveying.

'The widespread use of airborne magnetic survey by UNDP had a powerful stimulus from the work that Huntings did in Uganda in 1962/63. The names appearing on the reports were Bruckshaw, Paterson and Tornquist but they learned from me, not the other way round.'

A further indication of his international standing came in 1967 when he was the invited speaker on interpretation of aeromagnetic surveys at the Canadian Centennial Mineral and Ground Water Conference in Niagara. The resulting landmark paper[7] became the entry point for many, like ourselves, who pursued careers involving aeromagnetics.

'After ten years with Huntings Jennie said she was fed up; get another job and settle down. This seemed reasonable so I applied for geophysics posts in Leeds and Edinburgh but did not get them, which was fortunate for the job in Adelaide has been very much better for me.'

It seems that the mutual respect between David and Eric Rudd played a key role in David's appointment to the inaugural Chair of Geophysics in Eric's Department of Economic Geology. David arrived in Adelaide with Jennie and two sons James and Hugh and commenced teaching immediately in March 1969. The Adelaide Uni years resulted in a 'breed' of graduates and professional associates that is pictorially expressed his 90th birthday 'slide show'[1] and the accompanying poster[3] that we presented to him at the ASEG lunch.

1973 Honours Geophysics class outside the Mawson Labs, Adelaide University.

Outside of teaching geophysics, David became involved in the University's administration.

'Much to my surprise I was asked to be Dean of the Faculty of Science in 1976 and at the end of my term as Dean I was asked to be Chairman of the Standing sub-committee of the Education Committee, and after that, chairman of the main academic committee of the university. In 1980 I was a Member of the Corbett Committee which proposed the creation of a more democratic system of University government and reduced the numerous university committees into one and replaced the two Deputy Vice-Chancellors with members of the new committee. I found this work very interesting as it introduced me to workings of the university, which I would not have had anything to do with otherwise. I never thought of myself as much as an administrator but I was obviously not unsatisfactory. During this period I had two spells of about five weeks and some shorter spells as acting vice-chancellor while Don Stranks, the vice-chancellor, was in China. It was fun but enough to convince me that I was better off as Professor of Geophysics. I was amused how possessive you get when you are put in the top spot; I suddenly felt it was 'my university'. In positions of authority I have always felt very strongly that I act for the community and do not use the position to further my own interests; this is not always so in the university.'

His other activities included becoming Chairman of the Animal Ethics Committee at Adelaide University where he had experimenters and animal rights activists working together. This resulted not only in the establishment of the ANZCCART (Australia and New Zealand Council for the Care of Animals in Research and Teaching) but the relocating of the central office of this function from Canberra to Adelaide.

David also had two years, 1986 to 88 as President of the Geological Society of Australia and during this period he used the President's Letter to alert people to the importance of reviving geological mapping in Australia. Around this time he also worked with Reg Nelson, David Tucker and others at the SA Geological Survey on the strategies for 'province scale', semi-detailed airborne surveys. These early efforts bore fruit with South Australian Exploration Initiative, which resulted in an explosion of exploration activity and several key discoveries, and it became a model for future 'pre-competitive' data gathering by government bodies.

David travelled widely as the Professor from Adelaide.

'During the period in Adelaide I visited Japan, Korea for the Asian Development Bank, India for the Department of Science, (several visits Hyderabad, Madras, Bangalore, New Delhi, Baroda and Roorkee and Calcutta) and had study tours which took me to Finland, the USA, Canada, UK,

[7] https://spaces.hightail.com/receive/HQFhu

France and Spain. I enjoyed them all but India and Finland were my favourites, India for its sculpture, art and architecture, Finland for its architecture, scenery and geology and both for the people.'

His special link with and love for India was forged by Dr Dasu Atchuta Rao who was aware of David's Indian involvement during the Huntings years, and became recipient of a Colombo Plan post-doc scholarship from 1974–76. David was instrumental in setting up the 'India-Australia scientific and technology co-operation programme (1975)', which helped finance Indian scientists to come to Australia and vice-versa. This programme and Dr Rao played key roles in getting Shanti to Adelaide for her PhD studies. His enduring connection to India is reflected in the publishing of obituaries in three of India's premier geoscientific journals – *The Journal of the Geological Society of India*, *The Journal of the Indian Geophysical Union* and *The Journal of the Association of Exploration Geophysicists (India)*.

Although he retired from the Chair of Geophysics in late 1992, the Prof remained busy continuing to assist in the supervision of PhD students and supporting Irena Kivior, his 'last' PhD student, in her quest to advance the use of potential field data in sedimentary basin exploration and deep crustal studies.

He continued his support for overseas students by initiating a segment on University Radio Adelaide named 'International Links' where he interviewed students, encouraging them to tell their stories. The families of the students in their home country could listen online and share the experience. In 2009 there was a celebration of the 500th programme with David Tucker interviewed by Meg Abbott. In the ten years to that time students were heard from over 50 countries in all six continents and from most schools and departments in the University of Adelaide.

More important is to expand on the man. He liked people and he was wise. He saw the big picture very clearly, and was always bold enough to chase the 'impossible dream'. He lived life with a smile on his face – in fact his nickname at school was 'smiler'.

His offices, at the Uni and at home, were notoriously messy and he claimed to be disorganised and a poor manager of his time – the quintessential 'absent-minded Professor'. Absent minded he may have been, but when it counted he was sharp, accurate and astute.

His life away from the profession was about family and was not always plain sailing, but the warmth of his memorial service, driven by children Hugh and Sarah, gave those of us who knew him closely in a professional sense, but rarely had insights to his 'personal life', some new gems. He was a capable pianist and cellist. The very fitting finale to his memorial service saw his close colleague Peter Brooker deliver a moving rendition of Beethoven's 'Moonlight Sonata'. He was a keen student of philosophy – two of his recurring sayings were DesCartes' 'accept nothing that you have reason to doubt' and Einstein's 'make things *(solutions, explanations)* as simple as possible, but no simpler'.

The Prof was an active member of the Presbyterian Church, but not especially religious. He enjoyed good wine, beer and malt scotch whiskey and was ever available for a 'lunch'. His daily regimen always included walking and many of us will recall trying to keep up with him – his legs were long and his stride was unwavering.

Walking and enjoying the rocks at Kata Tjuta, July 2016.

His daughter Sarah took him to Uluru for his 90th birthday – according to Prof, day one was the warm up – only 8 km – next day was the main event of 11 km!

Those of us who knew him well will miss him sorely, but we can rest assured that his influence will remain strong and that the products of his doctrine will likely perpetuate his way of attacking problems and life in general. His 'way'? – optimism, enthusiasm, wisdom, energy, and determination – and, above all, (attributed to his first boss at Huntings, and relayed to EVERY student)…

'If you don't know what to do, do SOMETHING!'

We conclude with a very appropriate Persian proverb:
'he who knows, and knows that he knows is wise, follow him'

David Tucker and David Isles
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Our thanks to David's children, Sarah and Hugh for providing insights into his personal life, some family photos and for allowing us to use his recollections in this piece. Thanks also to Zhiqun Shi and Irena Kivior for the photos and videos that add much to the story above. And, of course, thanks to all for sharing the fun![8]

[8]https://spaces.hightail.com/receive/O1Lcb

Near surface passive seismic surveying for mineral exploration, environmental and engineering applications: Notes on the 2016 ASEG-AIG-PESA conference workshop

A one day workshop on 'Near surface passive seismic surveying for mineral exploration, environmental and engineering applications' was presented on the Saturday before the 2016 ASEG-AIG-PESA conference and was organised by Jayson Meyers and Chris Wijns. Despite a low conference turn-out the workshop was well attended with 50 participants from the minerals industry, academia and government, 13 of whom were presenters.

A small but growing number of geophysicists and geologists are starting to use near surface passive seismic methods for regolith and sedimentary cover mapping, either as a stand-alone survey method or in conjunction with other classical geophysical survey methods such as gravity, magnetics, EM, ERT, GPR and seismic reflection/refraction. While passive seismic surveying has been around for a long time, it has mainly been the subject of research and has only been utilised on a large scale by seismologists interested in earthquake hazard mapping. Passive seismic surveying is now starting to gain traction as a practical geophysical exploration method because the advantages of the technique are becoming increasingly apparent. Surveys can be done quickly using a single seismometer instrument or small array of seismometers, there is no need for an active seismic source, depth calibration can be easily and reliably done by taking readings at drillholes that intersect acoustic basement, the data are simple to process, and results can be quite robust. Despite these advantages there is still a lot of uncertainty and scepticism amongst geoscientists concerning the reliability of various passive seismic methods and their results. The workshop was designed to adddress some of these concerns.

The keynote address was given by Professor Michael Asten from Monash University, who has been a pioneer of shallow passive seismic research since the mid-1970s and has continued to be a leader in this field (Figure 1). He shared his global experience on passive seismic theory and methods, mainly Spectral Analysis of Surface Waves (SPAC) and Horizontal to Vertical Spectral Ratio (HVSR) methods, showing key examples of the different types of survey systems, acquisition methods, ground responses, and data processing and modelling results; some of this from calibration test sites. This address set the stage for the remainder of the workshop.

Jeremy Magnon from Moho SRL presented the basics of seismic theory, focussing on the vertically incident Sh-wave motions that produce the HVSR signal for detecting the thickness and S-wave velocity of poorly indurated sedimentary deposits and regolith overburden sitting above hard bedrock, where a strong acoustic impedance contrast can be detected as a peak frequency. Moho developed the 'Tromino' seismometer, which has been miniaturised into a self-contained instrument that is becoming widely used for rapid geological and engineering sub-surface mapping applications.

Nick Smith from PassiveX and Alexi Gorbatov from GA both gave presentations on passive seismic theory and research at mineral exploration sites, where they used very sensitive seismometers in arrays for collecting SPAC and HVSR data. The data were used for determining velocity vs depth structure of geological layers in the

Figure 1. *Michael Asten from Monash University presenting the keynote address at the shallow passive seismic workshop.*

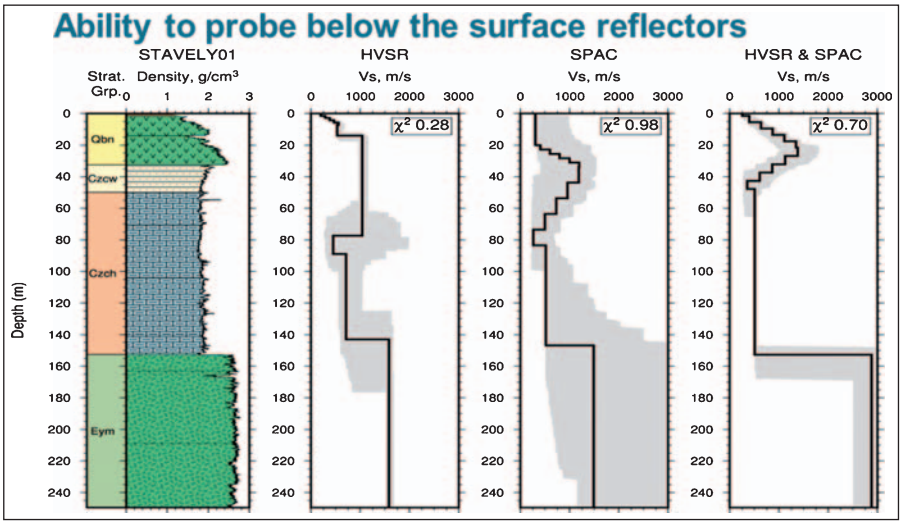

Figure 2. *Passive seismic inversion results carried out on SPAC and HVSR data sets, and combined inversion results, compared to geological and density logs from a diamond drillhole (from Gorbatov, Czarnota and Buckerfield, Geoscience Australia).*

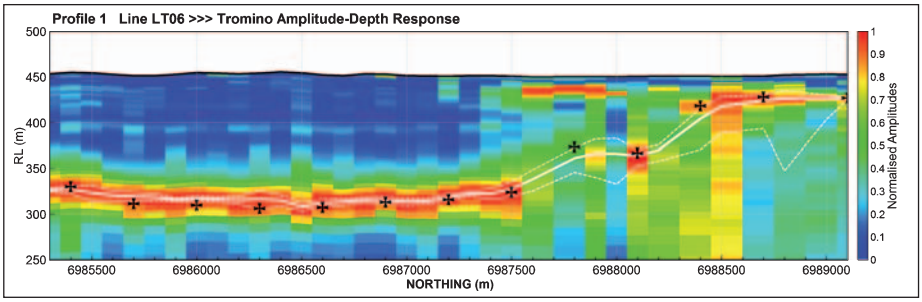

Figure 3. *HVSR passive seismic cross-section showing high amplitude bedrock response (hot colours) defining the base of a palaeochannel sitting below a broad salt lake playa in WA, with depth estimations from a drillhole calibration equation (while line with dashed error bars) and 1D modelling results (black Xs); also note the lower amplitude horizons caused by calcrete layers within the channel deposit sequence (from Owers and Meyers, Resource Potentials).*

regolith, extending into the underlying hard rock layers by direct estimation and inversion methods (see Figure 2 for example).

Several industry presenters and one presenter from the GSWA then showed case histories of predominantly HVSR survey results from different types of geological, regolith and mineral deposit settings, where passive seismic results were also compared to drilling data and results from other geophysical survey methods. The HVSR method was clearly shown to be a valuable mapping tool for detecting thickness of cover and regolith, and for mapping some layering within the regolith where there is a sufficient acoustic impedance contrast. Passive seismic survey results were shown for layer thickness and velocity mapping in the following geological settings: Kalahari cover in Southern Africa, loess thickness in northern China, laterite and saprolite in Australia, palaeochannels in Australia for sulphate of potash brines (Figures 3 and 4), alluvial gold, calcrete uranium and channel iron deposits, ironsand deposits in New Zealand, tundra and glacial cover thickness in Canada, mining waste dump and tailings dam embankments in Australia, and shallow intra-cratonic basin mapping in Australia. Other direct detection applications were also shown for: cementation zones and unconformities for sedimentary uranium deposits, detecting tops of high density ore bodies surrounded by host rocks with no HVSR response due to broad gradients in velocity and density, and using cover mapping results to remove the regolith anomaly response from gravity data.

Anya Reading presented research results obtained by her and her students at UTAS using 'big data' sets and high power computing to study how ocean storms that impact coastal areas generate microseisms that propagate across the Australian continent and contribute to the passive or ambient source signal (Figure 5).

The workshop finished off with a panel discussion, where Michael Asten, Anya Reading, Jeremy Magnon, Nick Smith and Alexi Gorbatov addressed fundamental questions posed by Chris and Jayson, and then fielded questions from the rest of the workshop participants.

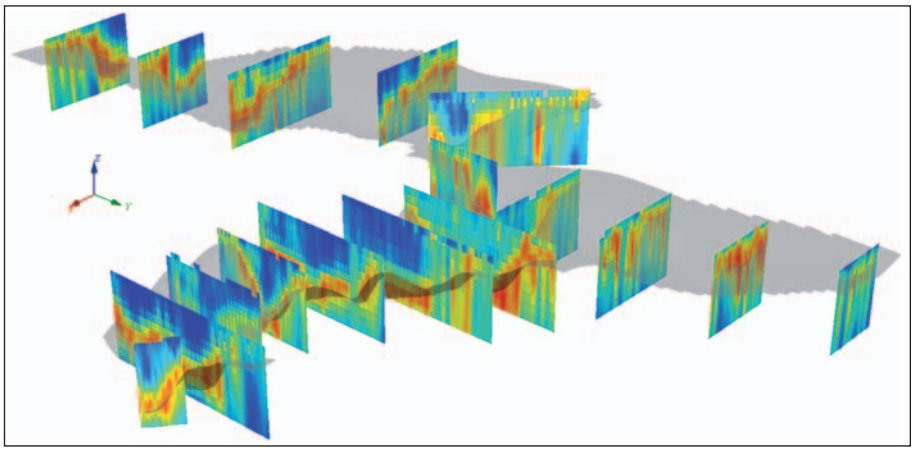

Figure 4. *3D fence diagram of HVSR passive seismic cross-sections and a base of palaeochannel surface generated from the cross-sections (from Owers and Meyers, Resource Potentials).*

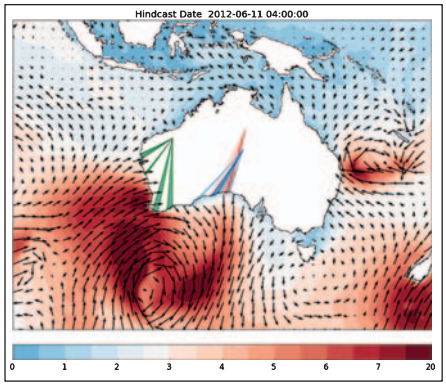

Figure 5. *Passive seismic source vectors within the Australian continent from seismometer array data recorded well within the continent compared to coincident storm events impacting the Australian coastline. The results indicate that far-field storm wave and wind action along the coastline contributes to the microseismic signal for passive seismic surveying over a thousand kilometres inland (from Reading, Gal and others, University of Tasmania).*

Thanks to ASEG Webmaster David Annetts, the presentation PDF files from the workshop are freely available at: https://www.aseg.org.au/workshop-proceedings.

There was a 'buzz' going around the conference following the shallow passive seismic workshop and presentations given during the conference sessions, indicating that interest in this method will continue to grow. For those who could not attend the Adelaide conference and workshop, a similar shallow passive seismic workshop is being organised through the Australian Institute of Geoscientists (AIG) to be held in Perth on 2 May this year. For more information about this workshop, please contact the authors of this article or visit the AIG website at www.aig.org.au.

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- Comes with Grilla processing and modelling software

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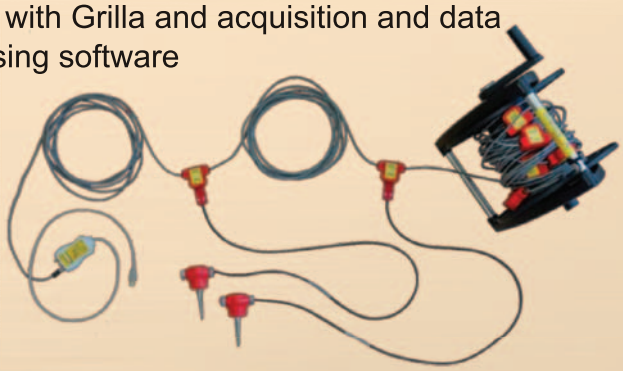
- Self-contained digital multi-channel seismic for 1D/2D passive seismic and all conventional active and passive seismic (MASW, REMI, refraction, reflection)
- Lightweight, A-D conversion at geophone take-outs
- USB direct connection and power with PC only
- Comes with Grilla and acquisition and data processing software



ELECTRA

- Self-contained networked multi-channel resistivity surveying and ERT
- Lightweight A-D conversion at cable
- USB direct connection to PC, comes with acquisition software

For instrument sales, Tromino® trade-ins, rentals, data processing and surveying enquiries, please call + 61 8 9289 9100 or email info@respot.com.au

AEGC 2018: update from the Conference Organising Committee

The conference organisation is progressing well. The conference webpage is up and running (http://www.aegc2018.com.au/), and the venue has been confirmed (http://www.iccsydney.com.au/). The Sponsorship and Exhibition Prospectus has been released (http://www.aegc2018.com.au/sponsorship-and-exhibition.php) and we already have some confirmed sponsors and exhibitors.

The technical committee has been talking with prospective keynote speakers and discussing the technical programme. The focus of the conference will be exploration and the technical programme will have three overarching themes:

- Energy
- Mineral Geoscience
- Near Surface and Groundwater

Each of the main themes has five sub-themes, which will result in an exciting and dynamic technical programme:

Energy

- Case Histories
- Petroleum Conventional
- Petroleum Non-conventional
- Coal
- Renewables

Table 1. AEGC Conference fees

Category	Early	Standard	Late
Member Full[A]	$900	$1100	$1300
Non Member Full	$1150	$1350	$1550
Member Retired[B]	$550	$750	$950
Student[B]	$150	$150	$150
Member Day	N/A	$495	$695
Non Member Day	N/A	$645	$845
Welcome Reception (guests)	$85	$85	$85
Dinner	$130	$130	$130

[A]Members of The Australian Society of Exploration Geophysicists (ASEG), The Petroleum Exploration Society of Australia (PESA) and the Australian Institute of Geoscientists (AIG).
[B]Retired and Student Members must provide confirmation from the associated society.

Mineral Geoscience

- Case Histories
- Geology, Geochemistry, Geophysics
- Ore genesis
- New Technologies
- Strategic and Industrial

Near Surface and Groundwater

- Case Histories
- Groundwater
- Environmental
- Geotechnical
- Archaeology and Forensics

Confirmed keynote speakers are:

Peter Baillie, CGG
Katarina David, University of New South Wales
Natasha Hendrick, Santos
Kevin Hill, Oilsearch
Jim Macnae, RMIT
Graham Heinson, University of Adelaide

The **call for Abstracts is now open**, you can find the abstract template and submission portal on the conference website (http://www.aegc2018.com.au/call-for-abstracts.php), please do not forget to submit your 250 word initial abstract.

Registration for the conference will be available from late May 2017. The table above outlines the fees. Early bird registration closes 31 October 2017, standard registration closes 18 January 2018. The prices for conference registration (see Table 1) are in AU$ and include GST.

Mark Lackie
Co-Chair Minerals
mark.lackie@mq.edu.au

Max Williamson
Co-Chair Petroleum

First call for nominations for the 2017–18 ASEG Honours and awards

To be presented in conjunction with the AEGC, 18–21 February 2018, Sydney, 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

CALL FOR ABSTRACTS IS NOW OPEN

AEGC2018

FIRST AUSTRALASIAN EXPLORATION GEOSCIENCE CONFERENCE

18-21 FEBRUARY 2018 | SYDNEY AUSTRALIA **EXPLORATION • INNOVATION • INTEGRATION**

We would like to invite you to join us at the First Australasian Exploration Geoscience Conference to be held in Sydney, Australia from 18-21 February 2018.

This Conference is jointly hosted by the Australian Society of Exploration Geophysicists, the Australian Institute of Geoscientists and the Petroleum Exploration Society of Australia and incorporates the 26th ASEG-PESA Geophysical Conference and Exhibition and the Eastern Australian Basin Symposium and will be home to the highest quality technical program with a focus on exploration.

The Conference will bring together geoscientists involved in energy exploration and exploitation and also exploration and mining of metals and industrial mineral as well as near surface and groundwater exploration. We expect a large number of delegates from Australia, New Zealand, and our Asia Pacific neighbours.

The theme of the conference is "Exploration, Innovation, Integration" emphasising that innovation and integration are critical in exploration for commodities. The technical program will be based around three overarching themes of Energy, Mineral Geoscience, Near Surface and Groundwater. The themes highlight the diverse nature of geoscience research and we invite you to join us in making this the highest quality program possible.

Hosted by

Australian Society of Exploration Geophysicists

AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
Supporting Geoscientists

PESA
Petroleum Exploration Society of Australia
1967 50 2016

For further information on themes and subjects please visit http://www.aegc2018.com.au/

Mark Lackie and Max Williamson
Co-Chairs, First Australasian Exploration Geoscience Conference

AEGC2018
AUSTRALASIAN EXPLORATION GEOSCIENCE CONFERENCE
18-21 FEBRUARY 2018 • SYDNEY AUSTRALIA
EXPLORATION • INNOVATION • INTEGRATION

www.aegc2018.com.au

GA: update on geophysical survey progress from the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current on 15 March 2017)

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

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Murloocoppie	GSSA	GA	MAGSPEC Airborne Surveys	11 Feb 2017	109 560	200 m 60 m EW	19 540	TBA	Contract executed by GA 12 Jan 2017. The survey is 43% complete to 12 Mar 2017	183: Aug 2016 p. 34	TBA
Warrina	GSSA	GA	MAGSPEC Airborne Surveys	11 Feb 2017	135 628	200 m 60 m EW	24 140	TBA	Contract executed by GA 12 Jan 2017. The survey is 39% complete to 12 Mar 2017	183: Aug 2016 p. 34	TBA
Andamooka	GSSA	GA	Sander Geophysics	23 Feb 2017	81 396	200 m 60 m EW	14 560	TBA	Contract executed by GA 17 Jan 2017. The survey is 21% complete to 12 Mar 2017	183: Aug 2016 p. 34	TBA
Barton	GSSA	GA	Thomson Aviation	22 Jan 2017	111 758	200 m 60 m EW	20 560	TBA	Contract executed by GA 12 Jan 2017. The survey is 43% complete to 13 Mar 2017.	183: Aug 2016 p. 34	TBA
Fowler	GSSA	GA	Thomson Aviation	18 Feb 2017	95 009	200 m 60 m EW	17 360	TBA	Contract executed by GA 12 January 2017. The survey is 22.5% complete to 13 March 2017.	183: Aug 2016 p. 34	TBA
Torrens	GSSA	GA	Sander Geophysics	4 Mar 2017	79 990	200 m 60 m EW	14 800	TBA	Contract executed by GA 17 Jan 2017. The survey is 11% complete to 12 Mar 2017.	183: Aug 2016 p. 34	TBA
Coonabarabran	GSNSW	GA	UTS Geophysics	Estimated by mid-Apr 2017	50 827	250 m 60 m EW	11 000	TBA	TBA	184: Oct 2016 p. 23	The Contract was executed by GA on 16 Feb 2017. The survey is anticipated to start on 11 Apr 2017
Tasmanian Tiers	MRT	GA	TBA	TBA	Up to an estimated 66 000	200 m 60 m NS or EW	11 000	TBA	TBA	TBA	National Collaborative Framework Agreement between GA and MRT was expected to be executed in Apr 2017. The survey has been deferred to occur between Oct 2017 and Mar 2018
Isa Region	GSQ	GA	TBA	TBA	Estimated 120 000	100 m 50 m EW	11 000	TBA	TBA	TBA	National Collaborative Framework Agreement between GA and GSQ executed on 13 Dec 2016. A Quotation Request was being drafted by GA for release prior to 31 Mar 2017

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
Stavely	GSV	GA	Atlas Geophysics	3 Dec 2016	Approx. 3465	200 m station interval along 14 traverses	TBA	5 Jan 2017	23 Feb 2017	The proposed survey covers parts of the Horsham, Hamilton, Ballarat and Colac Standard 1:250 000 map sheets. The survey is to collect gravity stations spaced 200 m apart on 14 separate road traverses.	TBA
East Kimberley Airborne Gravity Survey	GSWA	GA	Sander Geophysics	8 Oct 2016	38 000 line km	2500 m line spacing	82 690	3 Dec 2016	14 Jan 2017	184: Oct 2016 p. 24	23 Feb 2017
Coompana – PACE area	GSSA	GA	Atlas Geophysics	30 Jan 2017	13 801	Regular grid of 2, 1 and 0.5 km	100 000	4 Mar 2017	TBA	183: Aug 2016 p. 34	TBA
Tanami-Kimberley	GSWA	GA	TBA	TBA	Up to 50 000	2500 m line spacing	110 000	TBA	TBA	This issue	Contract being drafted by GA with the preferred supplier
Kidson Sub-basin	GSWA	GA	TBA	TBA	Up to 70 000	2500 m line spacing	155 000	TBA	TBA	TBA	The proposed survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan standard 1:250 k map sheet areas
South Nicholson	GA	GA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	The proposed survey area covers parts of the Mount Drummond, Ranken and Avon Downs Standard 1:250 k map sheet areas	GA and NTGS are in discussion to refine the survey extents

TBA, to be advised.

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Musgraves – PACE Area	GSSA	GA	CGG Aviation	18 Aug 2016	8489	2 km; E–W lines	16 371	The survey completed flying on 17 Sep 2016	Expected on 24 Nov 2016	179: Dec 2015 p. 23	Preliminary final data were supplied to GA on 30 Dec 2017
Musgraves – CSIRO Area	GSSA	GA	SkyTEM Australia	15 Sep 2016	7182	2 km; E–W lines	14 320	The survey completed flying on 13 Oct 2016	Expected early Dec 2016	179: Dec 2015 p. 23	Preliminary final data were supplied to GA in Jan 2017
Isa Region	GSQ	GA	Geotech Airborne	8 Aug 2016	15 692	2 km; E–W	33 200	The survey completed flying on 4 Nov 2016	TBA	182: Jun 2016 p. 23	Preliminary final data were supplied to GA on 12 Jan 2017
AusAEM (Year 1)	GA	GA	TBA	TBA	<50 000	20 km with areas of infill	TBA	TBA	TBA	186: Feb 2017 p. 18	The responses to the EOI are under review by GA
Ord-Keep River	GA	GA	TBA	Apr 2017	6146	Variable	TBA	TBA	TBA	TBA	The contract was executed by GA on 25 November

TBA, to be advised.

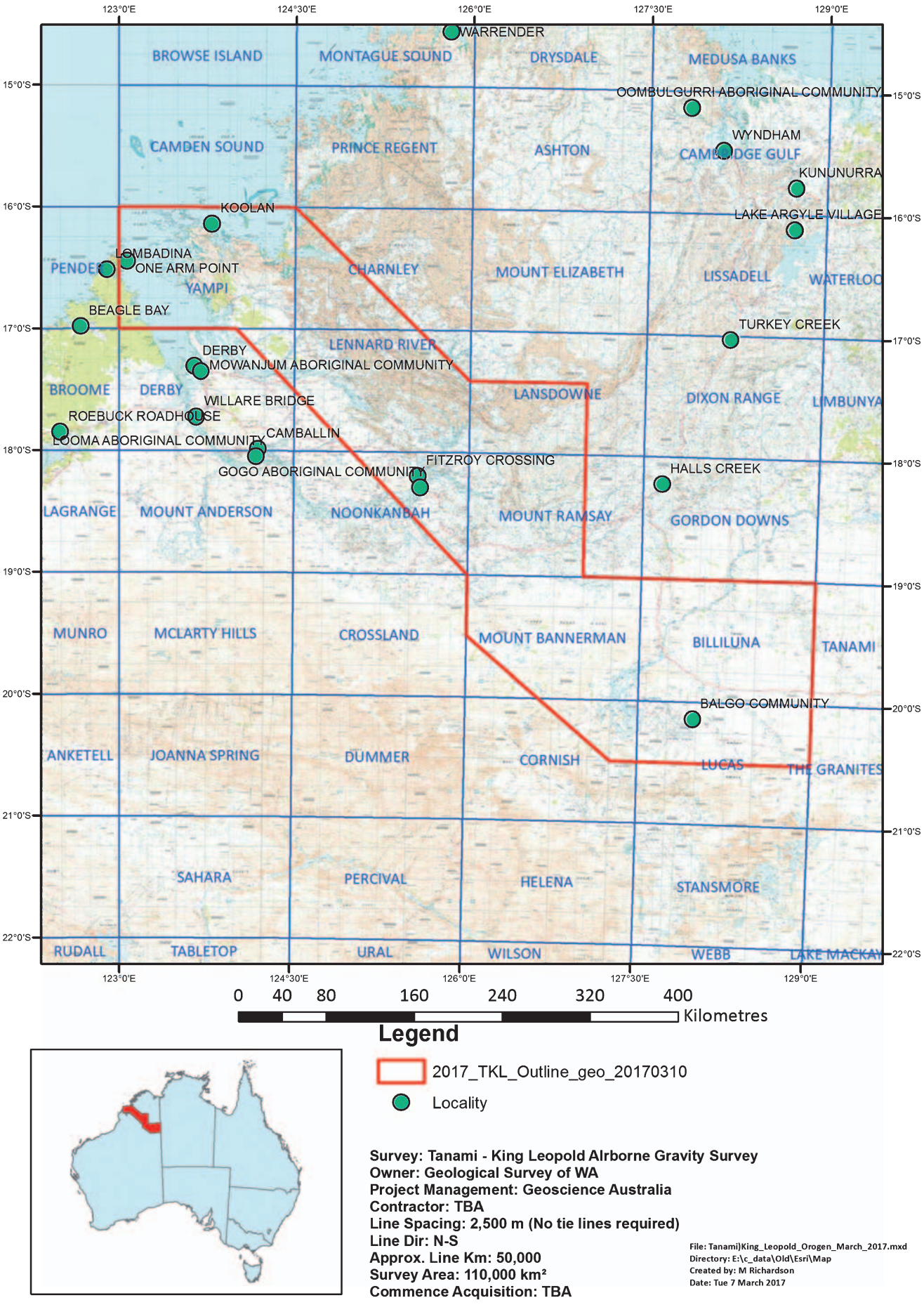


Figure 1. *Location of the Tanami – King Leopold Orogen airborne gravity survey.*

Geological Survey of New South Wales: Coonabarabran airborne magnetic and radiometric survey

The Geological Survey of New South Wales has a large repository of geophysical data, much of which is available to the public. The data originates from private and government surveys. The NSW government has been acquiring regional geophysical surveys as funding becomes available. We now have 85% of the state covered with airborne magnetic and radioelement data with a line spacing of 400 m or closer (Figure 1).

As part of ongoing airborne geophysical acquisition we are filling a gap in our magnetic and radioelement coverage around Coonabarabran. The Coonabarabran airborne survey is being managed by the Geological Survey of New South Wales (NSW Department of Industry) in conjunction with Geoscience Australia, the Commonwealth Government geological agency.

The survey is due to start at the end of March 2017. The aircraft will be flying about 60 m (200 feet) above the ground. It will fly in a grid pattern along east–west lines spaced 250 m apart with ties lines 2500 m apart. The survey area is shown in Figure 2. Data from the survey are expected to be released in the second half of 2017.

For further information about the survey please contact:

Ned Stolz
Manager – Geophysics & 3D modelling
Geological Survey of New South Wales
Tel: (02) 4931 6554
Mobile: 0429 055 321
ned.stolz@industry.nsw.gov.au

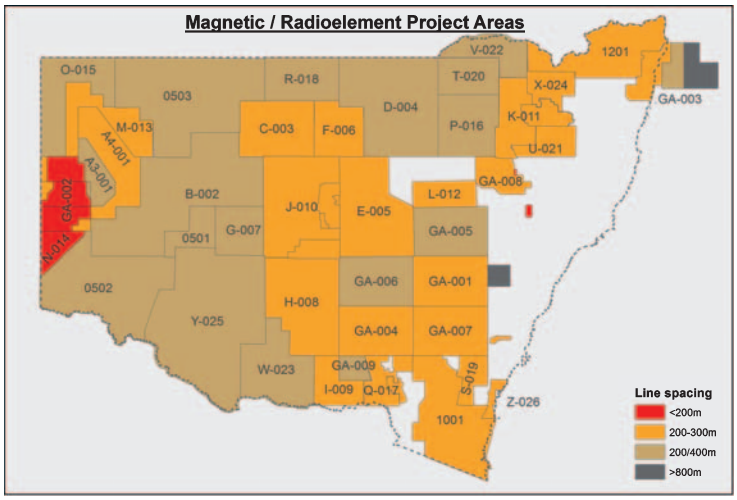


Figure 1. *Government airborne magnetic and radiometric coverage of NSW. White areas over the eastern seaboard are covered by 1600 m-spaced BMR surveys.*

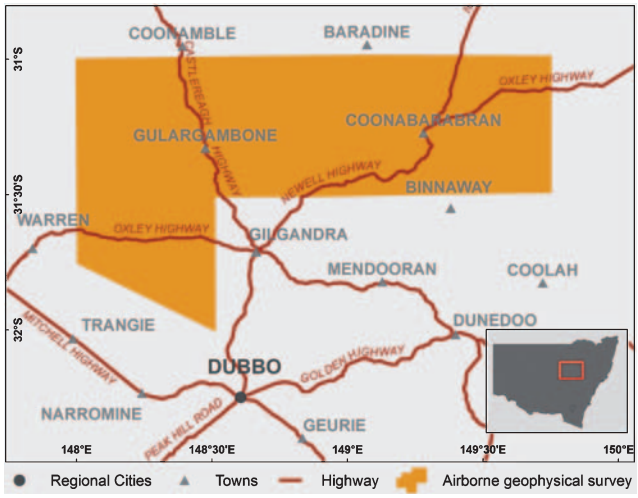


Figure 2. *Boundary for the Coonabarabran airborne magnetic and radiometric survey.*

Geological Survey of South Australia: SARIG update

A new version of SARIG has gone live. This version of SARIG displays a modern platform with a focus on improving the user experience when accessing online information (Figure 1).

Key points:

- The SARIG Url has changed from sarig.pir.sa.gov.au/Map_to map.sarig.sa.gov.au_– please change your bookmark
- The expansion of the SARIG acronym has also changed from South Australian Resources Information Geoserver to South Australian Resources Information Gateway
- The old SARIG has now retired and is no longer accessible

Some new features to check out:

- Modern interface including new menus layout responsive design (touch screen)
- Introduction of map layers themes and search and filter in the new map layer catalogue
- Raster datasets utilising Web Map Tile Services (WMTS) for display, each raster has a custom transparency slider
- Mineral and Petroleum Industry Indicators dashboard – view and download resources industry statistics
- Commodity Dashboard – interactive production and resource graphs from a state level down to project level, with corresponding maps to visualise commodities in South Australia
- Expanded spatial search and links to related data downloads
- Improved save map capabilities and map share options
- New release section, new coordinate tools, additional base maps and location service…and more…

Tips: SARIG logo = Home button, and we recommend using Chrome internet browser

Geophysical information is still available however it is accessed differently. From the main page, click on Spatial Search, select your datasource (Geophysical data) from the dropdown menu, and click on

Draw Area. Draw a rectangle around your area of interest and available surveys will be listed. Click on the Advanced Search button to select specific geophysical data to download, and then follow the prompts.

Enjoy!

Christie Gerrard and Philip Heath
Geological Survey of South Australia
Philip.Heath@sa.gov.au

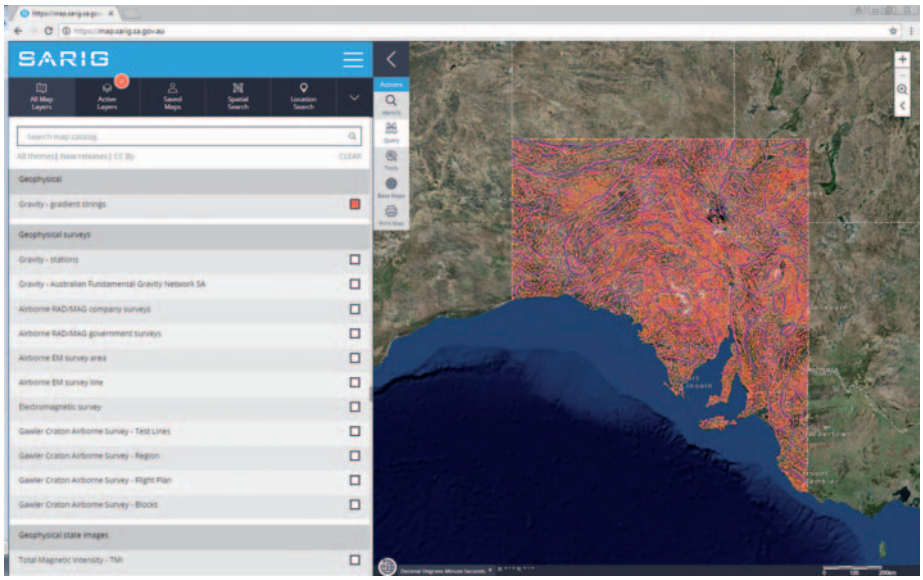


Figure 1. *The New SARIG – shown here displaying gravity gradient strings over South Australia – has been redeveloped with a modern platform.*

Geological Survey of Victoria: Geoscience investigations for gas

The Victorian Government has allocated $10 million in new funding to kick-start geoscience investigations into onshore conventional and offshore gas.

The investigations include a programme of scientific, technical and environmental studies on the risks, benefits and impacts of onshore conventional gas. The Victorian Government's Lead Scientist will oversee this work in consultation with a stakeholder advisory panel comprising farmers, industry, local government and community members with input from independent peer reviewers on the technical components.

Research will also be undertaken to examine prospectivity for near shore gas.

The Geological Survey of Victoria will build a state-of-the-art 3D geological model across the Otway Basin.

The proposed geoscience programme includes:

- Rock characterisation studies – analysis of geoscientific data and rock samples will be used to refine the geological model.
- Environmental studies – gathering new data on groundwater quantity, quality and soil conditions.
- Modelling and mapping – the potential for future gas resources will be assessed using the 3D geological model and rock property data, coupled with data from past conventional gas production in the Otway Basin.
- Geophysical surveys – low-impact geophysical surveying techniques to indicate potential new near shore gas resources.
- Gas prospectivity/resource estimates – all of the above components will be used to assess gas prospectivity and to estimate resource potential for the Otway Basin.

The results of the Programme can be used to inform any future consideration of the moratorium policy by the Victorian Government.

For more information please contact:
Paul McDonald
Director, Geological Survey of Victoria
Paul.A.McDonald@ecodev.vic.gov.au
Or visit http://onshoregas.vic.gov.au

Ralf Schroers (GSV) sampling trace groundwater chemistry in western Victoria.

Geological Survey of Western Australia: Status of regional aerogravity surveys in Western Australia

Data from the 38 000 line-km East Kimberley 2016 regional aerogravity survey were released on 23 February 2017. The survey area covers some 84 000 km^2 and encompasses much of the Halls Creek Orogen and parts of younger basins to the north and east (Figure 1).

The survey was funded by the Government of Western Australia as part of the Government's Exploration Incentive Scheme. It was the first airborne gravity survey to be contracted by the Geological Survey of Western Australia (GSWA) and Geoscience Australia (GA) as part of the Western Australia Reconnaissance Gravity Project. The data were acquired by Sander Geophysics Ltd over a period of eight weeks between 8 October and 4 December 2016.

Survey lines were flown east–west at 2.5 km line spacing (25 km tie-lines) at a nominal height of 160 m above ground level. With an along-line spatial wavelength resolution of 5 km, the survey configuration provides equivalent 2D spatial resolution with the 2.5 km grid of ground data that have been acquired from helicopter-assisted surveys in the southern and western parts of Western Australia since 2009. The precision (repeatability) of the Bouguer gravity data after filtering with a 100 second low-pass filter is 0.54 mGal – estimated from 18 separate passes along a 50 km test line.

A data package with located data and grids, and including georeferenced images and the operations report, is available from geodownloads.dmp.wa.gov.au/downloads/geophysics/71156.zip. Located data and grids can also be downloaded from the Australian Geophysical Archive Data Delivery System at www.ga.gov.au/gadds.

The located dataset at 2 Hz (c. 25 m samples) includes unfiltered and uncorrected raw gravity – gravimeter acceleration minus aircraft acceleration – so that you can apply your own corrections and filters.

The new data have also been incorporated into the WA State gravity 400m-cell compilation grid that is available from www.dmp.wa.gov.au/geophysics. Figure 2 shows the added resolution of the new airborne data in 'before-and-after' images.

GSWA and GA are planning two new aerogravity surveys also at 2.5 km line spacing for implementation in the 2017 flying season between May and October with data release anticipated for early 2018. The proposed survey areas are shown in Figure 1:

- The Tanami – King Leopold project area of about 110 000 km² (50 000 line-km) in the southern Kimberley, contiguous with the East Kimberley survey area and extending from the Billiluna region near the border with the Northern Territory to Derby in the west.
- The Kidson project area of about 155 000 km² (70 000 line-km) over the Kidson sub-basin in the central Canning and covering parts of the Gibson and Great Sandy Deserts.

Programme plan updates are published at www.dmp.wa.gov.au/geophysics or contact geophysics@dmp.wa.gov.au for further information.

This info-item also appears in GSWA Fieldnotes Issue #82, April 2017.

David Howard
Geological Survey of Western Australia
David.HOWARD@dmp.wa.gov.au

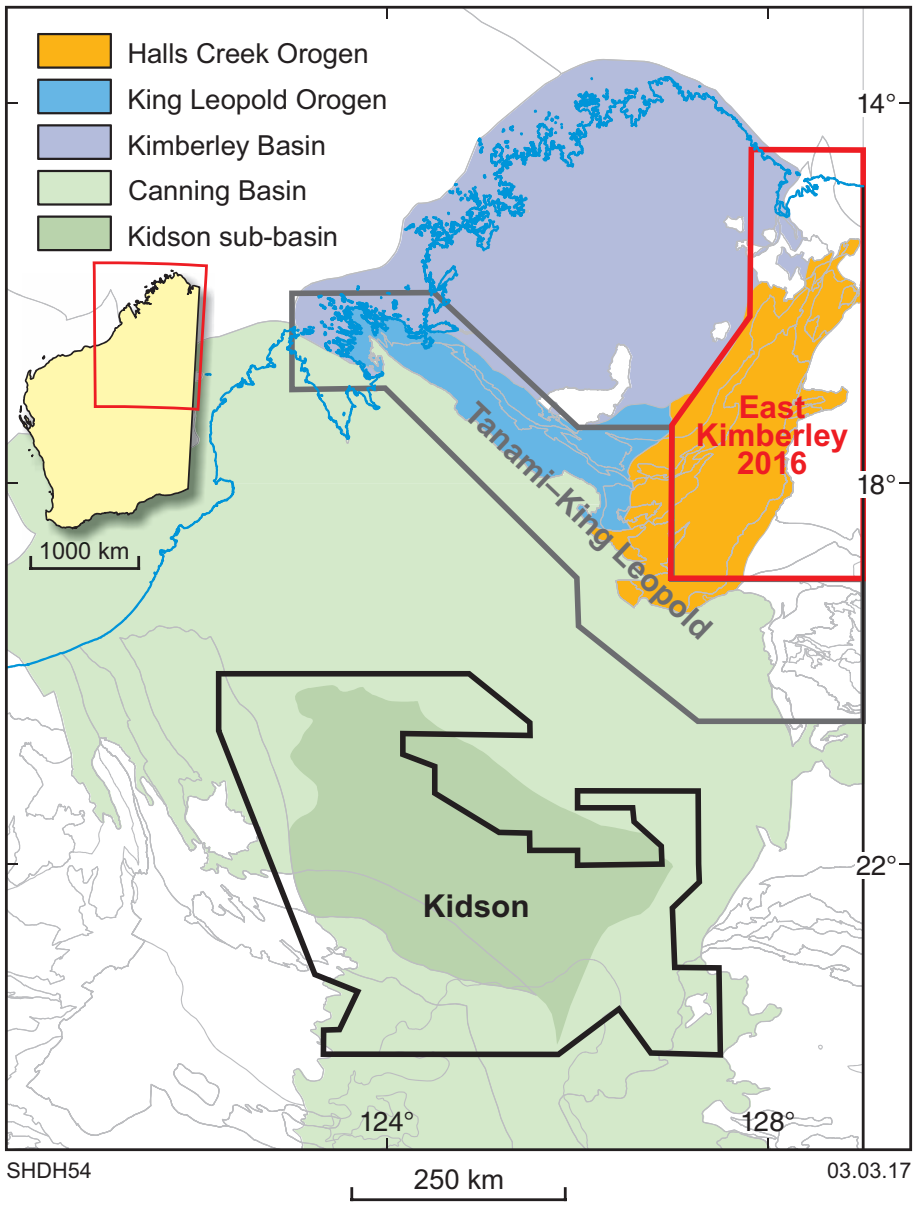


Figure 1. *Location of aerogravity surveys.*

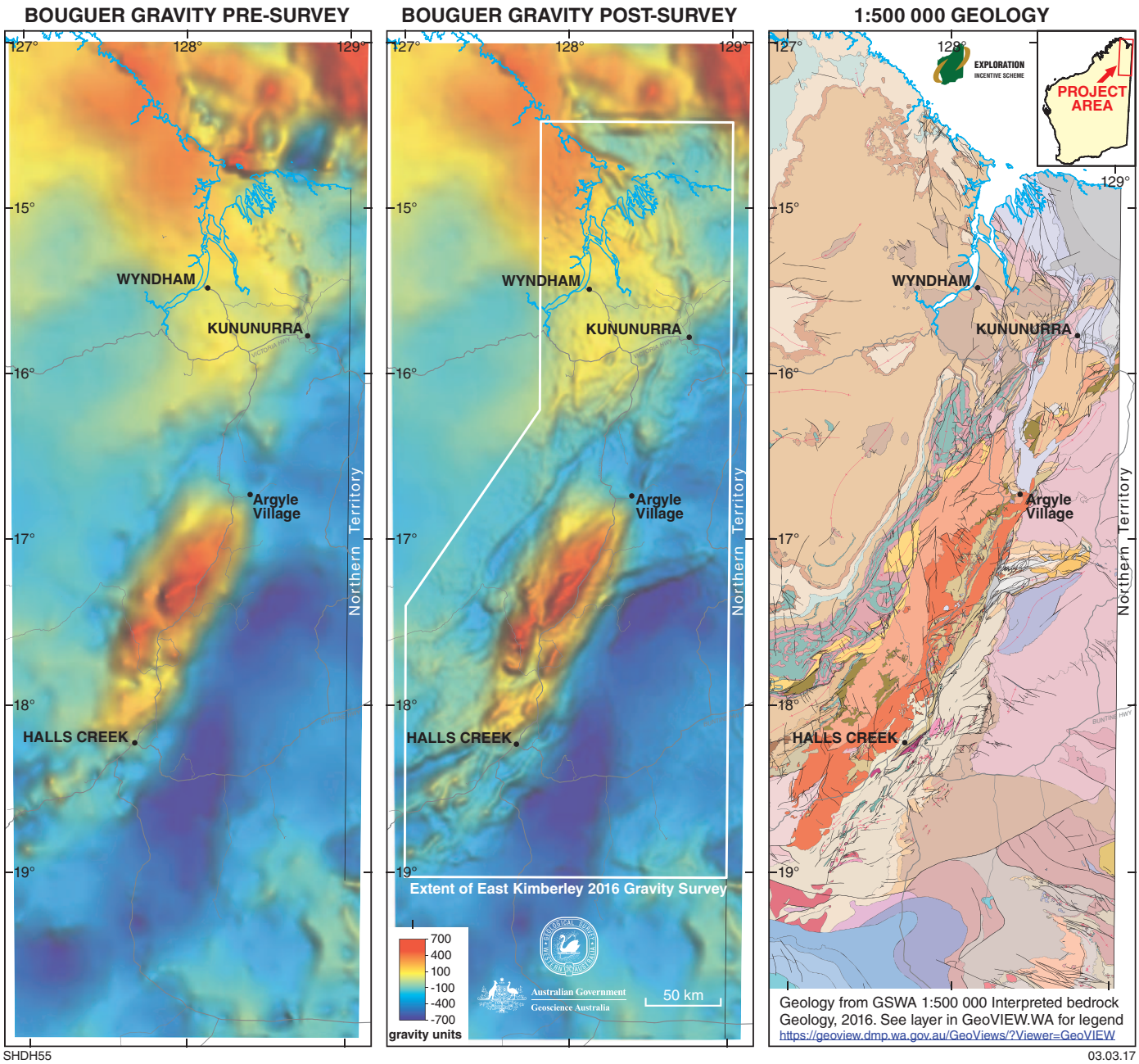


Figure 2. *East Kimberley aerogravity survey results.*

Canberra observed

David Denham AM
Associate Editor for Government
denham1@iinet.net.au

We need action now to avoid third world power cuts

The time has come for the blame game to stop over what caused load shedding and blackouts in southeast Australia. It's time for all sides of the political spectrum to come together and develop a national strategy to ensure a reliable electrical grid that will serve the country for the foreseeable future.

We are caught between a rock and a hard place. The rock is that we need a reliable supply of electricity throughout the Australia. The hard place is that we need to reduce our greenhouse gas emissions in accordance with our commitment to the Paris Agreement on climate change, which came into force in November 2016. In practice this means our inefficient coal fired power stations must be de-commissioned. These are currently suppling the main base load throughout the country and also causing most of our emissions.

It doesn't make sense to blame renewable energy for the blackouts because it only makes up a small percentage of the total generating capacity. For example, in 2015 (https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html) renewable energy provided 14.6% of Australia's electricity. Of this component, 40% came from the Tasmanian and Snowy Mountains hydro schemes. Wind and solar combined contributed only 7% to the total production. The grid should not be totally dependent on a source that only provides such a small percentage of the total supply.

What are the options?

Judging by the antics in the House of Representatives in February, when the Treasurer Scott Morrison passed around piece of coal, the Coalition government wants to pursue a policy built on coal. Is this a wise course to follow?

There are problems with coal.

1. The price of thermal coal has dropped steadily from US$130/t in 2011 to US$40/t in 2017, therefore new coal mines are not attractive investments.
2. Coal is a major polluter, not only of greenhouse gases but also of smog and acid rain. There is no such thing as clean coal. We should try to minimise its use.
3. The technology for Carbon Capture and Storage has not developed sufficiently to be applied routinely to coal power stations. The costs are difficult to estimate and they would vary considerably for each site.
4. There could be a lead time of at least five years before any operating facility could be commissioned.

It doesn't make sense to blame renewable energy for the blackouts

There are problems with renewables.

1. The lead time for stored hydro could be at least five years for each site and the costs have not been estimated.
2. Large scale battery storage has not been costed or tested in Australia.
3. Wind farms are not very popular with the community unless they are getting a rent from the turbines.

What about gas?

1. Gas produces fewer emissions than either coal or oil.
2. Gas power stations can be powered up and shut down much more effectively than coal power stations.
3. Australia has a huge gas reserve (3.5 trillion m^3) and at present is producing approximately 70 billion m^3 annually.
4. We need a regulatory framework so that we can access our own gas for domestic use and appropriate infrastructure to process and distribute it. At present most of our gas is exported.

Support for increasing the gas option came from the Australian Energy Market Operator (AEMO). It warned that 'Australia is facing energy shortages if governments do not carry out national planning as exports continue to dominate the country's gas supply.' (https://www.aemo.com.au/Media-Centre/-/media/be174b1732cb4b3abb74bd507664b270.ashx). The AEMO report predicts that New South Wales, Victoria and South Australia will be impacted from the summer of 2018–19, and warns that the tightening of the domestic gas market will have flow-on effects to the electricity sector unless there is an increase in gas supplies and development.

What about nuclear power?

It would provide a clean reliable base load, but it needs to be costed and it cannot adapt rapidly to fluctuating demands. Furthermore, the politics are against anything nuclear.

The way forward

We should use natural gas to replace coal for the next ~20 years and at the same time increase our renewable capacity in wind, solar, pumped hydro and battery storage, as these technologies evolve. There should be a carbon tax to cover the environmental costs of burning coal and other fossil fuels and all government subsidies should be withdrawn so that the real costs of supply are accessible.

Well that's what I think!

Petroleum Resource Rent Tax regime under investigation

The Turnbull government is contemplating measures to boost the revenue it collects from offshore oil and gas projects, after collections under the PRRT regime fell by more than half after 2012–13 (Katharyn Murphy, *The Guardian*, 11 March 2017). It is estimated that under the current arrangement the Gorgon Project will pay no tax until 2030. A new royalty regime is being proposed by Diane Kraal from Monash University.

I have never understood why the present arrangement is called a 'Rent Tax'. To me, if you rent a house or a car you return the asset in reasonable condition after you have used it. Not so with oil and gas. Once the resource has been extracted it is gone for good! It should really be called an Extraction Tax.

The tax…should really be called an Extraction Tax

Taxpayers to subsidise clean ups

Anyway, it seems that the terms of the current PRRT should be reviewed because at present Australian taxpayers will have to subsidise the clean-up costs of any oil spills in Australian offshore tenements due to the terms of the Petroleum Resource Rent Tax.

At Senate Estimates in 2016 Treasury officials confirmed that companies would be able to claim a tax deduction for expenses incurred from cleaning up pollution. (*The Guardian*, 25 February, 2017). Different 'uplift rates' would apply to clean-up costs depending on whether the spills resulted from exploration or production activity. It means the costs of cleaning up oil spills from exploration wells would be tax deductible, and could be held over and 'uplifted' into future years at an annual rate of 17.5%.

An interesting situation!

Minerals exploration rebound continues; petroleum still in the doldrums

Gold drives mineral exploration recovery

Investment in mineral exploration continues to increase, according to the mineral and petroleum exploration data for the final quarter of 2016, released on 27 February 2017 by the Australian Bureau of Statistics (http://www.abs.gov.au/ausstats/abs@.nsf/mf/8412).

The trend estimate increased 3.4% ($12.0m) to $369.5m in the December quarter 2016. This is an increase of 4.6% above the December quarter for 2015.

The largest contributor to the increase was Western Australia (up 4.3%, $10.0m). WA now hosts 60% of the country's mineral exploration investment and approximately half of this amount was invested into gold exploration ($133m).

In original terms, mineral exploration expenditure rose 6.2% ($23.6m) to $403.1m. It is now at similar levels to what it was in the December quarter 2005, but well below the peak of $1163m in the June 2012 quarter (see Figure 1). The other good news is that exploration on areas of new deposits rose 15.0% ($17.1m), which exceeds the increase in expenditure in areas of existing deposits, which rose 2.5% ($6.7m).

In other words, companies are starting to look for new deposits.

All data have been normalised to December 2016 A$s, using the CPI. The raw data were supplied courtesy of the Australian Bureau of Statistics. See: http://www.abs.gov.au/ausstats/abs@.nsf/mf/8412.

The minerals exploration rebound is in lock-step with the value of the market capital of the main resource companies listed on the ASX (Figure 2). This bottomed out in January 2016, which coincides with the minimum quarter for exploration data in March 2016. If you invested in shares represented by the companies that were used in calculating the All Ordinaries Index in July 2000 your return would have been approximately 1% per year plus dividends. If you invested in the major resource companies the return would have been approximately 5% per annum plus dividends. A good investment!

The minerals exploration rebound is in lock-step with the value of the market capital of the main resource companies

Petroleum still in the doldrums

The story for petroleum is not so good. Both onshore and offshore exploration fell in the December 2016 quarter and the trend estimate for total expenditure is now at its lowest level in the 2005–2016 period. It fell 2.9% (–$9.5m) to $320.0m in the December 2016 quarter. This is well below the peak of $1593m recorded in the June 2014 quarter.

Exploration expenditure on production leases fell 30.9% ($10.2m) however, the exploration expenditure on all other areas rose 1.0% ($3.0m). The largest contributor to the decrease in the trend estimate was Western Australia – down 9.3%, to $214m. However, WA captured 64% of the national total so there is a good base for a re-bound. As can be seen in Figure 1, the downward slope appears to be decreasing.

The other bad statistic is the level of oil production by Australia. This continues to decline (see Figure 3) and the oil price is still hovering around US$50/bbl – nowhere near the heady heights of US$100/bbl between 2011 and 2014.

The production of natural gas might save us. This has increased steadily from 1100 Mm^3 a quarter to 1500 Mm^3 from 2010 through 2016. However, the politics of this resource are complex and unpredictable.

Domestic consumers are complaining about Australian gas being shipped and sold to wholesale customers in Japan for 40% less than it is sold to Australian customers, despite the extra costs of liquefying and shipping the gas there (https://www.theguardian.com/business/2016/aug/16/australian-gas-40-cheaper-japan-than-australia-despite-export-costs).

Furthermore, there are questions about the level of the resource rent tax. Companies in Australia operating large gas-to-liquefied natural gas (LNG)

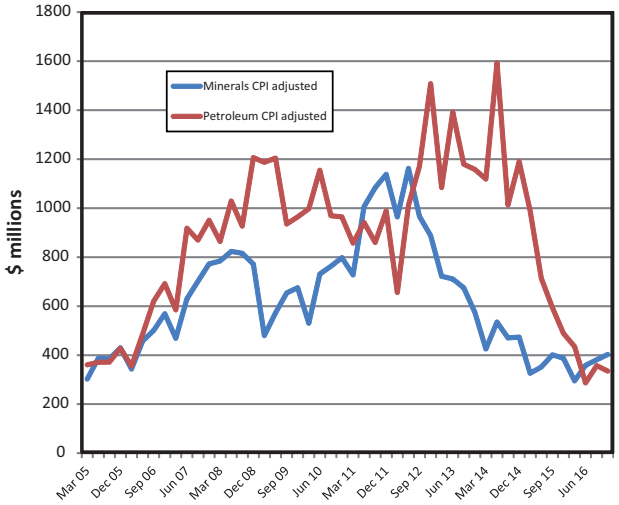


Figure 1. *Quarterly mineral and petroleum exploration investment for the period 2005–2016.*

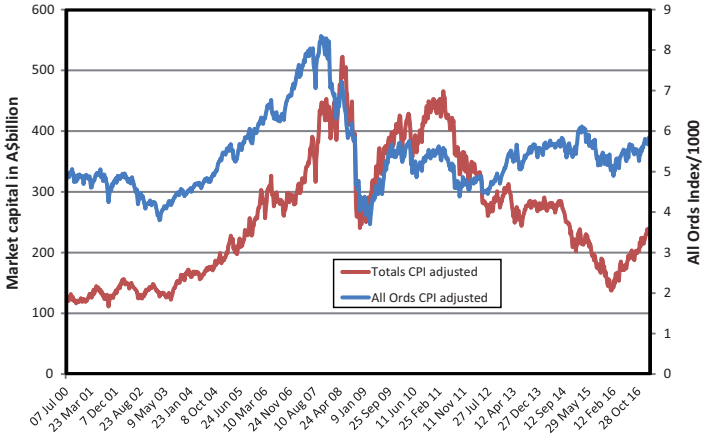


Figure 2. *All Ords Index and market capital of resource companies listed in the top 200 companies in the ASX between 2000 and 2016. All values have been corrected using the CPI to December 2016 dollars.*

projects pay a resource rent tax (a tax levied on above-normal profits) as well as the regular company tax. Above-normal profits from these new projects are perhaps a decade away, which is why there has been a recent drop in resource tax revenue (https://www.theguardian.com/environment/2016/nov/22/australia-must-catch-up-with-other-countries-on-how-it-taxes-gas).

This all too complicated for a mere geophysicist, but the message is: beware the politics when governments try to do deals on the run.

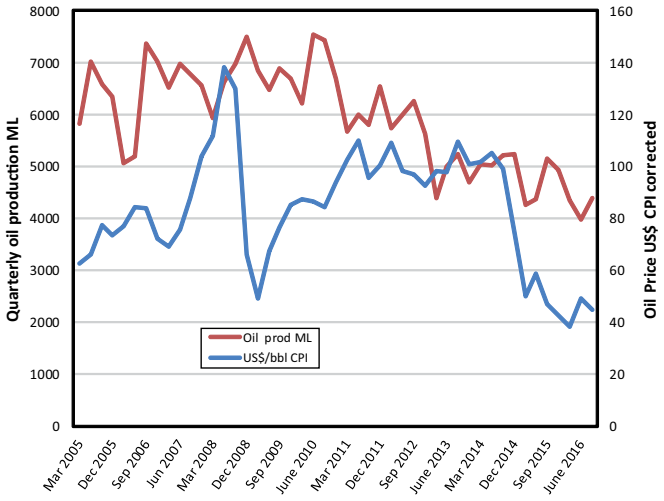


Figure 3. *Total Australian Oil and Condensate quarterly production 2005–2016 in ML per quarter and West Texas crude oil price in US$/bbl, normalised to December 2016 dollars. Sources from: http://www.environment.gov.au/energy/petroleum-statistics and http://www.economagic.com/em-cgi/data.exe/var/west-texas-crude-long.*

Education matters

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NExUS: a new national field school for geophysics

The University of Adelaide and the Minerals Council of Australia have teamed up to run a three week student field camp in geophysics, with a strong UNCOVER theme. The national UNCOVER project http://www.uncoverminerals.org.au/ is supported by Geoscience Australia, all the State geological surveys, a range of industry partners, and is a guiding light for much of the academic research conducted in Australia for the mineral industry.

The University of Adelaide, led by Professor Graham Heinson and Research Fellow Dr Richard Lilly, has taken a further initiative to run a three-week field camp for geoscience students, exposing them to the excitement and challenges of mineral exploration and the geophysical techniques which are making deep exploration possible. The inaugural camp took place in the Adelaide Hills and the Yorke Peninsula of South Australia, and attracted 30 students from 13 universities around Australia. Richard Lilly highlighted a goal of the course thus:

'The tools and processes introduced in the programme are those which will be required by the next generation of explorers in the hunt for the next Tier 1 mineral deposits.'

The NExUS national programme is uniquely targeted to Australian requirements, but it builds on a tradition started 35 years ago in North America by the University of Arizona. The Summer of Applied Geophysical Experience (SAGE) programme has reached its 35th field season, and has an impressive track record of demonstration of the 'discovery-oriented approach' to teaching, having been involved in geophysical characterisation of buried waste, mapping archaeological sites, and studying tectonic

Graham Heinson

Richard Lilly

NExUS students at their final field location of the 2016 NExUS Programme with (at right) Steve Hill (Director of GSSA).

structure and water resources of the Rio Grande rift (Baldridge, 2012).

Back in South Australia, our inaugural NExUS programme began at the state of the art South Australia Drill Core Reference Library at Tonsley, SA, with presentations from senior industry representatives including Gavin Lind (MCA), Robbie Rowe (NextGen/UNCOVER), Steve Hill (GSSA), Stephan Thiel (GSSA), Carmen Krapf (GSSA), Malcolm Sheard (GSSA), Ross Cayley (GSV), Jon Huntington (CSIRO), Ravi Anand (CSIRO), Ian Lau (CSIRO) and Graham Heinson (UofA). Workshops included regolith characterisation and mapping interpretations, a HyLogger hyperspectral data workshop, core logging and 3D visualisation of the South Australian geology database and geochemical dispersion in regolith. During the evenings chances for networking were encouraged, with senior industry professionals flying in especially to meet with and share career tips with the NExUS students.

In the second week students went exploring in the Adelaide Hills. Hillgrove Resources supported the programme by providing ground access and data resources to one of their exploration tenures in the area. Participants carried out detailed mapping and practiced acquiring ground based geophysical data (including magnetics, gravity, magnetotellurics (MT), induced polarisation (IP) and Nano TEM) across the historical Wheal Ellen Cu (Zn-Pb) deposit. Soil geochemistry and an awareness of the different approaches for regolith sampling were also on the agenda for the students. During the evenings students processed the geophysical data acquired in the field with assistance from industry geophysicists including Matt Zengerer (Gondwana Geoscience). Soil samples were analysed with a pXRF, followed by creation of thematic geochemical dispersion maps of the results using GIS software. Data was then collated, which allowed students to determine potential further exploration targets. Hillgrove Resources also provided the opportunity to visit the Kanmantoo Cu Mine and kindly laid out grade control drill core for the NExUS students to log and practice their mineral identification skills.

For the final week, NExUS headed for the historic 'Copper Coast' of the Yorke Peninsula, SA. The focus for the start of the week was identification of ore and gangue minerals, hydrothermal alteration and breccia textures and mineral paragenesis. Building from the skills gained over the past two weeks, students were again provided with a practical learning exercise of logging and interpreting the mineral paragenesis of exploration drill core with senior geologist Craig Went at REX Minerals Hillside Cu deposit, which was discovered under alluvial cover. Steve Hill (Director of GSSA) provided a one day field-based workshop on biogeochemistry and regolith, explaining the potential for exploration companies to use vegetation to better define targets before moving in with a drill rig. He also encouraged students to accurately describe the regolith, and explained the importance of understanding regolith evolution in order to ensure exploration activities, such as soil sampling, are conducted as effectively as possible.

As the end of the three week course was fast approaching, the programme moved from exploration into resource estimation and project feasibility. Students were introduced by Gavin Springbett (G&S Resources) to 3D ore body modelling in Vulcan and the process of resource and reserve calculations in accordance with the JORC Code. This process took the NExUS course full circle from conceptual exploration models to highlighting the importance of detailed reporting and ore body modelling.

On the final night students were given the opportunity to reflect and share what they learned during the 3 week course and to thank one another for their friendship, encouragement and teamwork during the course. The professionalism and comradery between all the NExUS students was observed by all involved and commented on by industry professionals throughout the programme, with some saying that they are happy to leave the mineral exploration industry in the hands of such talented individuals.

As Craig Pereira from UQ put it, 'The NExUS programme provided me with exposure to new technology and exploration techniques that have the potential to be game changers when exploring undercover'. Allison Cooke from Monash added, 'The diversity of experiences and material was inspiring as were the industry professionals who came to speak with us'.

The next NExUS course is planned for end of 2017; further information and application forms are available at www.nexus.org.au.

And, in a couple of decades time, may Australia's NExUS boast, like North America's SAGE, of a cadre of top professionals and ore-body finders who point to the student field camp as one of their key learning experiences.

Acknowledgements

Thanks to Genna McDonagh and Richard Lilly for their description of the programme; read it in full at https://www.linkedin.com/pulse/report-inaugural-nexus-national-exploration-undercover-richard-lilly.

Reference

Baldridge, W. J., 2012, SAGE at 30: *The Leading Edge*, June 2012, 702–708.

ASEG student member Kathryn Hayward wins an IGC Early Career Travel Grant

Congratulations to Kathryn Hayward, PhD student at the Australian National University, on winning one of five Early Career Travel Grants offered by the Australian Geoscience Council. The grants are offered annually and are made possible by the financial success of the 34th International Geological Congress held in Brisbane in 2014. The award will allow Kathryn to attend and present research at the Deformation, Rheology and Tectonics Conference in Inverness, Scotland and undertake state-of-the-art laboratory earthquake slip experiments at ENS Paris.

Kathryn Hayward in her laboratory, with a high-temperature deformation apparatus.

Kathryn uses experiments undertaken at pressure and temperature conditions comparable to those found deep in the crust to learn about the strength and behaviour of faults. Specifically she is interested in understanding the processes that occur during the first seconds of fault slip as this is central to understanding whether a fault rupture grows to become a large, damaging earthquake, or strain is accommodated as a small, possibly non-seismic event. During the first seconds of slip, the extreme forces acting on fault contacts, or asperities, result in heat generation, formation of damage and changes in the physical properties of a surface. As slip proceeds, these processes can result in an evolution of fault strength through a process referred to as 'dynamic weakening'.

A key aspect of the current research is the role that fluids play in affecting the behaviour of faults during the initial stages of slip. Fault zones are recognised as fluid conduits within the crust and large-scale injection experiments (such as in Basel, Switzerland) have shown a direct correlation between fluid pressure and rates of seismicity. This has important implications for the development of hydraulic fracture technologies such as enhanced gas recovery, geothermal energy extraction and geo-sequestration. However, presently little is known about how pore fluids modify fault strength and asperity behaviour during rupture and how this could facilitate or impede rupture propagation.

During the visit to the ENS laboratories Kathryn will be using experimental techniques pioneered by that lab to explore differences in fault processes between earthquakes resulting from increases in shear stress (such as classic mainshock-aftershock events) and those driven by changes in pore fluid pressure (e.g. during an injection driven swarm sequence). Experiments will focus on deformation occurring prior to and during the onset of slip using highly sensitive acoustic emission sensors. These measurements will provide information on rupture velocities at various conditions and waveforms will be inverted to characterise the 3-D geometry of earthquake nucleation and propagation. In-situ strain gauges will allow measurement of co-seismic stress drop in real time with a temporal resolution of approximately 1 million samples per second.

The next step in this research will be back in Australia making use of the latest high-resolution electron microscopy imaging techniques to provide information on the microstructural changes that are occurring on the fault surface during the early stages of slip. The combined mechanical and microstructural data will give us new insights about how fluids alter fault strength and behaviour during rupture. This knowledge will help us improve understanding of earthquake nucleation and potentially assist with mitigation of seismic risk associated with new injection technologies.

SEG 2017 Distinguished Instructor Short Course: Doug Oldenburg

Geophysical electromagnetics: fundamentals and applications

Doug Oldenburg

Summary

Electromagnetics has applications in oil and gas exploration and production, mineral exploration, groundwater exploration and monitoring, geotechnical and environmental industries. Although it has widespread applications as a geophysical technique, it is not generally understood by the geoscience community. As a result it is underutilised, and in some cases misused, as a technology.

The aim of this course is to provide a fundamental understanding about EM geophysics so that practitioners can decide if an EM technique can help solve their problem, select which type of survey to employ, and set realistic expectations for what information can be gleaned. Case histories, spanning applications from many areas in the geosciences, are used as an underlying framework to bind the material together. For more information, see the online resources at http://disc2017.geosci.xyz.

Fundamentals and applications

Case histories pertain to problems in resource exploration, including oil and gas, minerals, water, environmental, and geotechnical areas and are contributed by experts worldwide. (http://disc2017.geosci.xyz/).

These include:

1. resource detection (e.g. methane hydrates) or de-risking (e.g. offshore-hydrocarbons),
2. imaging SAGD steam chambers or monitoring hydraulic fracturing,
3. mineral exploration (on land, on the ocean floor sea floor massive sulfides),
4. water issues (e.g. monitoring salt water intrusion, imaging aquifers),
5. imaging geothermal systems,
6. detecting and discriminating unexploded ordnance,
7. geotechnical characterisation, including slope stability, and more (see http://em.geosci.xyz/content/case_histories/index.html for a growing list).

These applications are motivation for investigating fundamentals of electromagnetics. Applications successively investigated include those that make use of:

1. steady state fields (e.g. DC resistivity, induced polarisation),
2. frequency domain EM (e.g. marine CSEM, airborne surveys),
3. time domain EM (e.g. airborne, ground, borehole surveys),
4. natural source EM (e.g. magnetotellurics, Z-Axis Tipper/ZTEM).

The energy sources for these surveys can be man-made or natural. Man-made sources include inductive transmitters (loops of wire carrying a current) or galvanic sources where current is injected into the ground. The natural energy sources promote MT (magnetotellurics), which is important for characterising deep conductivity structures for geothermal energy, and ZTEM, which has proven to be valuable in geologic mapping and mineral exploration. The various surveys can be carried out in the air using helicopters or airplanes, on the earth's surface, or underground; the geoscientific question to be addressed determines which survey is selected. Case histories and survey types presented will be tailored to each location at which the DISC is presented, and chosen based on the local problems of general interest.

Each case history is presented in a seven-step process that begins with the description of the geologic or geophysical problem to be solved and ends with the impact of the EM geophysical survey to help solve the problem. At points in the middle, the details of the particular EM survey are investigated, together with some fundamentals of electromagnetic induction, and techniques for processing/inverting the data. The ability to move seamlessly between these different levels of information, so that relevant questions or concepts can be addressed, is facilitated by new open-source numerical software, interactive simulations, and the 'textbook' resource http://em.geosci.xyz. Although we work continually with Maxwell's electromagnetic equations, the presentations are mathematically 'light' and the learning aspect is facilitated by the use of open-source, interactive numerical software and visual aides.

The site http://disc2017.geosci.xyz contains further details on the course, its goals, links to the open-source resources that will be used, and ways to get connected!

Who should attend?

Geophysicists and any geoscientists who have the potential to use, or be associated with, electromagnetic data. The 2017 DISC is designed to be of interest to a broad audience, including researchers, practitioners, and industry geoscientists, and accessible to those with little background in EM.

Biography

Doug Oldenburg's 40-year research career has focused upon the development of inversion methodologies and their application to solving applied problems. He, with students and colleagues at the University of British Columbia Geophysical Inversion Facility (UBC-GIF), have developed forward modelling and inversion algorithms for seismic, gravity, magnetic and electromagnetic data. The inversion techniques and software are widely used in resource exploration problems. In recognition for his work building collaborative interactions between industry and academia, he was awarded the NSERC Leo Derikx and the AMEBC Special

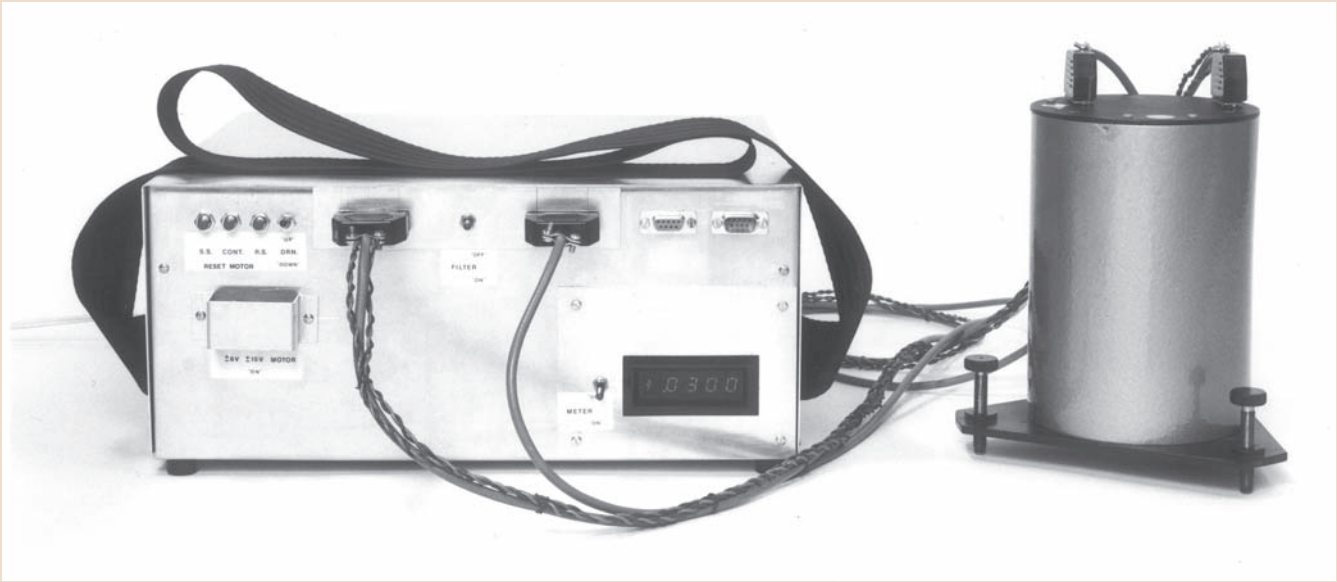
Tribute awards as well as the J.Tuzo Wilson medal. In 2011, Doug was the SEG Distinguished Lecturer; his presentation was entitled 'Imaging the Earth's near surface: The why and how of applied geophysics for the 21st century'.

Doug's current research activities include: inversion of EM data and their application to a wide range of problems, development of practical methodologies for combined inversion of geophysical and geological data, development of software for unexploded ordnance discrimination, and the use of self-potentials for dam safety investigations. He is passionate about the development of open-source educational resources for applied geophysics and increasing the visibility and benefits of using quantitative geophysics to help solve geoscience problems (http://geosci.xyz). These efforts will form the cornerstone of the SEG 2017 DISC.

Doug received his BSc Honors degree in Physics in 1967, and his MSc in geophysics in 1969, from University of Alberta in Edmonton. He completed his PhD in 1974 at UCSD in earth sciences. After a three-year postdoc in Alberta, he joined the Geophysics and Astronomy department at University of British Columbia. He remains at UBC where he is currently a Professor, Director of UBC-GIF and holder of the TeckCominco Senior Keevil Chair in Mineral Exploration. He is an honorary member of the CSEG, SEG and a Fellow of Royal Society of Canada

The schedule for Doug Oldenburg's DISC course is being finalised with the SEG over the coming weeks. If you are interested in the course you should contact your Branch Secretary or Emma Brand, Chair of the Continuing Education Committee continuingeducation@aseg.org.au so as to ensure that your Branch/State doesn't miss out!

Upcoming OzStep course: 'Reservoir Geophysics – Applications', a one-day course by Bill Abriel will be held at various locations in May. Please contact Emma Brand, Chair of the Continuing Education Committee continuingeducation@aseg.org.au for more information.



*The gravimeter shown in this photo is the **Flinders gravimeter**, a prototype gravity meter manufactured in South Australia. It was developed over the period 1980 to 1984 by Andrew Hugill, a PhD student at Flinders University of South Australia. Although other gravimeters at the time used electronics, the distinguishing feature of the Flinders gravimeter was that electronics was integral to the design, rather than being used to enhance an existing design.*

Improvements of this sensor over earlier instruments were:

- *Highly sensitive electronic displacement sensing and force feedback utilized in the meter design enabling the development of a gravity sensor that was much less complicated and easier to build than existing instruments that were based on microscopes, finely tuned mechanisms and complicated systems of screws and levers.*
- *Automatic electronic feedback making the meter easier to align and read and less prone to operator errors.*
- *Eliminating the requirement for mechanical feedthroughs, thereby ensuring the chamber containing the sensor in the Flinders gravimeter had better sealing and temperature control, further simplifying the mechanical design.*

In 1984, Dr Hugill took up a position as project leader for the development of a new gravimeter at Scintrex Ltd in Canada. Scintrex's quartz technology and data acquisition expertise was used to build on the Flinders gravimeter design to produce the CG-3 Autograv, the first of a new generation of gravimeters, the latest of which being the CG-6.

Since being released in 1987, the CG-3 and its successor, the CG-5, have sold over 2000 units. Flinders University received one of the first CG-3 gravimeters in exchange for providing Scintrex with the Flinders gravimeter for use in the development project.

Environmental geophysics

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Sometimes it is not the latest and greatest, or the most fantastic, expensive and complicated geophysics that find economic viability. In the environmental market it is more often geophysics that is focused on the needs of the client that is most viable (nothing too profound there – but not always done). In our age of cheap memory, reliable GPS and the advent of the Internet of Things (IoT), 'focused' geophysics is even more important. This month I have asked Dave Allen of Groundwater Imaging (http://groundwaterimaging.com.au) to put together some of his thoughts based on his years of working as a practicing geophysicist in the environmental field, both developing instrumentation and then running surveys. Much of his work is with farmers, helping identify issues on their land, often to improve their irrigation infrastructure. In this article Dave talks about developments that he has made on the systems that he builds and runs to collect data over canals, and other watercourses. Dave also designs, builds and runs shallow-TEM systems for farm fields, wetlands, etc., and has applied the same improvement principles to these as well (worth looking at on his website).

Here is what Dave has to say:

Focused geophysics
(from the perspective of an applied environmental geophysicist)

Dave Allen
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My experience applying electrical geophysics to the problem of imaging beneath watercourses has taught me that simple and appropriate geophysics 'sells'. Quite a few of my clients really have relatively simple questions. A very common one is: where am I losing water under my irrigation canals? This is not one of the 'deep' hydrogeological problems that I set out to solve when, many years ago, I started my PhD research on imaging groundwater salinity and groundwater-river connectivity using electrical techniques. Sure, the relatively complex data acquisitions systems that I developed were useful to research-oriented hydrogeologists studying river-groundwater connectivity but, as my consultancy developed, I saw a much wider application of simpler (but more focussed) systems to the problems that farmers and other land-users had.

The process of 'simplification' is quite challenging. The innovations that I experimented with had to make the data that I collected useful to my clients, but couldn't actually make the data collection process more expensive. Additionally, there was the problem of letting the market know about the improvements that I had made. Many of my potential clients were relatively unaware of the obvious (to all of us?) advantages of using geophysical data. Additionally, they required geophysical data sets that provide information they can interpret without a large amount of training. Obviously the geophysicist needs to interact with potential clients at an appropriate level; often the solutions that are suggested to clients may achieve results that they never thought possible.

simple and appropriate geophysics 'sells'

My work on environmental geophysics started with my Honours work in 1991 on towed array resistivity. It continued in 2002 as I started constructing waterborne geo-electric streamers as part of my PhD research. My first attempts at array construction were big, heavy, floating streamers using conventional dipole-dipole arrays that were deployed with large receiver systems and transmitter equipment that needed hundreds of volts of input and put out several amps. The transmitter system required power from not one but two truck batteries, making field logistics literally horrific. Additionally, data quality was not as good as it could be – but a start was made. I was using state-of-the-art, off-the-shelf geophysical equipment and software that were not really appropriate for the problems I was working on; ultimately it was just not marketable. Over the years 'simplification' of equipment and software has resulted in the development of systems suitable for imaging sediments under irrigation canals, drains, reservoirs and general river surveys.

Some of the refinements that I have made to improve the data collection system include:

- replacing the conventional dipole-dipole array that I used at first (based on the needs of mineral exploration) with an exponentially spaced bipole array to improve SNR and data distribution (this exponential array refers to variable spacing that uses shorter spaced receiver electrodes for electrodes collecting shallow data, and larger spacings for deeper data);

- optimising the array – with better spacing it was possible to use fewer channels to collect the same data as with the larger less optimal arrays;
- identifying and minimising noise sourced from streaming potential;
- setting up the cable so that the array is now often dragged along the watercourse bottom. This improves the resolution of the water-sediment interface and also improves thickness estimates of (what I like to call) the sludge layer.

I have also worked on improving the robustness of the system, making it stronger, easier to move and less likely to break in the field. Some of these improvements are:

- the streamer is now constructed of a simpler, multi-channel (thick wire) copper conductor cable with moulded-on electrodes (much stronger and more robust than some of the network cable variations that were used originally);
- new receiver/transmitter electronics that were tested until a compact solution providing enough power for the more efficient array configuration described above was developed (Figure 1 shows the significantly smaller receiver/transmitter unit);
- instead of requiring a boat to tow the electronics and array, the new, smaller electronics package is built into a waterproof floating enclosure that can be pulled by one person using ropes from canal banks, making the entire setup easier to drag over the obstacles that are frequently found in canals. The unit can still be towed by boat where appropriate (Figure 2 shows the unit being dragged past a typical canal obstacle – a small irrigation regulator);
- a set of dedicated software and 1D inversion code was written to robustly and efficiently process the resistivity data collected by this system (1D modelling is quite fast and provides sufficient information for nearly all of the data that are collected);
- code has also been written to display, in '3D' on Google Earth, imagery of the inversion results that clients could understand and geo-locate with reference to features that they are familiar with on their properties (Figure 3). Using their knowledge of the soil and other conditions on their farms, along with their own observations of canal water loss, they could interpret the geophysical data and understand what it was telling them – again integrating their own knowledge with sensible presentation of the data.

Geophysics focused on solving real world problems simply, and in a cost-effective fashion…

I am constantly trying to improve the usefulness of the data that is provided to my farming (and other) clients. For example, I am presently working on integrating (and simplifying) data collected using a commercially available full-waveform sonar to provide additional information on sediment firmness at the base of canals, information that may be useful when canal leaks are being repaired and earthmoving contractors are working in the drained canal. Geophysics focused on solving real world problems simply, and in a cost-effective fashion, is what keeps my business viable.

Figure 1. *New receiver/transmitter electronics package being towed along an irrigation canal. The electrode array is being towed along the canal bottom and is not visible.*

Figure 2. *Electronics and array being dragged through typical canal obstacle. Small regulators, like these, and other obstacles may occur every 100 m along a typical canal.*

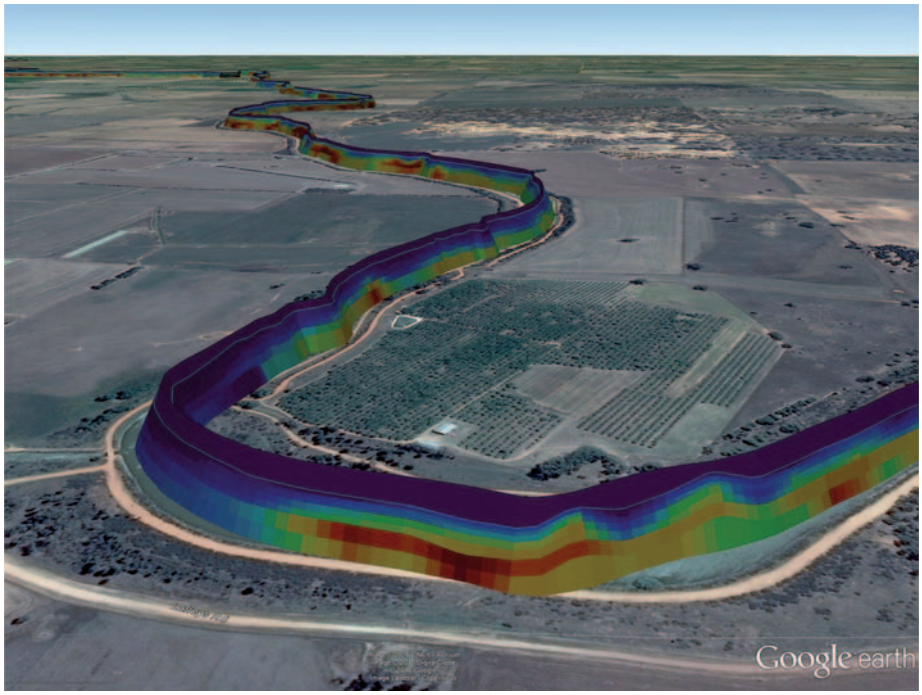

Figure 3. *Electrical resistivity projected along a canal. The aqua line represents the canal bed. Reds in the sections are conductive, while purples are resistive. Indurated bedrock, weathered eluvium, and possibly windblown sand, are inferred to be representative of the materials under this canal.*

Minerals geophysics

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Mineral geophysics – a grumble, some good news, and GiGi

I started writing this contribution on my early morning flight at the start of a three week work stint on site. The exploration industry may have turned a corner; commodity prices are on the rise and geophysical contractors are reporting increased activity. Despite this somewhat rosier outlook, I felt a bit disgruntled. The pre-dawn departure time aside, one source of my discontent was the apparent widespread lack of knowledge of, and public indifference to, the science behind the technology that has had, and continues to have, an enormous impact on our everyday lives.

The contribution of the resource industry is, at best, grudgingly acknowledged in some quarters, yet it is vital to our well-being. Many aspects of the way our industry uses science are brilliant, but they are not well publicised. Is it a lack of interest and awareness, for which our industry must take some of the blame, or wilful ignorance? This is a theme I'd like to develop in future issues, and I'd welcome your thoughts. Perhaps the situation is not as bleak as it seems to me.

The particular aspect of scientific endeavour that I will touch on in this issue is how cross-pollination of ideas and experience from other sciences, and from other branches within the geosciences, has benefitted mineral geophysics. There has been a reverse flow of ideas too. I won't include any of the numerous and ingenious adaptions of the principles of physics and mathematical techniques to mineral geophysics, but focus on a few practical examples.

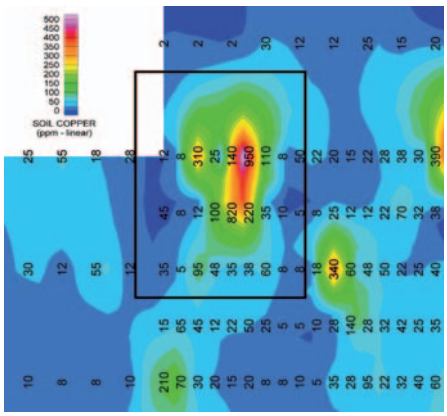
The oil exploration industry developed down-hole logging, some tools being quite specific to industry needs, others more general in nature. The use of nuclear physics to measure density (through gamma ray absorption) and porosity (through neutron capture by hydrogen) has always struck me as being particularly ingenious. Inspired by the oil industry usage, mineral geophysics now utilises borehole-logging to measure a wide range of physical properties of interest. And, arguably, our use of boreholes to position energy sources and/or geophysical sensors for 3D bore-hole based surveys surpasses current practice in the oil industry.

Refraction seismics has a history of usage in engineering and mineral exploration, but reflection seismics, once the exclusive domain of the oil exploration industry, is increasingly being trialled in hard rock exploration. Geological environments encountered in mineral exploration can be dramatically different to those in oil and gas; particularly in terms of the dominance of steeply-dipping disruptive structures and irregular rock boundaries over well-defined, near-horizontal reflectors. Modern 3D seismic survey design and processing is looking to address this.

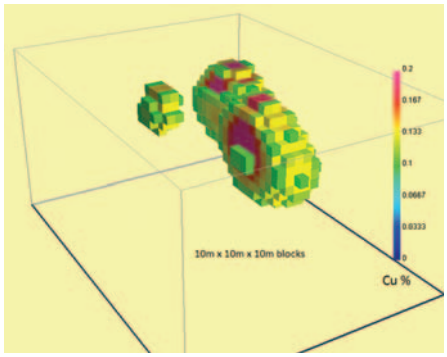
In environmental, engineering and archaeological geophysics computer controlled systems using one multi-electrode array for both transmitting and receiving are now used to efficiently conduct detailed electrical surveys. Adaptions would be needed to cope with higher power outputs used in mineral exploration, and there is a need for non-polarisable electrodes for IP measurements, but the technique could address the under-sampling that plagues many conventional mineral exploration IP-resistivity surveys. And who knows, the ability to record readings from a myriad of non-conventional arrays may give us further insights into inversion processes.

Finally, in keeping with the cross-pollination theme, I thought I'd help out our geochemical brethren with a geophysical contribution. I've named it GiGi* and I reckon it will revolutionise geochemical data presentation. GiGi inputs geochemical survey data into 3D magnetic inversion software, uses 10 000 (ppm to percentage) as the inducing field and, hey presto, generates a block model of metal grade – a veritable virtual orebody. I used published government geochemical data in my trial (see results below) to give the procedure more gravitas. Exact processing details must, of course, remain confidential, and I haven't actually got around to testing the concept against drilling, but never mind, it looks glossy on paper.

I leave you to decide whether this analysis might be taking geophysical processing just a little bit too far out of context!



Turn this….



into this!

*Geophysically inspired Geochemical inversion.

Seismic window

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Seismic resolution

Seismic resolution is a term that is often misunderstood, but it is quite a simple concept that has its origins in physics. Resolution is defined as the ability to separate two features that are very close together, or to show two features as separate rather than blended together. In optical physics the Rayleigh criterion defines the minimum resolvable detail, and it is half a wavelength. For seismic data the limit of resolution is the tuning thickness, which is a quarter of a wavelength (because the energy travels through the layer twice). At this separation the reflection from one event and the first side lobe of the preceding or following event are aligned, and only one reflection is seen. My own experience demonstrates how seismic resolution is commonly misunderstood.

First, I often hear the term 'sub-seismic' in meetings, usually when an imaginary fault is randomly placed on a map in order to close a prospect or to explain the strange performance of a production well. When pressed, the user of the term usually describes the fault as having a throw less than tuning thickness and, therefore, below seismic resolution. Using this logic, and if it is assumed that the dominant wavelength is 60 m, faults with a throw of less than 15 m would be sub-seismic. Actually sub-seismic faults are much smaller.

Second, I was lucky enough to spend a few days on a field trip along the Taranaki coast in New Zealand earlier this year. Here the cliffs reveal sediments deposited in environments ranging from deep water fans and slope fans to upper slope feeder channels. In the shallower environments there were channels everywhere and, while discussing the inadequacies of seismic data, someone remarked that most of the channels were less than 15 m and would not be seen on seismic.

Figures 1 and 2 show two channels in the cliff face. The channel in Figure 1 is quite large, maybe 100 m across and up to 5 m deep. Figure 2 shows a much smaller channel about 1 m deep. Both these channels were deposited in a much larger channel system that is 2 km across. Therefore, at least three channels are present, varying in size by an order of magnitude or two. Which, if any, of these three channels can be detected by seismic?

If the data has a high signal to noise ratio and high frequency content I would be tempted to say maybe all of them. This gets to the point of this article. Detection and resolution are not the same thing and semantics are important. Something below seismic resolution can still be detected and identified as a channel, even if we are unable to determine the thickness. Figure 1 shows a quarter wavelength for a typical seismic wavelet (60 m wavelength). This is much larger than the channel so the top and base reflections would not be resolved. But, the channel is detectable and would appear as a change of seismic amplitude, possibly meandering across the area of interest.

Detection can be described as sensing or measuring the presence of something. For seismic data the limit of detection is often quoted as 1/30th of a wavelength, which in this example is 2 m (I suggest it would have to be exceptional data to detect the small channel in Figure 2). The same limits are similar for faults. There are many attributes that use phase to identify faults and a 15 degree lateral change of phase is visually discernible by most interpreters. Computers can probably pick a 10 degree difference, which is 1/36th of a wavelength. So, using this logic, sub-seismic faults are less than 2 m.

Two metres is quite small, but the fine scale variations in geology are much smaller than the seismic method can measure. There can be quite rapid changes in geology over very short distances, and I found the real value in the Taranaki field trip was the recognition that geology can change rapidly both vertically and horizontally, and how much of this detail is not captured by seismic data.

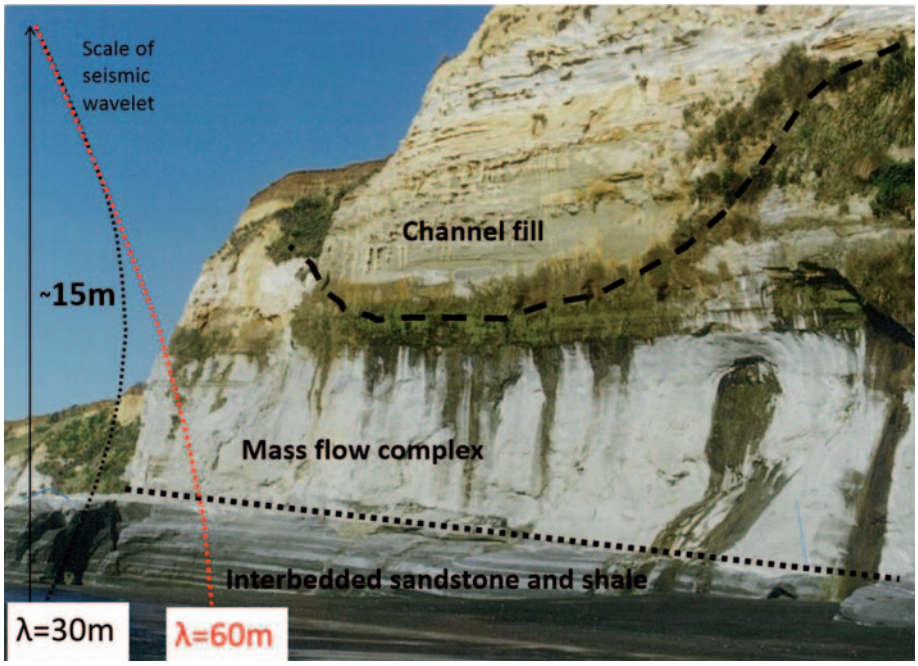


Figure 1. *This channel in the Taranaki cliff face is about 100 m across and 5 m deep and would be detected by seismic, but the top and base of the channel would probably not be resolved in typical seismic (represented by the red curve on the left).*

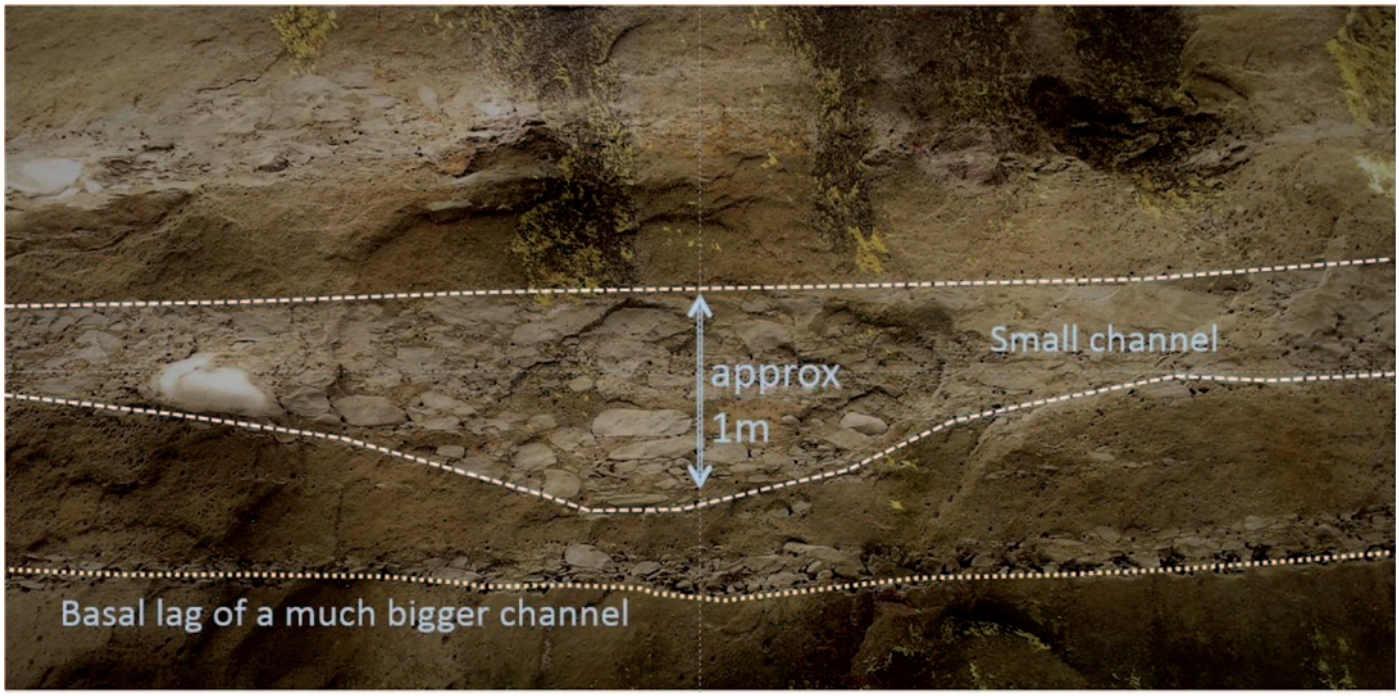
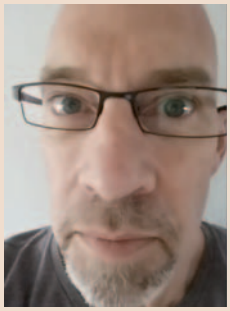


Figure 2. *A small channel approximately 1 m deep. Seismic data would have to be exceptional to detect this feature, which may be important in modelling a reservoir.*

Webwaves



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Refining the ASEG website

This edition of Webwaves touches on refinements to the Virtual Museum and the Contractor's database, as well as some of the benefits of making workshop (or other) material available on the ASEG website.

As a first step, Ian James has added many contractors to the contractor database, mostly from Africa. In coming months we (... Ian) will be working so that the process of searching for a contractor is much easier. This has taken much longer than anticipated, mostly because of the inconsistencies in the information provided. However, the process is on the home stretch.

Of course, additions to the contractor database can be made by emailing details to webmaster@aseg.org.au.

Accompanying Brian Spies' article in this issue of *Preview* is a new exhibit in the Virtual Museum. This latest addition is the MPPO-1, and it may be viewed at https://www.aseg.org.au/equipment-museum/mppo-1.

The central point is that with an effort that pales in comparison to that of setting up a workshop or assembling a talk, the material can be disseminated much more widely than a conference workshop

Material from another article in this issue (Near surface passive seismic surveying for mineral exploration, environmental and engineering applications: Notes on the 2016 ASEG-AIG-PESA conference workshop) was made available late in 2016 at https://www.aseg.org.au/workshop-proceedings. Figure 1 shows a Google Analytics summary of the page since its creation. At the time of writing this page has been viewed by 81 unique users. The majority of these views occurred soon after Members were notified of its existence in a news item in November 2016, and there has been the odd spike in viewing since then. Investigation of users' behaviour on the website suggests that provision of a direct link to workshop material makes for easy access, as for some users this page was their first view on the site. The website and the current PV article have allowed dissemination of material presented to 46 workshop participants, a leverage of around 1.75:1.

The central point is that with an effort that pales in comparison to that of setting up a workshop or assembling a talk, the material can be disseminated much more widely than a conference (or other) workshop. Organisers benefit because of greater interest in their work. Presenters benefit because more people can examine material they put together. Members benefit because even though they may not have been able to attend the workshop, they can avail themselves of high-level summaries. The ASEG benefits from increased workshop and conference attendance. Indeed, it is difficult to see a downside to making material available post-workshop. Space for presentations is unlikely to be an issue, and it is likely that other concerns, perhaps around confidentiality or timeliness, can be addressed to the satisfaction of all parties. Therefore, when putting together a workshop, please consider making workshop material available to a wider audience.

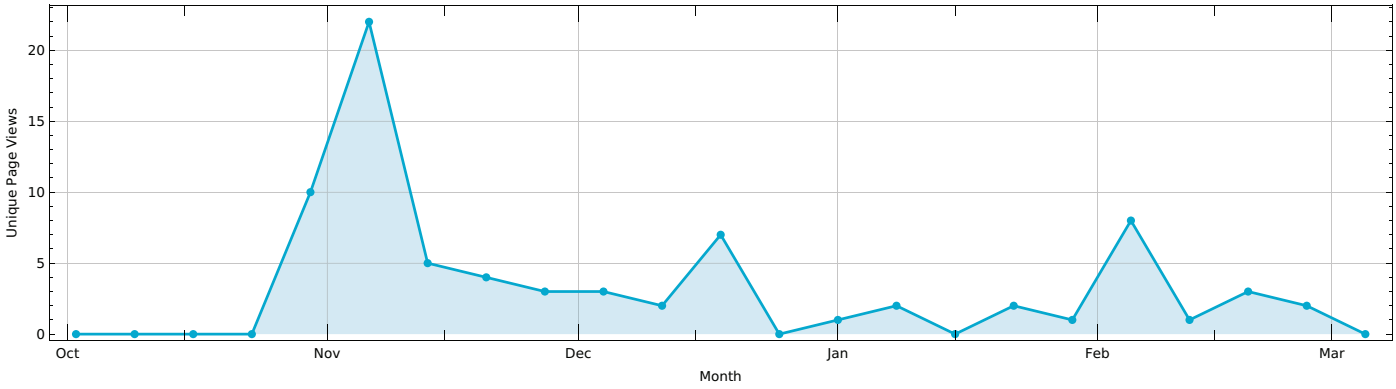
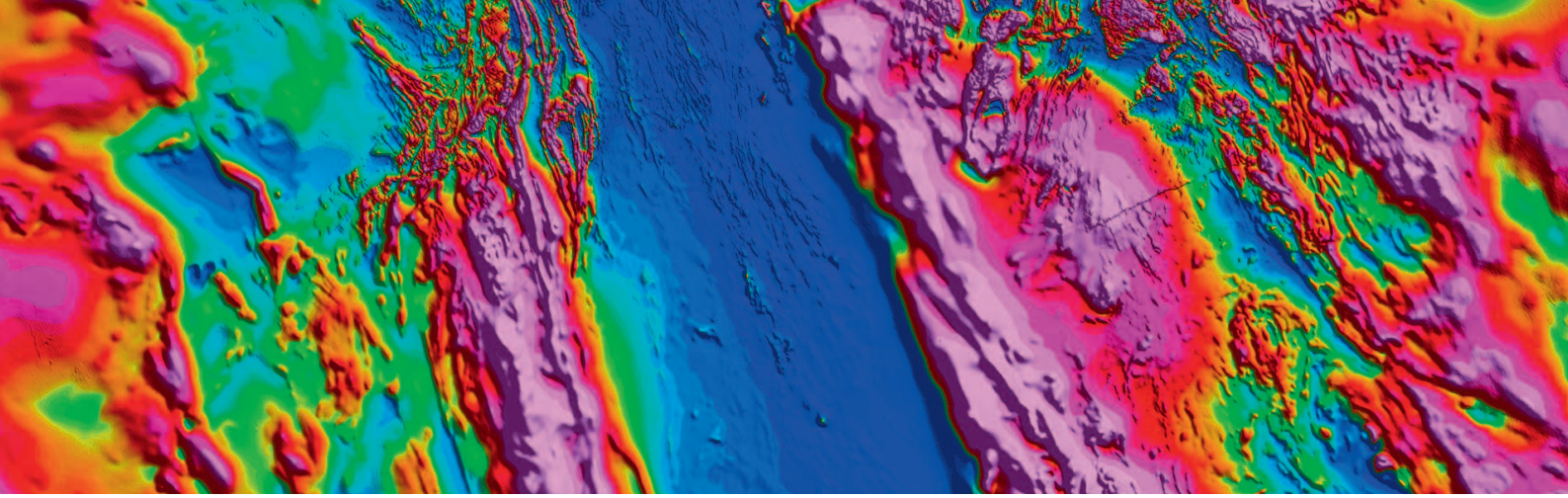
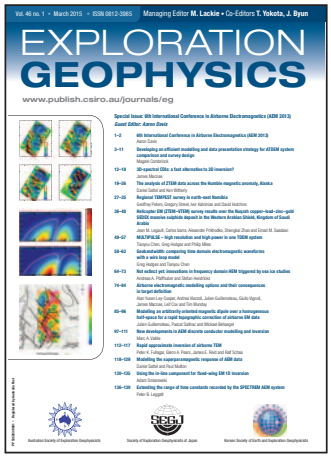


Figure 1. *Views of the website page associated with the Adelaide workshop. Of the 137 total views, 87 are from unique URLs suggesting that the website was able to leverage presentation of the material by around 1.75:1.*



Exploration Geophysics

The Journal of the Australian Society of Exploration Geophysicists



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

Preview

The Magazine of the Australian Society of Exploration Geophysicists

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

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Data trends

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Idle resources

Who would have thought that people would be willing to pay to sleep on an air mattress in a complete stranger's house when they are on a business trip? Let's extend that thinking and really ponder if anyone, even the AirBNB founders themselves, would have thought that their company would be valued at more than any other major hotel chain in the world, despite having almost no real estate of their own?

Uber, of course, has taken the same path. Getting picked up by a complete stranger at 2 am and driven to your home via the kebab shop? I don't think so. But look who is the largest taxi fleet in the world – and they don't really even own any taxis!

Recently, I have seen offerings where if you need a photographer for a photo shoot, a designer for a logo, or some marriage counselling at 1 am, there is a site to go to get what you need done. All of these businesses are using the general idea that there are idle resources lying about that can be put to good, profitable use as long as these resources can be connected to the demand stream – although my gut tells me that most marriage counsellors are already at 110% utilisation as it is. All we have to do is connect the needs of the consumer with the idle resource and *voilà* – a new industry is born.

I started to wonder why the geophysical industry has not dipped its toes in this water, or even ventured a little deeper, like right up to its metaphorical thigh!

Here are some features of the oil and gas industry:

- A lot of unemployed geophysicists and geologists.
- A lot of dry docked seismic vessels.
- A tonne of seismic acquisition, gravity and magnetic recording equipment in storage sheds waiting for the next boom.
- Major oil companies interested in getting more data, but not so interested in paying much for it.

So the industry has idle resources, idle capital and an idle industry in general.

I started to wonder why the geophysical industry has not dipped its toes in this water, or even ventured a little deeper, like right up to its metaphorical thigh!

The founders of some of the largest companies in the world have found a way to marry idle resources with the needs of consumers to disrupt and transform industries in ways we never thought possible.

****

An hour ago, a cargo ship destined for Trinidad left the port of Fremantle, Western Australia carrying 26 tonnes of Vegemite (Trinidad is the second largest market for Vegemite). On deck is a crew of 12 including a few engineers, a cook, general maintenance crew, a navigator and a happy go lucky skipper. There are also six empty cabins on board. At the same time that this ship departs, Bazza, a sleepy geophysicist has just arrived home from his nightly Uber shift carrying passengers from local night clubs to their homes in the outer suburbs of Perth.

During his nightly shift Bazza found time to finally read the last chapter of the 1987 book by Dr Oz Yilmaz entitled – *Seismic Data Processing*, published through the Society of Exploration Geophysicists (he is the first one to ever read the whole book). Bazza has not worked in the oil sector for 9 months but has high hopes of landing a job soon.

Back on board, the navigator of the ship plots a course to Trinidad across the Indian Ocean with a stop in Cape Town to drop off 60 000 pairs of Ugg boots, and then across the Atlantic up to the Gulf of Paria to the final destination of the Port of Spain, on the west coast of Trinidad.

On this route, the ship will pass over thousands of miles of unexplored ocean where no seismic, gravity or magnetics have ever been recorded.

On board, the ship's cook plans his usual comfort meal of meatloaf, corn on the cob, chips and hot gravy. Tears stream down his face as he mindlessly dices an onion for the meatloaf. He dreams of one day getting off the ship and starting his own business as an Uber driver.

Meanwhile, after submitting three more resumes, Bazza lays on his couch and grabs the remote. He plans to binge watch the entire first season of 'Top Chef' before his next shift as he has long since had a passion for cooking.

The dry docks and equipment storage units remain quiet. A senior geophysicist – come security guard – watches over the desolate facilities. He spends his hours trying to figure out a way to make use of all this idle equipment, eventually falling asleep. He dreams of a holiday in a remote location – somewhere like Trinidad.

Time domain EM comes to Australia: the early history of the MPPO-1

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Australia, with its extensive ancient and weathered terrain, has long been a testing ground for geophysics. The Imperial Geophysical Experimental Survey (I.G.E.S) carried out 18 months of fieldwork in Australia during 1929–30 'for the purpose of conducting thorough trials of the principal geophysical methods to determine their practical value and limitations under a variety of geological conditions' (Broughton Edge and Laby, 1931). Between 1935 and 1940 the Aerial, Geological and Geophysical Survey of Northern Australia (AGGSNA) used the latest aerial, geological and geophysical techniques to map and explore remote areas of Northern Territory and Queensland, and this led to the establishment of the Bureau of Mineral Resources, Geology and Geophysics (BMR) in 1946. For more than half a century Australia has proved a challenging and fruitful frontier for testing the latest geophysical technology.

Magnetic, gravity and electrical methods were widely used and well understood, but electromagnetics (EM), which worked so well in Scandinavia and Canada, continued to confound and disappoint when brought to Australia. These EM systems operated in the frequency domain, and measured the in-phase and out-of-phase response referenced to the transmitted primary sine wave. Operating at relatively high frequencies, and suitable for the highly resistive shield areas of Canada and Sweden, traditional EM systems were severely hampered by the thick conductive weathering that covered much of Australia and rendered the systems mostly ineffective.

That was until 1970–71, when two Australian geophysicists independently visited the USSR to learn of new techniques that had not yet reached the West[1]. The intrepid travellers, Hugh Rutter of Western Mining Corporation (WMC) and Elmer Sedmik of the BMR, reported back to their respective organisations about a new technique, transient electromagnetic (TEM), which might solve the problem of how to explore beneath Australia's regolith.

Canadian Tony Barringer, who attended a scientific conference in Russia in 1965 where he heard about the MPPO-1 (Les Starkey, pers. comm.), preceded Hugh and Elmer. Barringer was intimately familiar with time domain EM, having conceived the airborne INPUT (Induced pulse transient) system in 1956 while working for Selco Exploration. He tried to purchase an MPPO-1 instrument but to no avail – export of the MPPO-1 to non-communist countries was prohibited until the late 1960s.

Meanwhile, Newmont Exploration Ltd had been working on the theory of inductive transient techniques from as early as 1951, and had successfully tested their first Newmont EMP (EM pulse) system consisting of a large transmitter loop and roving receiver in Cyprus and South Africa. This large-loop system was brought to Australia in 1976 and remained in use until the mid-1980s.

These new techniques were developed and used under the strictest secrecy, lest companies lose their competitive edge, and little information permeated into the outside world.

Back in Australia, the sole agent with a license to sell Russian instruments, such as the MPPO-1, was Jack Zonnerville of the Industrial and Scientific Supply Company. Orders were delivered on six monthly intervals, with much paperwork involved. The first MPPO-1 unit to arrive in Australia was for Geotechnics (Les Starkey, pers. comm.). The unit ordered in 1969 was destroyed by fire in transit in Holland or Belgium, and a new order was finally received in 1971. Field tests were conducted over known ore bodies in the ensuing months. Western Mining staff were so impressed with the results that they bought two systems. Other companies purchasing an MPPO-1 included LA Richardson and Associates in the early 1970s. Aquitaine Australia Minerals Pty Ltd tested an MPPO-1 at the Steeple Hill massive sulphide deposit, 100 km east of Kalgoorlie (Gunn and Brooke, 1978).

The arrival of the MPPO-1 at the BMR

When I arrived at the Bureau of Mineral Resources, Geology and Geophysics (BMR) in 1970, as a new cadet in the Metalliferous Branch (along with Peter Gidley, Ian Hone and Jovan Silic), my supervisor Elmer Sedmik told me that my job would be to take charge of a new EM system from Russia, mysteriously called the 'MPP0-1', which would arrive in the following year. I sat down to read all that I could on transient electromagnetics, starting with the classic 1967 booklet by Velikin and Bulgakov, loosely translated as 'Inductive electrical prospecting by the method of transient processes with combined source and receiver' (Figure 1). 'MPP' stood for 'Metod perekhodnykh protsessov', translated as 'method of transient processes'. The '0' referred to the single loop configuration. Later models MPP-3, MPP-4 involved separate source and receivers, including down-hole versions.

The BMR's MPPO-1 arrived in April 1972. The BMR technical officers set to work to try and understand the electronics so that

[1]Reports of developments in USSR geophysics had begun to reach the West in the late 1960s, e.g. via George Keller in the introduction to Van'yan et al. (1967) and via a U.S. Exchange Delegation (Keller et al., 1966). Keller's report focused on Van'yan's deep long-offset TEM sounding, and the US delegation was petroleum oriented.

they could upgrade components and conduct repairs if necessary. The transmitter was powered by expensive but effective 6V rechargeable silver-zinc batteries housed in a small box (Figure 2). This unit proved to be quite reliable, with replacement batteries readily available in the West.

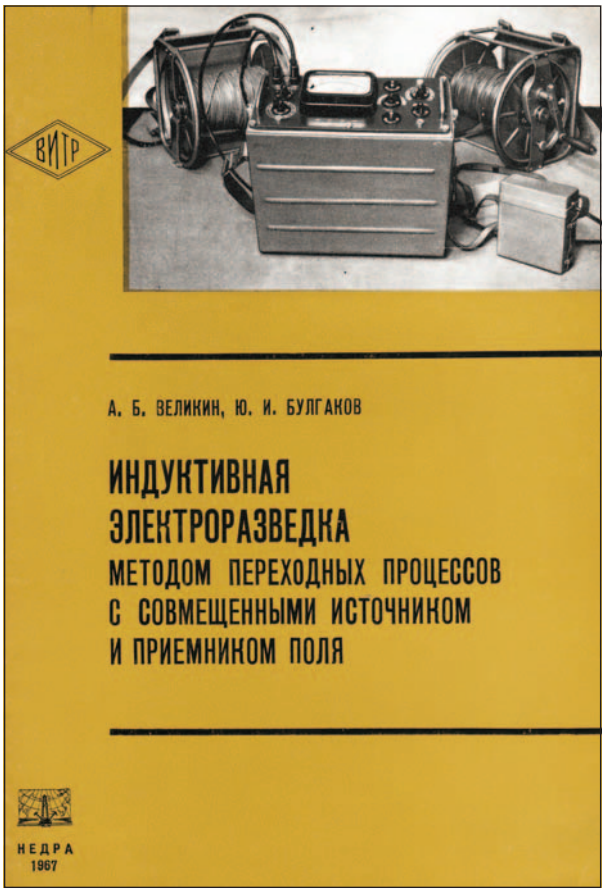

Figure 1. *Cover of booklet by Velikin and Bulgakov (1967), with a photo of the MPPO-1 receiver (centre) and transmitter (right). The breast-mounted cable reels contains wire used to make square loops ranging from 10 m to 200 m square.*

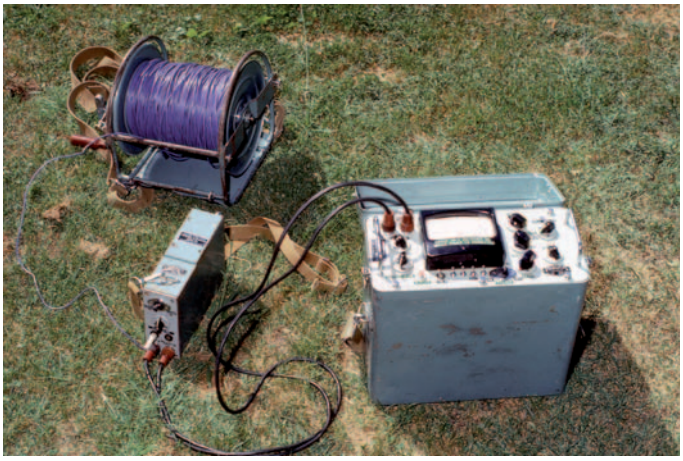

Figure 2. *MPPO-1 transmitter pack (lower left) and receiver unit (right). The main settings on the receiver are selection of transient decay time (bottom left) ranging from 1 ms to 15 ms, amplification (mid-right), and two settings of noise damping (bottom right). The transmitter sends 20-ms wide rectangular pulses at the rate of 18 Hz into the combined transmitter/receiver loop.*

The main receiver unit was more difficult to reverse engineer. The most complex aspect of the MPPO-1 was that the same loop of wire was used for transmitting and receiving. A 2-amp, 20-ms wide square waveform was transmitted into a loop of wire laid on the ground and abruptly terminated in a few tens of microseconds. The circuitry was then switched to a sensitive set of amplifiers, which recorded the voltage in the same loop of wire induced by the decay of secondary currents from the earth. Quite sophisticated electronics is required to measure microvolt-level signals in the same wire loop that a few microseconds earlier was subject to hundreds of volts in back-EMF generated as the transmitter current was terminated.

The circuitry contained a number of unique features. Seven rechargeable cylindrical nickel-cadmium battery packs provided power to separate parts of the receiver circuitry to prevent ground loops and cross-interference. Russian transistors were quite leaky by Western standards, but their performance was boosted by ancillary circuits that counteracted their inherent limitations. Each time the BMR technicians attempted to 'improve' a component or part of circuitry they marvelled at the skills of the original designers in making the instrument work so well. Indeed, no other manufacturer has been able to replicate a functional system that uses a single loop of wire for transmitting and receiving. One addition the BMR technicians did make was to add two early-time channels of 0.57 ms and 0.79 ms. WMC added a box on the side with additional circuitry which could utilise higher voltage batteries, and thus higher transmit current, and increased the number of time windows (Figure 3).

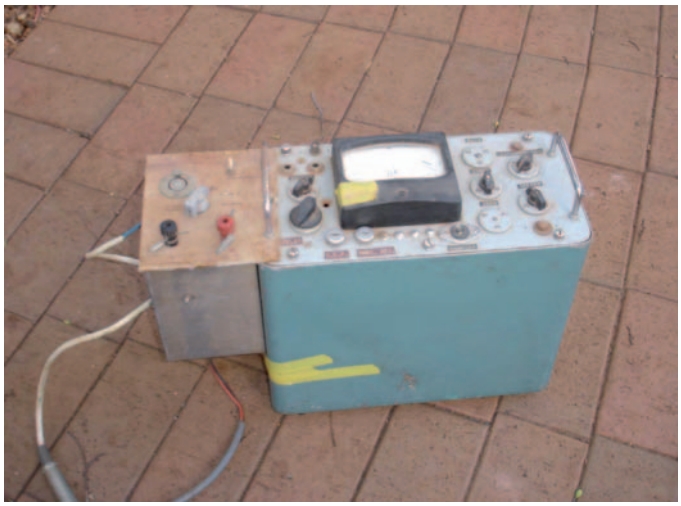

Figure 3. *MPPO-1 modified by WMC with larger battery pack to provide higher transmitter currents. This instrument now resides in the ASEG Museum (courtesy John Coggon).*

First field tests

The BMR conducted its first field campaign using the MPPO-1 in Northern Australia from August to October 1972 (Figure 4). The areas selected for test surveys included iron deposits at Tennant Creek and conductive shale and gossan at Rum Jungle, Mary River and Cloncurry (Spies, 1974a). These surveys tested loop sizes from 10 m to 200 m in a variety of terrains, with comparisons with other techniques.

The 1973 field season returned to Rum Jungle and Mt Isa/Cloncurry (Hone and Spies, 1974). These investigations included

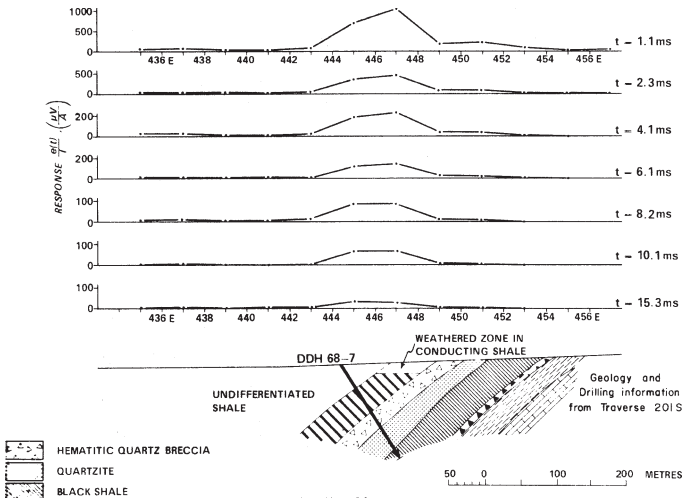

Figure 4. *First BMR MPPO-1 results, 1972 in the Rum Jungle, Mt Minza area, showing a strong anomaly over a dipping black shale. Note the high data quality.*

depth sounding using different loop sizes, and trials of a figure-of-eight configuration ('dual loop'), to enhance the response of vertical conductors and reduce that of horizontal conductors. At Cloncurry anomalously small or negative responses were recorded over conductive shale. It was postulated that these responses could be caused by IP effects. The sign reversals were subsequently replicated by a prototype SIROTEM instrument.

Elura – A prime geophysical test site

The Elura zinc-lead-silver deposit was discovered by Electrolytic Zinc Company of Australasia (EZ) at the extremities of an aeromagnetic survey (Davis 1980). Following drilling to confirm the viability of the deposit, EZ made the area available to the BMR and other parties who carried out an extensive series of surveys with a wide variety of techniques between 1974 and 1979. The MPPO-1 instrumentation was the first TEM trialled at Elura, in December 1974 (Hone, 1976), and 'the results were encouraging'. In contrast, other EM methods tested over the deposit in early years, including airborne INPUT and ground Crone (loop-loop) PEM, gave disappointing results (Davis, 1980). Extensive EM surveys were carried out between 1974 and 1979, these surveys included detailed comparisons between the MPPO-1 and SIROTEM, PEM and others.

A comparison of MPPO-1 data over the Elura deposit from the 1974 survey and a SIROTEM profile in 1978 (Figure 5) clearly shows the advantages of the modern technology, with much longer averaging times and sferics rejection.

The ASEG convened an Elura Symposium in 1980 and published a comprehensive set of papers in a special issue of *Exploration Geophysics* (Emerson, 1980).

Elura presented a unique opportunity to test a range of TEM instruments with different loop configurations, including small multiturn loops, separated loops and dual loops. Anomalous responses could be tested and retested, with loops raised off the ground, or transmitting and receiving loops displaced by varying distances. These tests led to rapid advances in the understanding that viscous magnetisation due to maghemite in the soil could adversely affect TEM readings with combined transmitter and

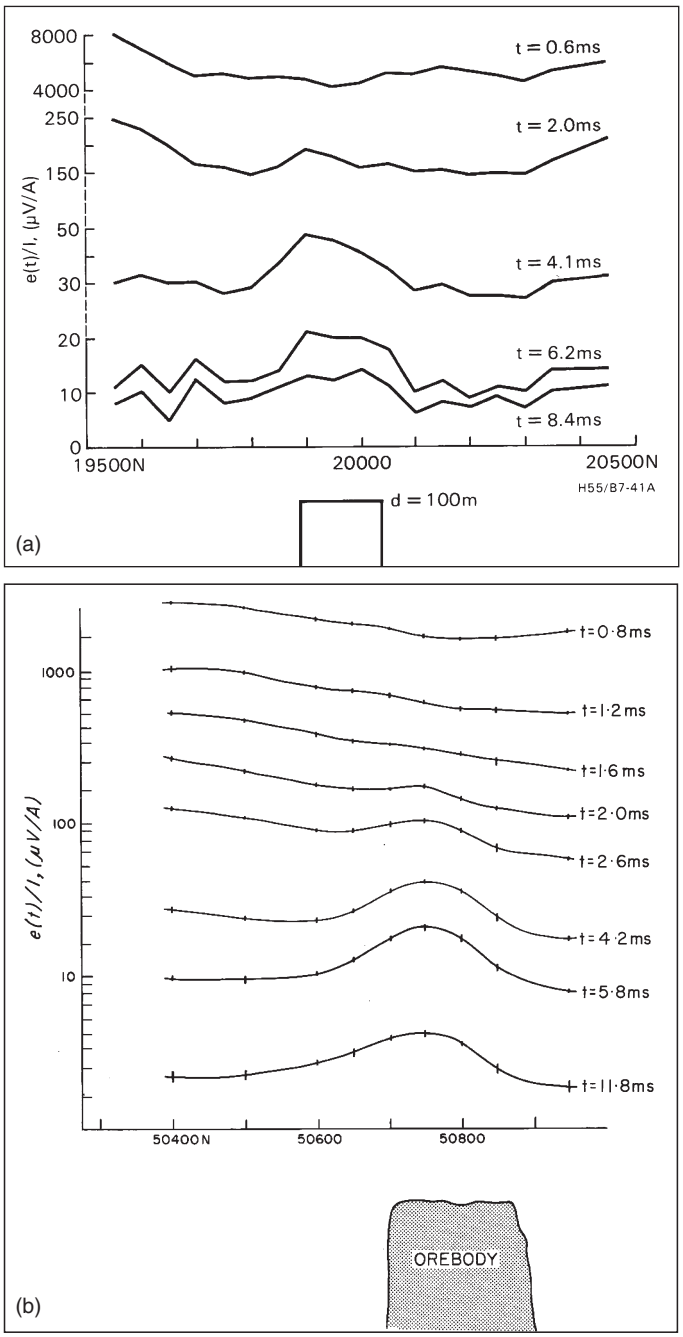

Figure 5. *Comparison of MPPO-1 (1974) (a) and SIROTEM (1978) (b) results over Elura (Spies, 1980). The orebody is evident at sample times later than 2 ms.*

receiver unless large loop sizes or displaced receiving and receiving loops were used, as described later in this paper.

WMC's Benambra VHMS discoveries

The volcanic-hosted massive sulphide (VHMS) deposits at Woodlawn and Captains Flat in NSW led Western Mining Corporation (WMC) to explore for comparable deposits in the Lachlan Fold Belt in Victoria in the late 1970s. Regional aeromagnetic and radiometric surveys, followed by helicopter EM, ground geochemistry, magnetics, IP and Crone shoot-back EM were carried out in the Benambra area, but exploratory drill holes failed to intersect significant mineralisation (Rajagopalan and Haydon, 1999).

WMC knew that TEM was likely to be more effective than IP in detecting massive sulphides, but difficult terrain condition delayed their use. Failure with IP, dip-angle EM and airborne EM prompted WMC to re-evaluate the use of TEM. In 1977–78, WMC carried out field trials of the MPPO-1 in the Benambra area and found the rate of ground coverage to be better than expected, and quality of the data was encouraging.

Supervising geophysicist Don Esdale ran an MPPO-1 survey with 50 m loops at the Wilga prospect. A strong early-time anomaly was detected 150–200 m from the nearest geochemical anomaly and previous drillholes (Figure 6). Drilling of the MPPO-1 anomaly intersected 25 m of massive sulphides assaying 4.1% copper, 0.46% lead, 7.28% zinc and 31 g/t silver.

A larger 100 m loop was used for discovery of the Currawong deposit in 1979 (Figure 7). The availability of the SIROTEM system in the early 1980s allowed WMC to change from 100 m loop MPPO-1 surveys to 200 m loop SIROTEM surveys, increasing the depth of exploration. Later, the Geonics EM37 system and borehole EM were also used. The Wilga and Currawong zinc-copper orebodies are the largest base metal deposits discovered in Victoria.

WMC's MPPO-1 results from the Yilgarn Block are briefly described by Coggon (1978).

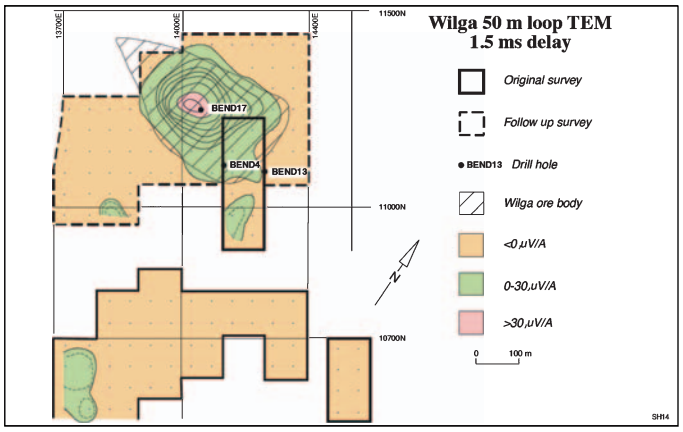

Figure 6. *Wilga 50 m loop, 1.5 ms. Selected drillholes and outline of the Wilga orebody (Rajagopalan and Haydon, 1999).*

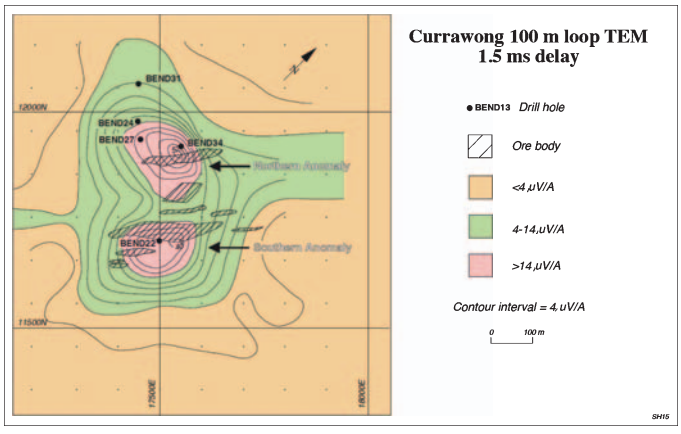

Figure 7. *Currawong 100 m loop, 1.5 ms. Selected drillholes and outline of the Currawong orebody (Rajagopalan and Haydon, 1999).*

Depth sounding

In addition to profiling for exploration, early studies with the MPPO-1 investigated the potential of TEM for depth sounding. Lee and Lewis (1974), amongst others, derived expressions for calculating layered-earth responses for TEM systems, and it was known that the depth of investigation increased with sample time according to the diffusion equation, rather than the loop size.

For instance, it was understood from theory that with the 20 ohm-m overburden present at Elura, the orebody at a depth of 70 m should be first visible at 2 ms. However, loop-loop TEM systems detected an anomaly at much earlier times. Grid coverage revealed the presence of a shallow north-south surficial conductive zone in the soil, which was the cause of the loop-loop anomaly. Theoretically it should have been possible to detect Elura with a small multiturn loop, but the TEM response obtained with this geometry was found to result in unexpected 1/t decay at late times. This anomalous response was later found to be caused by viscous magnetisation in the soil.

Further depth sounding experiments with MPPO-1 equipment were carried out at Pooncarie and Pirlta in western NSW in a test TEM survey conducted jointly by BMR and Macquarie University in November 1975.

The depth sounding experiments led to development of two-layer master curves for field interpretation (originally an internal CSIRO report; later published as Raiche and Spies, 1981). As quantitative interpretation methods advanced, it became easier to distinguish between true inductive responses that could be used for depth sounding, and anomalous responses due to viscous magnetisation and IP effects, particularly with smaller loops.

Model studies

Between field seasons, starting in 1973, the BMR's MPPO-1 was used extensively in scale model studies in BMR's basement to aid field interpretation. Multiturn loops ranging from ½ cm to 15 cm diameter were connected to the MPPO-1. A travelling carriage slowly moved the loop over the model and the output fed to a chart recorder (Figure 8). Models included Woodlawn and Gubberah Gossan with different loop geometries (Spies,

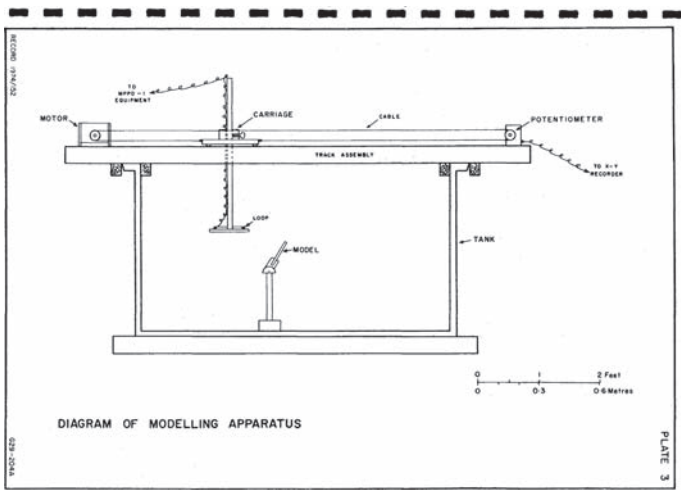

Figure 8. *Model setup at BMR using MPPO-1 (Spies, 1974b).*

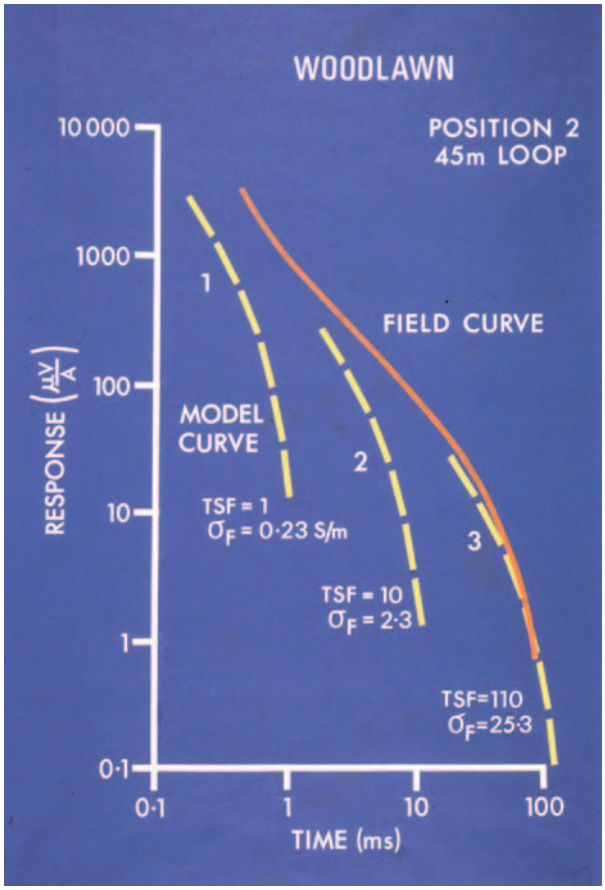

Figure 9. *Model and field results from Woodlawn. The average conductivity of the orebody was inferred to be 25 S/m (Spies, 1979).*

1974b, 1976) and tabular and dipping plates with the dual loop configuration (Spies, 1975).

Figure 9 shows a TEM decay curve obtained over the Woodlawn orebody with a 45 m loop (field curve) and data measured over a graphite model of the orebody (model curve). Using TEM scale modelling relations (Spies, 1977) with a time scaling factor (TSF) of 110, the average conductivity of the orebody was interpreted to be 25 S/m.

Other uses of the MPPO-1

Unexploded ordnance (UXO) presents a major problem in much of the world. The BMR was approached by the Commonwealth Department of Construction to see whether TEM could be used to detect UXO at the old Majura Field Firing Range area, Gungahlin, ACT, which was to be developed as a police drivers training centre. The MPPO-1 was tested here, as well at Holsworthy near Sydney, using small multi-turn loops over a series of buried shells and compared with gradient magnetometers (Hill, 1978).

The dual-loop configuration referred to earlier was also tested in an attempt to cancel out the ground response. The tests demonstrated that in many areas magnetic methods were overwhelmed by variations in the magnetic properties of the soil, whereas TEM was relatively insensitive to changes in magnetic susceptibility in the subsurface and could successfully detect UXO to a depth of up to 1 m (Figure 10). (A note to the reader: These tests should have suggested to any entrepreneur the potential of TEM metal detectors for gold fossicking and treasure hunters, a market currently worth over $200m pa. Airport security screening is now a $5b market)!

Figure 10. *Ordnance detection with small multiturn loops, Port Botany.*

The rise of SIROTEM

Inevitably, Aussie knowhow and ingenuity challenged the scientists and engineers at CSIRO to develop a fully digital version of the MPPO-1 using modern electronics and digital signal processing. The rise of SIROTEM is expertly reported by Henderson (2014). The CSIRO Division of Mineral Physics, under the leadership and vision of Dr Ken McCracken, started investigations soon after the MPPO-1's arrival in 1972, and launched an AMIRA-funded project in 1975. Early SIROTEM prototypes were compared with the BMR's MPPO-1 in Cloncurry in 1974, and later at Woodlawn and Elura. Competition between the BMR and CSIRO was intense but friendly, spurring a decade of advances in TEM instrumentation, modelling, inversion and regolith petrophysics, as well as dozens of publications in peer-reviewed journals and a handful of higher degrees.

Perhaps the best ongoing legacy of the MPPO-1 is that it is still the only ground TEM instrument designed to use a single wire loop for transmitting and receiving. The single loop setup was efficient to use in the field – no separate receiver to put in the centre of the loop, and no second loop wire.

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References

Broughton Edge, A. B., and Laby, T. H., 1931, The principles and practice of geophysical prospecting being the Report of the Imperial Geophysical Experimental Survey: Cambridge University Press.

Coggon, J., 1978, TEM results, Western Australia, *in* B. Braham, R. Haren, D. Lappi, H. Lemaire, D. Payne, A. Raiche, B. R. Spies, and K. Vozoff, *Lecture notes from the US-Australia electromagnetic workshop: Bull ASEG*, **9**, 2–33.

Davis, L. W., 1980, The discovery of Elura and a brief summary of subsequent geophysical tests at the deposit: *Exploration Geophysics*, **11**, 5–9. doi:10.1071/EG9804005

Emerson, D. W. (ed.), 1980, The geophysics of the Elura orebody: the proceedings of the Elura Symposium, Sydney 1980: *Exploration Geophysics*, **11**.

Gunn, P. J., and Brook, W. A., 1978, MPPO-1, Crone PEM, SP, ground magnetic, MIP and Turam data over drilled massive sulphide mineralisation at Steeple Hill, W.A.: *Exploration Geophysics* **9**, 164–167.

Henderson, R., 2014, SIROTEM – Australia's first locally invented TEM system*: Preview* no. 172, 39–46.

Hill, P. J., 1978, Detection of subsurface ordnance by magnetic and transient electromagnetic methods: *Bureau of Mineral Resources, Geology and Geophysics*, Record 1978/61.

Hone, I. G., 1976, Transient electromagnetic survey, Elura Prospect, Cobar, New South Wales. 1974: *Bureau of Mineral Resources, Geology and Geophysics*, Record 1976/99.

Hone, I. G., and Spies, B. R., 1974, Transient electromagnetic field tests, Northern Territory and Queensland, 1973: *Bureau of Mineral Resources, Geology and Geophysics*, Record 1974/191.

Keller, G. V., Caldwell, R. L., Dobrin, M. B., Holekamp, O. G., White, J. E., and Zietz, I., 1966, Tour of petroleum geophysics activities in the U.S.S.R.: *Geophysics*, **31**, 630–637. doi:10.1190/1.1439801

Lee, T., and Lewis, R., 1974, Transient EM response of a large loop on a layered Ground: *Geophysical Prospecting*, **22**, 430–444. doi:10.1111/j.1365-2478.1974.tb00097.x

Raiche, A. P., and Spies, B. R., 1981, Coincident loop transient electromagnetic master curves for interpretation of two-layer earths: *Geophysics* **46**, 53–64.

Rajagopalan, S., and Haydon, S. J., 1999, The Benambra volcanic hosted massive sulphide deposit, *in* A. J. Willocks, S. J. Haydon, M. W. Asten, and D. H. Moore, eds, *Geophysical signatures of base metal deposits in Victoria*: Geological Survey of Victoria Report 119 – ASEG Special Publication 11, 23–47.

Spies, B. R., 1974*a*, Transient electromagnetic field tests, NT and QLD, 1972: *Bureau of Mineral Resources, Geology and Geophysics*, Record 1974/167.

Spies, B. R., 1974*b*, Transient electromagnetic model studies, 1973: *Bureau of Mineral Resources, Geology and Geophysics*, Record 1974/152.

Spies, B. R., 1975, Transient electromagnetic model studies, 1974: *Bureau of Mineral Resources, Geology and Geophysics*, Record 1975/44.

Spies, B. R., 1976, The transient electromagnetic method in Australia: *BMR Journal of Australian Geology and Geophysics*, **1**, 23–32.

Spies, B. R., 1977, Absolute electromagnetic scale modelling and its use in interpretation of TEM response: *BMR Journal of Australian Geology and Geophysics*, **2**, 89–95.

Spies, B. R., 1979, Scale model studies of a transient electromagnetic prospecting system using an interactive minicomputer: *IEEE Trans Geoscience Electronics* **GE-17**, 25–33.

Spies, B. R., 1980, One-loop and two-loop TEM responses of the Elura deposit, Cobar, NSW: *Exploration Geophysics* **11**, 140–146.

Van'yan, L. L., Bobrovnikov, L. Z., Dadidov, V. M., Kuznetosov, A. N., Loshenitzina, V. L., Morozova, G. M., and Shtimmer, A. I. 1967, Electromagnetic depth soundings: Selected and translated by G. V. Keller, Consultants Bureau, New York.

Velikin A. B., Bulgakov Y. I., 1967, Induktivnaia elektrorazvedka metodom perekhodnykh protsessov s sovmeshennymi istochnikom i priemnikom polia (Inductive electrical prospecting by the method of transient processes with combined source and receiver): Nedra, Leningrad; 56 pp. (Can still be purchased from Amazon $32.50, 1 used, shipped from Uzbekistan).

Biography

Brian Spies has held senior research and management roles in the mineral, petroleum and environmental sectors in Australia and the USA, including Chief Research Scientist at CSIRO and Director of Physics at ANSTO. His current research interests include the nexus between water, energy, climate change and the Australian economy. Recent publications include 'Sustainable water management: Securing Australia's future in a green economy' (ATSE), and 'The science and politics of climate change' (*Proc. Royal Soc. NSW*).

Brian has a degree in physics and geology from the UNSW and a PhD in geophysics from Macquarie University. He is a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) and the Royal Society of NSW, and in 2003 was awarded the Australian Centenary Medal for his services to Australian geosciences. He is past-president of the ASEG and past vice-president of the SEG.

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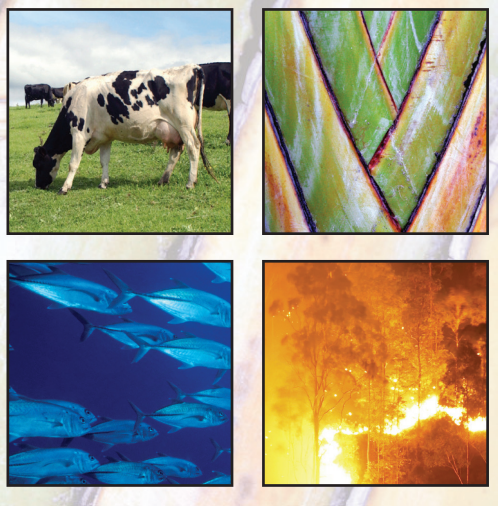

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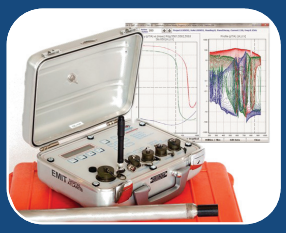

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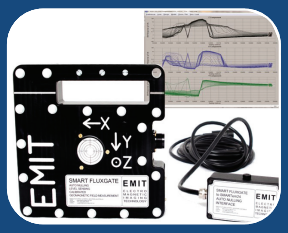

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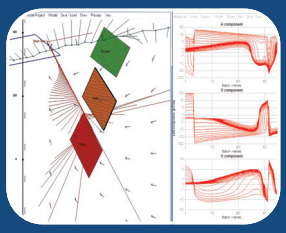

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