



Australian Society of
Exploration Geophysicists

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PREVIEW



NEWS AND COMMENTARY

Vale Kevin Wake-Dyster

Gold glitters

Evolution not revolution

Holiday reflections

Fracking

FEATURE

Australia's second lecturer
in exploration geophysics

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FRONT COVER



Dr Narain (wearing tie) reading what is possibly a Worden gravity meter in Australia in 1955. Image courtesy of the National Archives of Australia. NAA: A1501, A176/2. See the feature article in this issue for more about Dr Narain.

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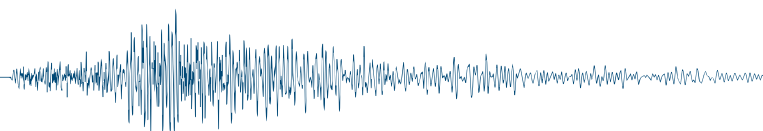
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Editor's desk



This issue of *Preview* is the first issue to be produced with our new publishing partners, Taylor & Francis. Needless to say, there have been teething problems, but we are working on resolving these problems and hope that the next issue of *Preview* will hit your inbox/mail box in a timely fashion.

If you are one of *Preview*'s valued advertisers and you haven't been contacted by Taylor & Francis staff please email me (previeweditor@aseg.org.au) or Roger Massey, the Taylor & Francis Business Development Manager (Roger.Massey@informa.com). Please also get in touch if you are new to *Preview* but would like to take advantage of the opportunity to advertise in our new global environment.

One of the advantages of engaging with Taylor & Francis is that they regularly update the ASEG Publications Team about global developments in scientific publishing. In January 2019 Marina Costelloe, Ted Tyne and I participated in a Taylor & Francis webinar/briefing on "Plan S", a plan which is being developed by a coalition of European public research funders (www.coalition-s.org).

Plan S sprang into life late in 2018 and aims to achieve full and immediate open access to publicly funded research outputs from 2020, with a

view to disseminating knowledge more effectively and facilitating the rapid progress of research. According to the developers, the long-term consequences of the widespread adoption of Plan S include changing the rewards and incentives structures that underpin academia, and making scholarly publishing more efficient and transparent. The developers also believe that adoption may, ultimately, end the subscription model of publishing.

So how does Plan S work? In a nutshell, researchers who receive funding from Plan S signatories will need to publish in:

- a fully open access journal
- an open-access platform
- and/or make the accepted or final version of manuscripts freely available without embargo in compliant repositories under liberal reuse terms.

A number of funding bodies have already signed up to Plan S, mostly within Europe, including the United Kingdom Research Institute, the Netherlands Organisation for Scientific Research, the Research Council of Norway and the Austrian Science Fund. Outside of Europe, the Bill and Melinda Gates Foundation has formally signed up, and there has been support expressed by China's National Science Library, National Science and Technology Library and the Natural Science Foundation of China. According to Taylor & Francis, Australian public funding bodies are yet to make the call.

Globally there has been a steady move to open access publishing so researchers who are funded by Plan S signatories will have no shortage of open access journals, including all the European Geosciences Union journals. *Preview* is also open access as the magazine is freely available online <https://www.tandfonline.com/toc/txp20/current>. Good news for publicly funded *Preview* contributors!

We'll keep you informed as Plan S develops.

Back to the current issue of *Preview*, which features an article by Roger Henderson on "The second lecturer in exploration geophysics in Australia – later to become Surveyor General of India" This article follows on from Roger's article on the first lecturer in exploration geophysics in Australia – which was published in the April 2016 issue of *Preview* (PV 180).

In addition, our regular commentators have been busy. David Denham (*Canberra observed*) takes a close look at the performance of resource-based companies in 2018. Michael Asten (*Education matters*) introduces us to Geoff McNamara, an outstanding science educator who has developed a Science Mentors scheme in the ACT. Mike Hatch (*Environmental geophysics*) reflects on changes in the practice of environmental geophysics over the past 25 years. Terry Harvey (*Minerals geophysics*), who is also in a reflective mood (holidays can do that for you), muses about the poor public image of mining and exploration in Australia. Mick Micenko (*Seismic window*) despairs about the poor public image of fracking. Tim Keeping (*Data trends*) keeps the conversation about passive seismic file formats going, and Dave Annetts (*Webwaves*) brings us up to speed with the debate around encryption.

Finally, Roger Henderson (who has been very busy!) treats us to a review of the book "The Spinning Magnet: The force that created the modern world – and could destroy it" by Alanna Mitchell. Roger is also reading "The Hunt for Earth Gravity: A history of gravity measurement from Galileo to the 21st Century" so watch out for that review in an upcoming issue of *Preview*.

Lisa Worrall
Preview Editor
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President's piece

Welcome to the first Taylor & Francis version of *Preview*. I would like to welcome our new publication partners and thank Lisa Worrall, Mark Lackie, Ted Tyne, Danny Burns and the Publications Committee for their herculean efforts during this time. I ask Members to be patient with Taylor & Francis while we are in this transition phase. Don't hesitate to let us know of any issues, problems or difficulties, just email the Secretariat secretary@aseg.org.au and they will direct your concern to the right person. A big thank you to CSIRO Publishing for the many years we have worked with them, particularly Helen Pavlatos who has been *Preview's* Production Editor for the last eight years. Helen has helped *Preview* Editors and the ASEG reach our valued Members, contributors and sponsors, with her professionalism, patience and generosity.

In December 2018 Minister Andrews announced the sixty successful women selected to take part in the second round of the Superstars of Science, Technology (<https://scienceandtechnologyaustralia.org.au/>), Engineering and Mathematics (STEM) programme. The programme supports women working in the STEM sector and gives them the opportunity to share their passion with the Australian community. The successful participants in this year's cohort represent some of Australia's most inspirational scientists, technologists and educators. Earth scientists were named superstars of STEM for the first time, and one of "ours", a geophysicist, was awarded this honour. Dr Kate Selway, ARC Future Fellow with the Department of Earth and Planetary Sciences at Macquarie University, shines brightly and represents geophysics in this illustrious cohort. We will ask Kate to keep us up to date during her two years as a star. The other earth scientists recognised include Dr Steph McLennan, a geologist working with the Australian Antarctic Science programme in Geoscience Australia; Dr Teresa Ubide, a volcanologist from the University of Queensland and Dr Verity Normington, a geologist from the Northern Territory Geological Survey. Please see the full list and their biographies at <https://scienceandtechnologyaustralia.org.au/what-we-do/superstars-of-stem/>. Congratulations to all the outstanding scientists selected!

The MinEx CRC announced their new directors in December 2018, and there are a couple of familiar names: John Emerson, Lindsay Gilligan, Kelly Keates, Linda Kristjanson, and Peter Rossdeutscher. Existing Board Members are Chris Pigram (Chair), Erica Smyth and Andrew Bailey (CEO). The MinEx CRC, is a \$218 million research collaboration aimed at developing technologies to increase the discovery of new mineral deposits. Find out more at <https://minexcrc.com.au/> I look forward with interest to seeing how MinEx progresses over the next 5–10 years.

At this time of year the ASEG State Branches hold their AGMs. I would like to send a big thank you to all the Branch committees and office bearers from 2018 and wish the incoming committees all the best. April will see the Federal Annual AGM, which will be held in Canberra. Dr Steve Hill, Chief Scientist at Geoscience Australia, will be the guest speaker at the AGM and there are plans underway to have the talk live-streamed. The Federal Executive will be asking for your support to make minor changes to the Constitution around being able to vote electronically, details will be sent out soon via email. The call to nominate for the Federal Executive is in this edition of *Preview*. If you are interested in joining the Federal Executive, or would like to nominate someone, just email Megan fedsec@aseg.org.au and put those names forward.

Talking about nominating, please nominate a mate, a colleague, a mentor, or a geophysical guru for one of the ASEG awards. The webpage <https://www.aseg.org.au/about-aseg/honours-awards> has all the details to help you nominate. If you want a hand, just email me and I can get you started. One of the awards, the ASEG Service Certificate, is "for distinguished service by a Member to the ASEG, through involvement in and contributions to State Branch committees, Federal Committees, Publications, and Conferences". Another, the Lindsay Ingall Memorial Award, is "for the promotion of geophysics to the wider community". Andrew Mutton is the Honours and Awards Chair. He does a marvellous job, with his committee, of overseeing the awards process. He is also a good source of information, and very able to give you some advice on how to nominate someone. He can be contacted at awards@aseg.org.au.

Remember to get your abstracts in for the AEGC 2019 Data to Discover Conference in Perth 2–5 September 2019. Tim Dean (ASEG) and the AEGC organisers have a cracker programme. Have a look at the updated website <http://2019.aegc.com.au>. Remember register early, submit an abstract and book into a workshop or two. I hope to see you there!

Marina Costelloe
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Heather Smith PSM Secretary of the Department of Industry, Innovation and Science and Marina Costelloe at the Institute of Public Administration Australia (IPAA) Women in Leadership event late 2018.



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Executive brief

The Federal Executive of the ASEG (FedEx) is the governing body of the ASEG. It meets once a month, via teleconference, to see to the administration of the Society. This brief reports on the monthly meetings that were held in December 2018 and January 2019. We hope you find these short updates valuable. If there is more you would like to read about on a regular basis please contact Megan on fedsec@aseg.org.au

Finances

The Society's financial position at the end of December 2019 is:

Year to date income: \$454 170

Year to date expenditure: \$596 892

Net Assets: \$960 047

Membership

Please remember to renew your ASEG membership for 2019. If

your membership has lapsed you should receive a reminder email soon. The number of Members current at the end of January 2019 is 519.

Welcome to the new student Members, graduate Members and all new Members. Please follow us on social media - search for Australian Society of Exploration Geophysics on LinkedIn, Twitter and Facebook. Remember that early and mid-career Members can join the ASEG Young Professionals Network <https://www.aseg.org.au/about-aseg/aseg-young-professionals>.

Survey

In the next month you will receive a short membership survey. Your feedback is important to the Federal Executive and we appreciate you taking the time to complete the survey.

Website

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

By the time you read this brief, the ASEG State Branches will be holding their AGMs and the federal AGM will be just around the corner. If you are interested in volunteering please contact Megan fedsec@aseg.org.au or your local Branch President.

Megan Nightingale
Secretary
fedsec@aseg.org.au

Notice of Annual General Meeting (AGM)

The 2019 AGM of the Australian Society of Exploration Geophysicists (ASEG) will be held at Geoscience Australia in Canberra on April 4 2019. The meeting will be hosted by the ACT Branch. Details will be supplied via email. Drinks will be available from 16.00 and the meeting will begin at 16.30.

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 2018.

The AGM will be proceeded by a scientific presentation. Dr Steve Hill, Chief Scientist at Geoscience Australia, will be the guest speaker and there are plans underway to have the talk live-streamed.

Invitation for candidates for the Federal Executive

Members of the Federal Executive serve in an honorary capacity. They are all volunteers

and ASEG 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 wish to know more about volunteering for your society. Self-nominations are encouraged.

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. Dr Ted Tyne was elected as President-Elect in 2018 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. Please forward 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), to the Secretary:

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Nominations must be received via post, fax or email no later than COB Tuesday 7 March 2019. Positions for which there are multiple nominations will then be determined by ballot of Members and the 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.



Welcome to new Members

The ASEG extends a warm welcome to 7 new Members approved by the Federal Executive at its December and January meetings (see Table).

First name	Last name	Organisation	State	Country	Membership type
Christian	Bell	Melbourne University	VIC	Australia	Student
Richard	Chopping	CSIRO	WA	Australia	Active
James	Groombridge	Retired/Consultant	VIC	Australia	Active
Muhammad	Iqbal	Curtin University	WA	Australia	Student
Syeda Sara	Mobasher	Schlumberger	SA	Australia	Associate
Kyle	Sterry	Terrex Seismic	QLD	Australia	Active
Tomas	Tam	University of WA	WA	Australia	Student



ASEG Research Foundation

Attention: All geophysics students at honours level and above

- **You are invited to apply for ASEG RF grants for 2019.**
- Closing date: **28 February 2019.**
- Awards are made for:
 - BSc (Hons) Max. \$5000 (1 Year)
 - MSc Max. \$5000 per annum (2 Years)
 - PhD Max. \$10 000 per annum (3 Years)
- Application form and information at: <https://www.aseg.org.au/foundation/how-to-apply>
- Awards are made to project specific applications and reporting and reconciliation is the responsibility of the supervisor.
- Any field related to exploration geophysics considered, e.g. petroleum, mining, environmental, and engineering.
- The completed application forms should be emailed to Doug Roberts, Secretary of the ASEG Research Foundation: dcrgeo@tpg.com.au
- The application documents have been reviewed and some rules have changed for 2019 and later grants.

ASEG Research Foundation

Goal: To attract high-calibre students into exploration geophysics, and thus to ensure a future supply of talented, highly skilled geophysicists for industry.

Strategy: To promote research in applied geophysics, by providing research grants at the BSc (Honours), MSc, and PhD level (or equivalent).

Management: The ASEG RF Committee comprises ASEG Members from mining, petroleum and academic backgrounds, who serve on an honorary basis, and who share the administrative costs to spare Research Foundation funds from operating charges.

The funds are used in support of the project, for example, for travel costs, rental of equipment, and similar purposes. Funds must be accounted for and, if not used, are returned to the ASEG Research Foundation.

Donations to the ASEG Research Foundation are always very welcome and are tax deductible. Contact the ASEG if you wish to make a donation

ASEG Research Foundation: Celebrating three decades and calling for grant applications

This year the ASEG Research Foundation (ASEG RF) celebrates an important milestone – for three decades it has been promoting Australian research and training in applied geophysics through research grants to worthy projects at the BSc (Honours), MSc and PhD levels (or equivalent).

The ASEG RF formally commenced its function in September 1989, with the first projects supported in 1991. It was established to address the decline, at that time, in student enrolments in exploration geophysics. The underpinning goal for the Research Foundation has remained the same over three decades – “to attract high-calibre students into exploration geophysics, and thus to ensure a future supply of talented, highly skilled geophysicists for industry”.

Bob Smith presented a passionate and compelling case to the ASEG in the late 1980s, which led to the establishment of the Foundation in 1989 with Bob as the inaugural chair. Peter Priest was the first and only treasurer, and continues to support the ASEG Research Foundation today. Many prominent members of the industry and academia have supported the Foundation over the years. Currently Phillip Harman as Chair, and Doug Roberts as Secretary, manage the Foundation with a committee of 19 senior ASEG Members.

ASEG Members from mining and petroleum areas, as well as from academia, serve on an honorary basis on the ASEG Research Foundation Committee. All administrative costs are borne by the committee members and no ASEG Research Foundation funds are used for operating expenses.

The number of concurrent Research Foundation supported projects has grown steadily over the period as shown in Figure 1.

More than 130 successful geophysical research project recipients of ASEG RF

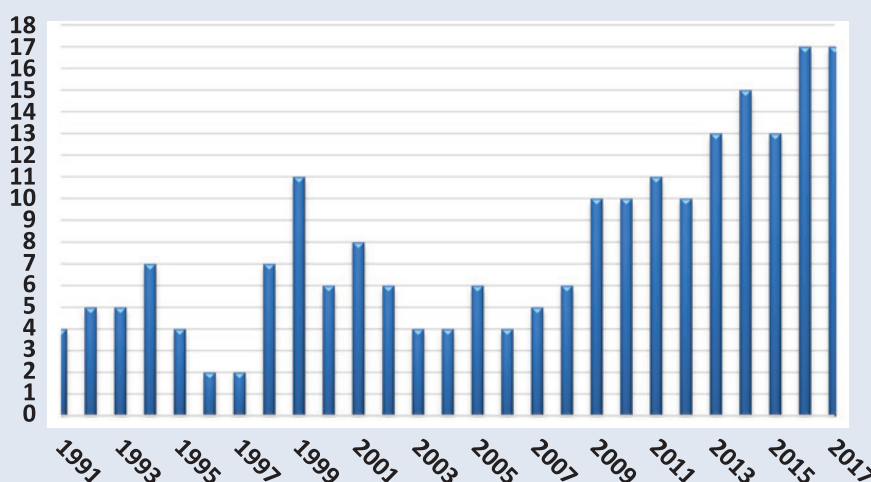


Figure 1. Concurrent ASEG Research Foundation supported projects from 1991 to 2017.

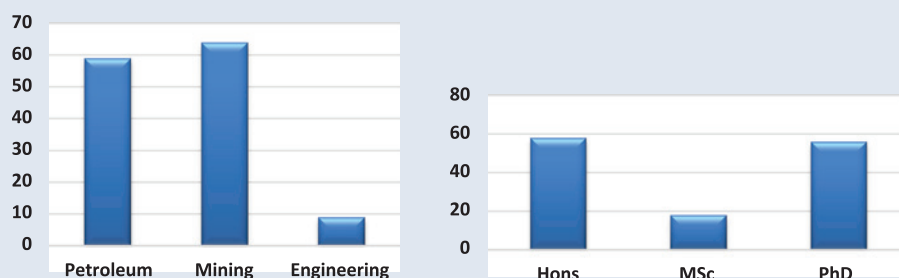


Figure 2. ASEG RF grants by field and by degree type.

grants over the period cover petroleum, mineral, engineering, environmental and groundwater disciplines, with the majority of grants awarded to worthy BSc (Hons) and PhD (or equivalent) based projects (Figure 2).

ASEG Members can view a full listing of the successful Research Foundation projects covering the period 1991–2018 at <https://www.aseg.org.au/foundation/sponsored-projects>.

The ASEG RF is funded in two ways. Funds are made available from the ASEG both directly and from corporate and Member contributors. Funds can also be donated directly by anybody. Members of the ASEG are encouraged to donate when they pay their subscriptions each

year. Donations of \$2.00 and over are tax deductible at 100% of the donation amount.

We encourage all geophysics students and their partner researchers to consider applying for the 2019 round of ASEG Research Foundation grants. The call for applications is open until 28 February and full details and links to application documents can be found at <https://www.aseg.org.au/foundation/how-to-apply>.

For further information, contact Doug Roberts, Secretary ASEG Research Foundation dcrgeo@tpg.com.au

Ted Tyne
president-elect@aseg.org.au

ASEG Young Professionals Network: An update

Applications for the QLD ASEG/PESA joint Mentoring Programme closed on 31 December 2018. These applications are being reviewed and the programme will be launched on 15 February 2019.

On 28 November, the Victorian Young Professionals seminar series concluded for 2018 with the much anticipated talk on Stakeholder Engagement by Steve Marshall, who is the operations director for CarbonNet. Steve and his team have had recent experience communicating their Carbon Capture and Storage project in the Gippsland region, where the project is located. Although the proposed storage site is offshore and could play a role in reducing global CO₂ levels, many local residents appear to have adopted a “lock the gate” or NIMBY mentality to pretty much anything put to them.

Steve provided many great examples of the challenges his team faced in engaging their portfolio of stakeholders, including the process followed and some (often hard) lessons learnt. A key takeaway was that there are some stakeholders who you will never appease

and it is important to find a respectful way to “agree to disagree”.

The Victorian YP network will resume in February 2019 with a social event and review of the mentoring programme

after its first year (and a bit). We welcome any new mentoring applications.

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



2019 ASEG Honours and Awards: Call for nominations



A reminder to all Members that nominations are open for the next series of ASEG Awards, which are scheduled to be presented in conjunction with AEGC 2019; 2–5 September 2019, Perth, Western Australia. All ASEG Members as well as State and Federal executives are invited to nominate those they consider deserving of these awards. The available awards are:

ASEG Gold Medal – for exceptional and highly significant distinguished contributions to the science and practice of geophysics, resulting in wide recognition within the geoscientific community.

Honorary Membership – for distinguished contributions by a Member to the profession of exploration geophysics and to the ASEG over many years.

Grahame Sands Award – for innovation in applied geophysics through a significant practical development of benefit to Australian exploration geophysics in the field of instrumentation, data acquisition, interpretation or theory. The nominee does not need to be a Member of the ASEG.

Lindsay Ingall Memorial Award – for the promotion of geophysics to the wider community, including geologists, geochemists, engineers, managers, politicians, the media or the general public. The nominee does not need to be a geophysicist nor a Member of the ASEG.

Early Achievement Award – for significant contributions to the profession by a Member under 36 years of age, by way of publications in *Exploration Geophysics* or similar reputable journals, or by overall contributions to geophysics, ASEG Branch activities, committees or events. The nominee must be a Member of the ASEG and have graduated for at least 3 years.

ASEG Service Awards – for distinguished service by a Member to the ASEG, through involvement in and contribution

to State Branch committees, Federal Committees, Publications or Conferences over many years. Where the nomination details outstanding contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years, consideration will be given to the award of the ASEG Service Medal to the nominee.

Nomination procedure

Any Member of the Society may submit nominations for candidates meeting the criteria for the above awards. Details of all award criteria and nomination guidelines can be found on the ASEG website at <https://www.aseg.org.au/about-aseg/honours-awards>

Pro forma nomination forms are also available by contacting the Committee Chair. Nominations including digital copies of all relevant supporting documentation are to be sent electronically to the Chair, ASEG Honours and Awards Committee via email: awards@aseg.org.au

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



ASEG Branch news

Western Australia

The WA Branch finished off 2018 with our Annual General Meeting (AGM) and Christmas Party on 12 December. I take this opportunity to welcome two new Committee members **Jane Cunneen** and **Mark Brailey**.

2018 saw the Branch host a number of technical and social events, including a SEG DISC seismic workshop (**Kurt Malfurt**), talks by SEG Distinguished Lecturer (**Satish Singh**) and Honorary Lecturer (**Mazin Farouki**), ASEG-PESA Young Professional speaker nights and mentoring programme, and the ASEG-PESA Golf Day. These were in addition to our monthly technical nights, which comprised a range of topics including FWI, passive seismic, hydrogeology, and exploration techniques in mining operations.

In 2018 we received a strong level of sponsorship support for our Tech Night events and we continued to keep our venue costs down by using the CGG facilities. We look forward to ongoing support from all our sponsors in 2019.

We congratulate **Alex Costall** (PhD in geophysics, Curtin University) on winning the ASEG WA Student Award for 2018. We also congratulate **Alejandro Sanchez** (MSc in geophysics, Curtin University) for winning the ASEG WA Branch best student presenter at our event on 28 November 2018.

The calendar for 2019 is starting to be populated, including presentations by SEG Honorary Lecturer **Boris Gurevich**, **Andrew Long**, **Richard Chopping**, and **Marina Costelloe**. We are looking forward to the return of OzSTEP workshops, which are currently being developed by our federal Education Committee, and a planned SEG DL short course. The Branch is also excited to be hosting the AEGC 2019 at Crown Burswood in early September 2019.

I would like to take this opportunity to thank the 2018 WA Branch Committee and event volunteers who work tirelessly to bring you a diverse range of technical and social programmes; specifically **Matt Owers** (WA Secretary), **Mat Cooper** (WA Treasurer), **Alex Karvelas**, **Amir Hashempour**, **Andrew Fitzpatrick**, **Brett Adams**, **Brett Harris**, **Cameron Adams**, **Carolina Pimentel**, **Partha**

Mandal, Shane Mule, and Tim Dean.

The activities of the Society would not be possible without these people!

Upcoming WA events include:

- 13 February Tech night – **Richard Chopping** will summarise his recent publication “The Australian Continent: a geophysics synthesis”

Heather Tompkins

wapresident@aseg.org.au

Australian Capital Territory

The ACT Branch is looking forward to a number of guest speakers and events in 2019. These include:

- 4 February – **Tim Dean** (Curtin University) – Recent Advances in Land Seismic
- 7 February – **Geoffrey McNamara** (MSATT) – Science Mentors ACT
- March – ACT Branch Annual General Meeting with guest speaker **Kate Selway** (ARC Future Fellow, Macquarie University)
- 4 April – Federal Executive Annual General Meeting with guest speaker **Steve Hill**

James Goodwin

actpresident@aseg.org.au

New South Wales

In November, **Paul Harvey** from Environmental Science Solutions presented a talk entitled “Emerging Pollutants and Emerging Problems”. His abstract for the meeting was as follows:

In a world where rapid advances in technology call for an ever more diverse range of resources, we are beginning to face a lag in our understanding of environmental pollutants. This talk will look at some of the latest resources required for modern life and the challenges that we face in understanding the environmental fate of these resources, the environmental and human health exposure tolerances and the need for up-to-date environmental regulations. We also need to consider ways to detect and analyse for these emerging pollutants in the environment as many traditional methods are not suitable. This calls for research in the realm of analytical chemistry and

physics to improve our capabilities.

This talk will explore emerging pollutants such as lithium, PFASs and pharmaceuticals, among others.

This topical presentation attracted audience members from a wide range of backgrounds and disciplines and was well received by all.

In December the NSW Branch of the ASEG put a pause on geophysical technical talks and celebrated upcoming holidays with the annual quiz night. The question topics ranged from general knowledge and events in 2018 to movie trivia, and even a handful of geophysics questions. As with most trivia events, the night was not without controversy, with one of the most difficult questions puzzling even the most experienced members and resulted in the audience wishing they remembered the authors of *Applied Geophysics*, Edition 1. For those interested, the answer is Telford, W.M., Geldart, L.P., Sheriff, R.E. & Keys, D.A. There was no shortage of prizes or enthusiasm from the audience, and it was a fun night enjoyed by all. The NSW Branch Committee thanks everyone who attended.

NSW Members enjoyed a well-deserved break in January and will be back in full 2019 swing with the first technical talk of the year given by **Richard Chopping** on February 20.

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

Stephanie Kovach

nswsecretary@aseg.org.au

Queensland

Jennifer Market visited Brisbane in November and gave the highly informative talk “Diamonds in the Noise – Treasures Lurking in Acoustic Data”. Jennifer is global acoustic advisor to Lloyd’s Register and Kinetic, and her role involves acoustic data processing and interpretation. Jennifer also provides industry training seminars to



2018 ASEG NSW Branch Annual Quiz Night winners and the NSW Secretary (left to right; **Doug Morrison**, **Steve Collins**, **Andrew Riznyczok** and **Stephanie Kovach**). Photo courtesy of **Mike Smith**.

widen the understanding of acoustic data acquisition and applications.

Jennifer spoke enthusiastically about acoustic data and a variety of additional processing that could be done with sonic data to reveal other physical properties, e.g. fracture characterisation, permeability, wellbore stability, hole size, cement evaluation, production optimisation, and brittleness maps. The talk was well attended and it was a pleasant evening at the excellent auditorium at the XXXX Brewery.

Our mentoring programme is still gathering pace and we are welcoming mentors to the programme, which will formally commence on 1 February 2019.

Richard Chopping will visit us in early March and present "Australian Continent: A geophysical synthesis".

Ron Palmer
qldpresident@aseg.org.au

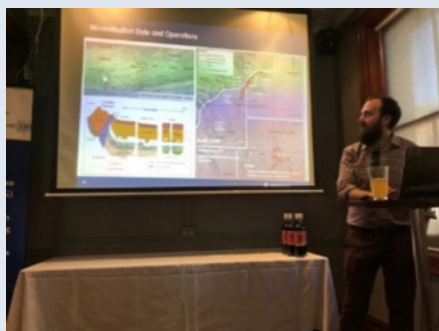
South Australia & Northern Territory

There was lots of action to close out the year for the South Australian/Northern Territory Branch. On the evening of Tuesday, 27 November we held our Industry Sponsors Night at our usual venue, the Coopers Alehouse. This was an opportunity to hear about projects that some of our sponsors are involved in, and to understand their businesses and products a little better. We had four sponsors present this year (but somehow only three photos of speakers): **Jonathan Ross** from Heathgate Resources, **Kelly Keates** from Zonge Australia, **Danny Burns** from Vintage Energy, and **Philip Heath** from the SA Department for Energy and Mining. This event is always well attended and a good chance for all of us (and especially students) to get to know who is doing what in industry around South Australia and the NT.

Our last event for 2018 was our annual Honours Student Night and Christmas Party, this year generously sponsored by Santos. The event was held on the evening of Tuesday, 11 December at the Coopers Alehouse. The night began with a fascinating talk by **Joel Stockill** from Santos titled, "Geology from Geophysics". This sponsor talk was a great chance to hear about the big-picture geophysics that Santos does. Next we had presentations from two students who completed their honours degrees this year: **Michael Rieger**, from the Australian School of Petroleum at the University of Adelaide, gave a talk titled: "Constraining the regional slope of Western Papua New Guinea: A study of lithospheric flexure", and **Robin Keegan-Treloar**, from Flinders University, gave a talk titled "A multi-method hydrological study of Wither Swamp, in the Fleurieu Peninsula, South Australia". We were all impressed by the breadth and calibre of their projects (and their presentations), and each student was awarded a monetary prize for their efforts from the SA/NT ASEG Branch.

The SA_NT Branch 2019 AGM will be held on February 11. The guest speaker will be the ASEG President, **Marina Costelloe**. Venue and timing on the day will be confirmed – check the ASEG website. If you are interested in joining the committee, please contact me as we are always looking for enthusiastic new members.

I would like to take this opportunity to thank all of our local sponsors for 2018: Beach Energy, Minotaur Exploration, the SA Department for Energy and Mining, Heathgate Resources, Zonge Engineering, and Vintage Energy. We would also like to thank our event sponsors, Terrex Seismic, who sponsored the Melbourne Cup; and Santos Ltd, who sponsored our Student Night. We could never supply so much



Presenters at the SA_NT Branch Industry Sponsors night (left to right; **Danny Burns** – Vintage Energy, **Jonathan Ross** – Heathgate, **Kelly Keates** – Zonge)



Student presenters at the 2018 Honours Student Night and Christmas Party (left to right; Joel Stockill – Santos, Robin Keegan-Treloar – Flinders University, Michael Rieger – ASP, University of Adelaide).

interesting material to our members without our sponsors; thank you for your support. If your company is interested in sponsoring the ASEG SA/NT Branch, please get in touch with our treasurer, **Adam Davey** at Adam.Davey@tafesa.edu.au.

Please feel free to drop me a line with any feedback: sa-ntpresident@aseg.org.au. If there is something you would like to see on the calendar in 2019, please do let me know.

Kate Robertson
sa-ntpresident@aseg.org.au

Tasmania

In February 2019 the Tasmania Branch welcomes **Richard Chopping**, who will be talking about the book he recently co-authored with **Brian Kennett** and **Richard Blewett**; *The Australian Continent: A Geophysical Synthesis*. This event will be held jointly with the Tasmania Division of the Geological Society of Australia, starting with nibbles

and drinks at 5.30 pm on Thursday 28 February 2019 in the Earth Sciences Building at the University of Tasmania. It will be preceded by the ASEG Tasmania Branch AGM. Further details are included in a more formal notice of meeting distributed to local Members.

An invitation to attend Tasmanian Branch meetings is extended to all ASEG Members and interested parties. Meetings are usually held in the CODES Conference Room, University of Tasmania, Hobart. Meeting notices, details about venues and relevant contact details can be found on the Tasmanian Branch page on the ASEG website. As always, we encourage Members to also keep an eye on the seminar programme at the University of Tasmania / CODES, which routinely includes presentations of a geophysical and computational nature as well as on a broad range of earth sciences topics.

Mark Duffett
taspresident@aseg.org.au

Victoria

The Victorian Branch will reconvene after the summer break on 28 February, when **Richard Chopping** will be giving Branch members a presentation on "The Australian Continent: A Geophysical Synthesis". Members are looking forward to hearing a digest of Richard's recently published book, which has the same title as his presentation.

An invitation to attend Victorian Branch meetings is extended to interstate and international visitors who happen to be in Melbourne at the time. Meetings are generally held on the third Thursday of each month from 5:30 pm in the Kelvin Club, 18–30 Melbourne Place, Melbourne. Meeting notices, addresses and relevant contact details can be found on the Victorian Branch page of the ASEG website.

Seda Rouxel
vicpresident@aseg.org.au



ASEG national calendar: technical meetings, courses and events

Date		Branch	Event	Presenter	Time	Venue
4	Feb	ACT	Tech talk	Tim Dean	1600	Scrivener Room, Geoscience Australia, Symonston
7	Feb	ACT	Tech talk	Geoffrey McNamara	1230	Sir Harald Raggatt Theatre, Geoscience Australia, Symonston
11	Feb	SA_NT	AGM	Marina Costelloe	1200	Ballroom, Ayers House, Adelaide
13	Feb	WA	Tech night	Richard Chopping	TBA	TBA
15	Feb	QLD	Launch joint ASEG PESA YPN Mentoring Program	Various	TBA	TBA
19	Feb	QLD	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks	1730	XXXX Brewery, Corner Black Street and Paton Street, Milton, Brisbane
20	Feb	NSW	Tech Talk	Clive Foss	1730	99 on York Club, 99 York Street, Sydney
21	Feb	VIC	Tech talk	Richard Chopping	1730	The Kelvin Club, 18–30 Melbourne Place, Melbourne
21	Feb	QLD	Tech talk	Andy Brett SA Exploration	1730	XXXX Brewery, Corner Black Street and Paton Street, Milton, Brisbane
28	Feb	TAS	AGM and Tech night	Richard Chopping	1730	Earth Sciences Building, University of Tasmania, Sandy Bay, Hobart
4	Mar	ACT	AGM	Kate Selway	1600	Sir Harold Raggatt Theatre, Geoscience Australia, Symonston
5	Mar	QLD	Tech night	Richard Chopping	1730	XXXX Brewery, Corner Black Street and Paten Street, Milton, Brisbane
13	Mar	WA	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models	1800	TBA
15	Mar	ACT	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models	1230	TBA
20	Mar	NSW	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models	1730	99 on York Club, 99 York Street, Sydney
21	Mar	VIC	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models	1800	TBA
21	Mar	TAS	Tech night	Paul Winberry	TBA	Earth Sciences Building, University of Tasmania, Sandy Bay, Hobart
21	Mar	TAS	Tech talk	Paul Winberry	TBA	Earth Sciences Building, University of Tasmania, Sandy Bay, Hobart
25	Mar	SA_NT	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models	1730	Coopers Alehouse, 316 Pulteney St, Adelaide
27	Mar	TAS	SEG HL	Boris Gurevich Seismic attenuation, dispersion, and anisotropy in porous rocks: Mechanisms and Models	1300	TBA
4	Apr	ACT	National AGM	Steve Hill	1600	Sir Harald Raggatt Theatre, Geoscience Australia, Symonston
17	Apr	NSW	AGM	Marina Costelloe	1730	99 on York Club, 99 York Street, Sydney

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

Australasian Exploration Geoscience Conference 2019: Calling for abstracts

The second Australasian Exploration Geoscience Conference (AEGC) will be held at the Crown Resort in Perth 2-5 September 2019. The AEGC is co-hosted by the Australian Institute of Geoscientists, the Australian Society of Exploration Geophysicists and the Petroleum Exploration Society of Australia. The AEGC is the largest exploration geoscience conference in the southern hemisphere and is expected to attract well over 1000 delegates from around the world. Themes cover the full spectrum of Australian geosciences from the mineral, petroleum and water resource industries, government and academia. Given its location in Perth, there will be additional, dedicated, streams for Western Australian sedimentary basins, discovery techniques, mineral mapping and remote sensing applications.

The Organising Committee for the 2nd Australasian Exploration Geoscience Conference invites you to submit an abstract for presentation at the conference. The extended abstract is a short (maximum 5 page) paper summarizing your oral or poster presentation. Each abstract will be subjected to a peer-review process before being accepted for presentation at the conference. All accepted abstracts will be published in the digital conference proceedings and made available via the ASEG publication site. The conference incorporates the West Australian Basins Symposium (WABS) for which full papers will also be accepted. Authors wishing to follow this route should e-mail the WABS editors directly (WABS@pesa.com.au).

Papers are invited from a broad spectrum of themes such as new information from old data, cross disciplinary co-

ordination, industrial minerals and case studies. Disciplines encompassed by the conference include (but are not limited to) geology, geophysics, geochemistry, geomaterials, geostatistics, petrophysics, palaeontology, archaeology, geotechnical engineering, and mining geology.

All abstracts should be submitted using the official template available from the AEGC website (<http://2019.aegc.com.au/>) and the final submission date is Friday 22 March 2019. The results of the review process will be available by 3 May 2019, but the review process is continuous and abstracts submitted before the final submission deadline may be notified before this date.

Find out more at <http://2019.aegc.com.au/>

Helen Debenham
AEGC 2019 Technical Program Chair
helendebeham@gmail.com



AEGC2019

Data to Discovery

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

Incorporating the AIG, ASEG, PESA, and WABS

Call for Abstracts

Early Bird Registration Opens: 1 March 2019

Call for Abstracts Closes: 22 March 2019

Author Notification: 3 May 2019 or before

Registration Deadline: 31 May 2019

The Leading Exploration Geoscience Conference in Asia-Pacific



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www.aegc.com.au

Vale: Kevin Wake-Dyster (1953–2018)



Kevin Wake-Dyster (left) consulting with a South Australian farmer about an AGSO seismic survey being carried out over the Otway basin in 1992.

Kevin Wake-Dyster passed away in October 2018 following a 17 month long brave battle with a glioblastoma brain tumour.

Kevin was born Kevin Wake in Kimba, a small town north of the Eyre Peninsula in South Australia. When his father died in a farming accident his family returned to his mother's home town of Orooroo in South Australia, where his mother later met and married Colin Dyster and Kevin became Kevin Wake-Dyster. As both parents were school teachers the new family moved to Adelaide, where Kevin attended Adelaide High School. In 1974 he obtained a BSc (Hons) degree in geophysics from the University of Adelaide.

After graduating from university Kevin joined Exploration Logging of Australia and worked on well-site surveys, mainly on the North-west Shelf. In 1976 he joined the Geophysical Branch of the Bureau of Mineral Resources (BMR) and spent 1977 as an Antarctic geophysical observer, undertaking regional magnetic field survey work in Enderby Land and

observatory duties at Mawson Station, where he looked after the geomagnetic and seismic observatories. He undertook similar duties at the Macquarie Island Observatory in 1979. When he returned to the BMR in Canberra Kevin joined the seismic group as a geophysicist and worked on the Central Eromanga Basin Project. He carried out several deep seismic reflection surveys throughout Queensland from 1980 to 1986, firstly as a field geophysicist and then as Party Leader. He was the lead author of many of the final reports of these BMR/AGSO deep seismic reflection surveys.

Kevin married Pauline in 1987. They were introduced by Shiron, who was the wife of fellow geophysicist, Owen Dixon, who worked for GSQ.

Kevin continued working in the BMR's seismic group in the late eighties and early nineties, running a number of BMR onshore seismic surveys around the Cobar and Broken Hill regions, and the Gunnedah, Bowen, Surat, Otway and

Gippsland Basins. In the mid-nineties, he was appointed Manager of Land Seismic Operations at the Australian Geological Survey Organisation (AGSO, formerly BMR) and was involved in the formation of the reflection seismic component of ANSIR (the Australian National Seismic Imaging Resource). In this role, he undertook selection, procurement and delivery of the ANSIR facility's IVI Hemi60 vibrators, ARAM24 seismic system and, his personal favourite, the IVI T1500 Minivibrator.

In late 1998 Kevin left AGSO, and in 1999 he moved with his wife Pauline from Canberra to the warmer climate of Brisbane. Whilst in Brisbane he carried out environmental engineering research into the management of stormwater erosion of unpaved sand roads on Fraser Island with Queensland University of Technology. In 2003 he established EcoSeis to provide specialist shallow hi-resolution reflection and surface wave seismic imaging services with a variety of weight drop and shotgun sources with a RAS24 seismic acquisition system and a towed seismic array streamer that he had developed. He also undertook a number of engineering seismic refraction and MASW surveys with Koya Suto.

Kevin was an active Member of the ASEG, presenting at conferences and co-authoring several papers in *Exploration Geophysics*. His friends and former colleagues will also recall his passion for a bargain when collecting antiques, tractors and geophysical equipment. Purchases during his field trips over time meant he needed more and more storage space. Urban myth has it that after filling his Charnwood house in Canberra he had to buy a rather large shed on a big block in Boorowa NSW to accommodate his treasures. He would often drive down from Brisbane to visit this shed. The geophysical equipment will be sorted and catalogued by some of his friends and former colleagues over the coming months, and they will ensure that everything finds a good home.

Kevin is survived by his wife Pauline.

Kevin was always a cheery sort of character with a 'she'll be right' attitude that will be sorely missed.

Tim Barton
Geoscience Australia
tim.barton@ga.gov.au

Henk van Paridon
GeoSolve
henk@geosolve.com.au

Have SIROTEM, will travel



Roger Henderson with colleagues after demonstrating the use of SIROTEM in Niger in 1992.

One of the pluses of our profession is that it can involve international travel, sometimes to exotic places. Since part of my career involved global promotion of geophysical instruments I did, indeed, get plenty of travel. In fact, for a 30 year period from 1972 to 2002, I made a total of 99 international trips from my various places of residence, involving 170 countries and 228 cities. The most trips in any one year from Australia was seven, in 1983, involving 11 countries. Many years involved four and five trips per year.

Many trips involved participation in conferences and exhibitions. They included, in all, twelve EAGE meetings,

ten SEGs, six SAGEEP meetings and at least seven other well-known conferences. Often I attended more than one conference in the same year. The "others" included the 1977, 1997 and 2007 Decennial conferences in Canada, the 1st and 3rd International Conferences on Petroleum Geophysics in India, several in China, and numerous Prospectors and Developers Conferences (PDACs) in Canada.

One of the most memorable conferences that I attended was the geophysical symposium in Xian in 1986, sponsored by the Geological Society of China. It was attended by many well-known "wanguoren" from other countries. The Aussies included Bob Smith, John Stanley, Pat Cuneen, Noel Mattocks and Tony Howland-Rose, all ASEG Members. We appear in a photo of all 330 participants taken by a rotating camera while we were seated in a semi-circle. The photo is 166 cm long and a rare print adorned my office wall.

The first of my 15 visits to China was in 1974, which was during the "cultural revolution" and Chairman Mao still alive. I was part of a trade mission and our delegation included Harry Seigel,

then President of Scintrex and Sheldon Breiner, then President of Geometrics. We visited "Canton", Shanghai and Beijing and were treated as VIPs everywhere we went. At our exhibition in Shanghai, 1000 factory workers were bussed in each hour for three days to ensure we would be satisfied with attendance.

My one and only trip to Rangoon, Burma was in 1987. There were only two hotels available, and we preferred the "2 rat" hotel over the "3 rat" hotel. I did see one of the two rats in my room on a couple of nights.

I know that some other ASEG Members travelled as much as I did as I saw them repeatedly at conferences (Des Fitzgerald, Koya Suto, etc.). I am sure they also benefited from the one great advantage of all this travel, namely the large number of friendships formed, many of them long-lasting. One in particular, for me, is my translator for most of my visits to China. He got to know my SIROTEM paper so well that he could give it without me speaking. He now resides in Sydney and we still get together from time to time.

Roger Henderson
history@aseg.org.au

Geoscientists recognised in Australia Day 2019 Honours List

Officer (AO) in the General Division of the Order of Australia

Professor Ross Large, for distinguished service to education, and to scientific research in the field of economic geology, and to professional societies.

Emeritus Professor Brian Kennett, for distinguished service to the earth sciences as a leading academic and researcher, particularly in the field of seismology.

Member (AM) in the General Division of the Order of Australia

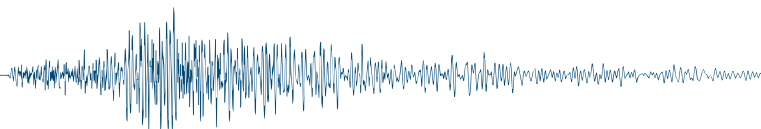
Dr Chris Pigram for significant service to public administration, particularly through scientific leadership roles.

Emeritus Professor Michael Knight, for significant service to scientific education, particularly to hydrogeology and groundwater management.

Medal (OAM) of the Order Of Australia in the General Division

Dr Jon Hronsky, for service to the mining sector.

Congratulations from the ASEG!!



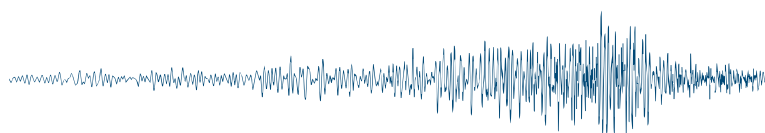
Update on geophysical survey progress from Geoscience Australia and the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current on 23 January 2019).

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

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km ²)	End flying	Final data to GA	Locality diagram (Preview)	GADDs release
Tasmanian Tiers	MRT	GA	TBA	TBA	Up to an estimated 66 000	200 m 60 m N–S or E–W	11 000	TBA	TBA	TBA	The National Collaborative Framework Agreement between GA and MRT is being updated
Tallaringa N (1A)	GSSA	GA	Thomson Aviation	26 Oct 2017	97 922	200 m 60 m E–W	17 320	26 Mar 2018	TBA	190: Oct 2017 p. 26	TBA
Tallaringa S (1B)	GSSA	GA	Thomson Aviation	26 Sep 2017	145 367	200 m 60 m E–W	26 010	12 May 2018	TBA	190: Oct 2017 p. 26	TBA
Coober Pedy (8A)	GSSA	GA	Thomson Aviation	18 Sep 2017	90 425	200 m 60 m N–S	16 140	21 Dec 2017	TBA	190: Oct 2017 p. 26	TBA
Billa Kalina (8B)	GSSA	GA	MAGSPEC Airborne Surveys	10 Oct 2017	90 353	200 m 60 m N–S	16 140	18 Dec 2017	27 Jul 2018	190: Oct 2017 p. 26	TBA
Childara (9A)	GSSA	GA	MAGSPEC Airborne Surveys	5 Nov 2017	134 801	200 m 60 m N–S	23 910	2 May 2018	30 Nov 2018	190: Oct 2017 p. 26	TBA
Lake Eyre (10)	GSSA	GA	MAGSPEC Airborne Surveys	2 Oct 2017	91 938	200 m 60 m E–W	16 180	22 Mar 2018	9 Oct 2018	190: Oct 2017 p. 26	TBA
Streaky Bay (5)	GSSA	GA	GPX Airborne Surveys	21 Jun 2018	90 630	200 m 60 m E–W	15 966	28 Sep 2018	TBA	194: Jun 2018 p. 19	TBA
Gairdner (6A)	GSSA	GA	GPX Airborne Surveys	31 Jul 2018	105 075	200 m 60 m N–S	18 307	TBA	TBA	194: Jun 2018 p. 19	100% complete at 23 Jan 2019
Spencer (7)	GSSA	GA	MAGSPEC Airborne Surveys	11 Jun 2018	50 280	200 m 60 m E–W	8716	6 Aug 2018	TBA	194: Jun 2018 p. 19	TBA
Kingooonya (9B)	GSSA	GA	MAGSPEC Airborne Surveys	5 Aug 2018	150 565	200 m 60 m N–S	26 651	TBA	TBA	194: Jun 2018 p. 19	67% complete to 21 Jan 2019
Tanami	NTGS	GA	Thomson Aviation	14 Jul 2018	275 216	100/200 m 60 m N–S/E–W	48 267	2 Dec 2018	TBA	195: Aug 2018 p. 16	100% complete to 2 Dec 2018

TBA, to be advised.


Table 2. Ground and airborne gravity surveys

Survey name	Client	Project management	Contractor	Start survey	Line km/ no. of stations	Line spacing/ station spacing	Area (km ²)	End survey	Final data to GA	Locality diagram (Preview)	GADDS release
Kidson Sub-basin	GSWA	GA	CGG Aviation	14 Jul 2017	72 933	2500 m	155 000	3 May	15 Oct 2018	The survey area covers the Anketell, Joanna Spring, Dummer, Paterson Range, Sahara, Percival, Helena, Rudall, Tabletop, Ural, Wilson, Runton, Morris and Ryan 1:250 k standard map sheet areas	TBA
Little Sandy Desert W and E Blocks	GSWA	GA	Sander Geophysics	W Block: 27 Apr 2018 E Block: 18 Jul 2018	52 090	2500 m	129 400	W Block: 3 Jun 2018 E Block: 2 Sep 2018	TBA	195: Aug 2018 p. 17	TBA
Kimberley Basin	GSWA	GA	Sander Geophysics	4 Jun 2018	61 960	2500 m	153 400	15 Jul 2018	TBA	195: Aug 2018 p. 17	TBA
Warburton-Great Victoria Desert	GSWA	GA	Sander Geophysics	Warb: 14 Jul 2018 GVD: 27 Jul 2018	62 500	2500 m	153 300	Warb: 31 Jul 2018 GVD: 3 Oct 2018	TBA	195: Aug 2018 p. 17	TBA

TBA, to be advised

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km ²)	End flying	Final data to GA	Locality diagram (Preview)	GADDS release
East Kimberley	GA	GA	SkyTEM Australia	26 May 2017	13 723	Variable	N/A	24 Aug 2017	Nov 2017	TBA	TBA
AusAEM (Year 1)	GA	GA	CGG	TBA	59 349	20 km with areas of infill	TBA	31 Jul 2018	2 Oct 2018	186: Feb 2017 p. 18	Released on GA website, 11 Dec 2018
Surat-Galilee Basins QLD	GA	GA	SkyTEM Australia	2 Jul 2017	4627	Variable	Traverses	23 Jul 2017	Nov 2017	188: Jun 2017 p. 21	TBA
Stuart Corridor, NT	GA	GA	SkyTEM Australia	6 Jul 2017	9832	Variable	Traverses	12 Aug 2017	Nov 2017	188: Jun 2017 p. 22	TBA

TBA, to be advised

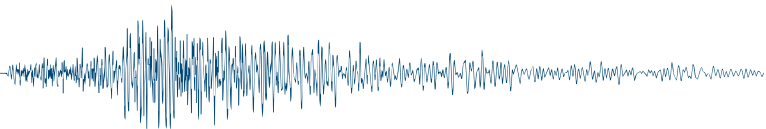
Table 4. Magnetotelluric (MT) surveys

Location	State	Survey name	Total number of MT stations deployed	Spacing	Technique	Comments
Northern Australia	Qld/NT	Exploring for the Future – AusLAMP	293 stations deployed in 2017–18	50 km	Long period MT	The survey covers the area between Tennant Creek and Mount Isa. The 2018 field season commenced in May 2018.
AusLAMP NSW	NSW	AusLAMP NSW	139 stations deployed in 2018 to date	50 km	Long period MT	Covering the state of NSW with long period MT stations at approximately 50 km spacing.
Olympic Domain	SA	Olympic Domain	320 total	Varied 1.5 to 10 km	AMT and BBMT	The survey area extends west of Lake Torrens and covers mineral prospects such as Carrapateena, Fremantle Doctor, Red Lake, Punt Hill, Emmie Bluff and Mount Gunson. The survey was completed to Jul 2018.

TBA, to be advised

Table 5. Seismic reflection surveys

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



Geological Survey of South Australia: Geophysical plans for 2019

2019 looks to be an exciting year for the Geological Survey of South Australia. At the time of writing, acquisition of the Gawler Craton Airborne Survey (GCAS) was 97% complete (Figure 1). After the final plane lands there will still be an ongoing effort to ensure all the data is of the highest quality before being delivered to stakeholders. The first inversion model packages courtesy of the CSIRO are already available: visit the GCAS webpage (http://www.energymining.sa.gov.au/minerals/geoscience/pace_copper/gawler_craton_airborne_survey_community_information) and click on the map on your area of interest to download a zip package containing all the enhanced geophysical imagery and magnetic source depth models.

The GCAS has already identified areas of interest that both the GSSA and CSIRO are keen to investigate. At the time of writing, the GSSA and CSIRO are planning fieldwork to examine closely some geophysical anomalies seen in the GCAS data, as well as geophysical anomalies seen in the Coompana area. Acquisition of ground magnetics and microgravity over the Gairdner Dykes will better constrain the magnetic source depth modelling undertaken by the CSIRO. In the Coompana area we plan to acquire new ground data over the ‘pimples’ seen in the airborne

magnetics. All going well, the results will be presented at the AEGC later this year.

The GSSA will build on the release of the AusLAMP SA data at the 2018 Discovery Day by modelling the follow-up in-fill MT survey across the Olympic Domain region, which was acquired in 2018. This year will also see the release of AusLAMP MT state-wide models through the online portal SARIG. In addition, we are planning a marine MT survey in the Spencer Gulf with colleagues of the Scripps Institution of Oceanography. This will fill the data coverage gap around the Eyre and Yorke Peninsulas, an area that covers fundamental lithospheric boundaries linking up into the Olympic Domain.

For more information, contact customer services at resources.
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Geological Survey of South Australia, Department of Energy and Mining

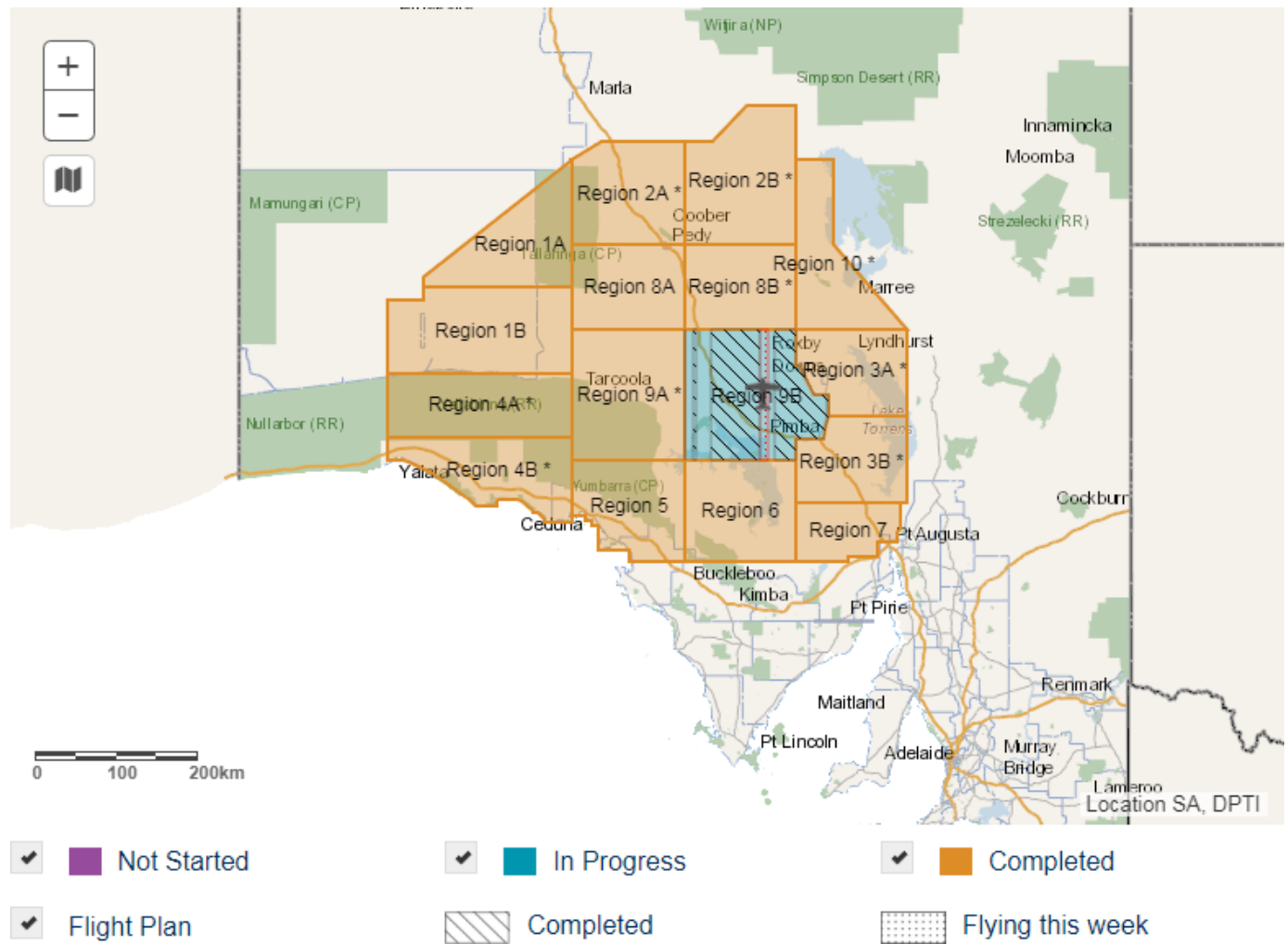


Figure 1. Gawler Craton Airborne Survey now 97% complete.

Canberra observed



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Gold glitters in 2018 – while coal, iron ore and petroleum companies languish

2018 was a poor year for most resource companies listed on the ASX, but it was even worse for the companies that are included in the All Ords Index (AOI). The market capital of the resource companies listed in the top 150 companies declined by 2.1% from \$281 billion at the start of the year to \$275 billion at year's end, while the AOI declined by 8.2% from 6230 to 5716 over the same period.

The better performance of resource companies relative to the average listed company is consistent with the longer-term results from 2000. [Figure 1](#) shows how the AOI and the market capital of the resource companies have changed over the last 18 years, with the values normalised for changes in the Consumer Price Index (CPI). When the AOI is adjusted to 2018 \$A, it has risen from 5070 in July 2000 to 5716 at the end of 2018. This is equivalent to an increase of approximately 0.7% per year and is not a good capital gain. It pays to make sure you invest in companies that pay good annual dividends!

Meanwhile, the market capital of the top resource companies has risen from \$127 billion to \$275 billion in the same period, at an average increase of 6.3% per year. As one would expect, there is more volatility in the resource industry than in the AOI but, if your timing is right, the rewards are more substantial.

The glittering gold

The small decline in value of the resource companies during 2018 was cushioned by the spectacular rise in the value of the companies producing and exploring for gold.

[Table 1](#) shows how the value of the main companies in the top 150 ASX companies fared during 2018. The numbers in the table are in \$A billions, or show the percentage changes over 2018. The companies have been grouped according to their main commodity

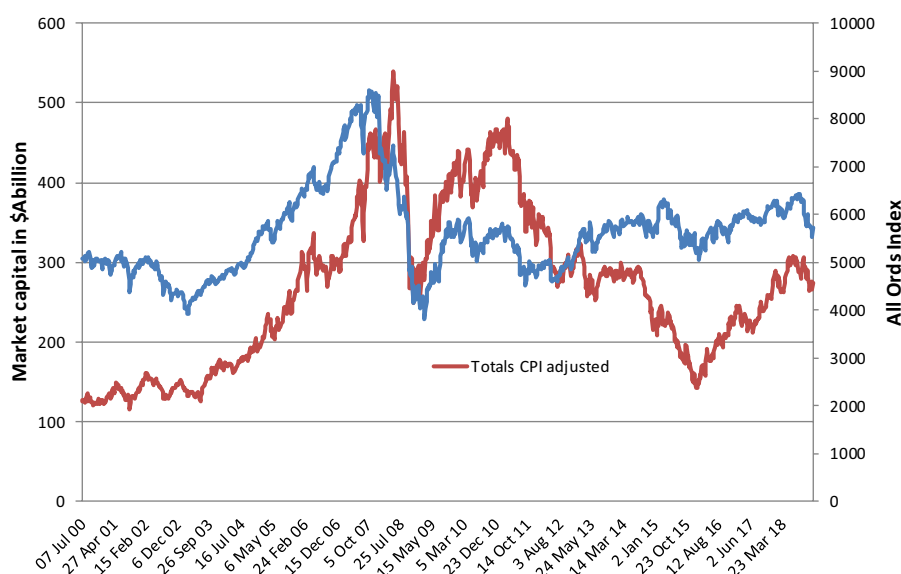


Figure 1. Market capital of the resource companies listed in the top 150 companies on the ASX from July 2000 through December 2018, and the AOI for the same period. The numbers have been normalised to December 2018 \$A using the Australian Bureau of Resources CPI.

Table 1. Market capital changes for 2018

	January 2018	December 2018	Change %
BHP	98.213	100.011	+2
Rio	32.271	28.984	-10
Fortescue	16.658	12.788	-23
Yancoal	5.934	5.156	-13
Whitehaven	4.637	4.514	-3
New Hope	2.119	2.759	+30
Woodside	29.123	29.348	+1
Origin	16.840	5.908	-32
Oil Search	12.204	10.878	-11
Santos	11.560	11.393	-1
Beach	3.004	3.064	+2
Newcrest	17.873	16.187	-9
Evolution Min	4.434	6.794	+53
Northern Star	3.649	5.908	+62
Ocean Gold	2.106	2.966	+41
St Barbara	1.976	2.464	+25
Regis Resources	2.182	2.426	+11
Saracen	1.401	2.337	+67
All Ords	6230	5716	-8
Market Capital	284.78	274.89	-3
Miscellaneous	Coal	Petroleum	Gold

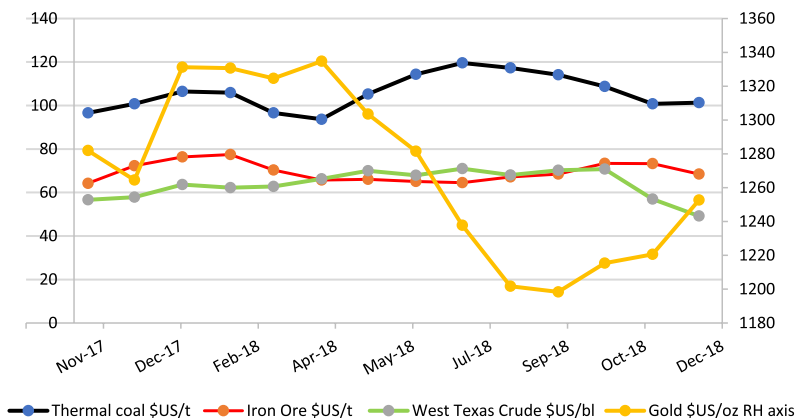
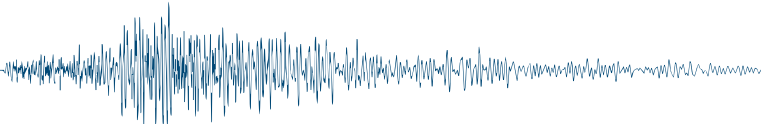


Figure 2. Selected commodity prices for thermal coal, iron ore, petroleum and gold for the period November 2017–December 2018. The right-hand axis relates to gold and the left had axis to the other three commodities. No CPI adjustments have been made.

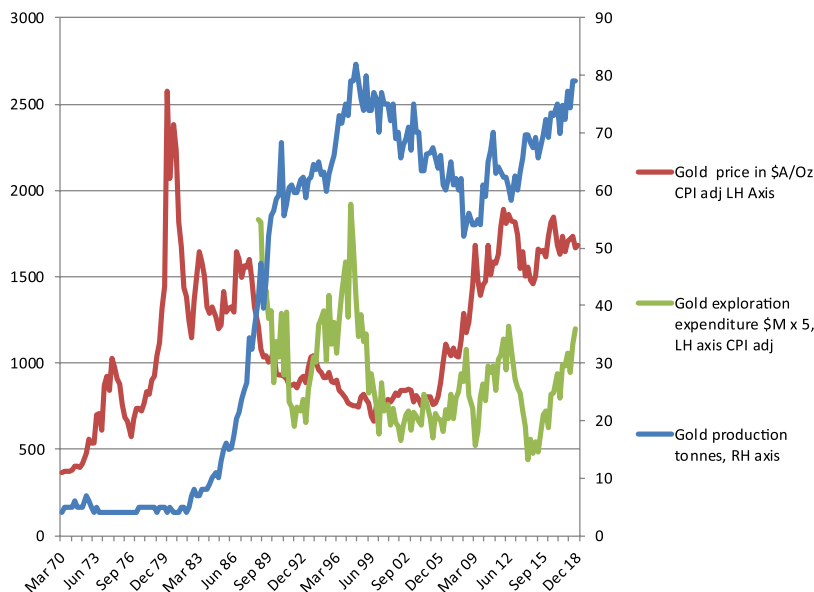


Figure 3. Quarterly gold production in Australia, investment in gold exploration and the price of gold in Australian dollars between 1970 and 2018. The dollar values have been normalised to December 2018 \$A using the ABS's CPI published values.

interest – apart from BHP and Rio Tinto, which have interests in several minerals and energy resources.

Notice how well the gold companies have performed, with Saracen and Northern Star both having had a wonderful year. Newcrest is the odd one out, but if the dataset was extended into 2019 it would also have finished in positive territory.

The petroleum companies were lacklustre, particularly Origin Energy, presumably because most of its business is in the retail energy sector and governments have been attacking the main players in this field to try to reduce electricity prices.

Of the three dedicated coal companies in the top 150, New Hope had a good year and Yancoal and Whitehavens' values both declined.

The price variations for thermal coal, iron ore, gold and petroleum are shown in Figure 2. Of these four commodities, petroleum had the highest volatility, ranging from, \$US 49–71/bl (45%), followed by thermal coal \$US 94–120/t (28%), iron ore \$US 64–78/t (22%), and gold \$US 1198–1331/oz (11%).

The relative stability of the gold price and the decline in the value of the Australian dollar against the US dollar makes gold an attractive investment,

particularly as most of the costs of extraction and exploration are in Australian dollars.

Figure 3 gives an indication of the variation in the gold price in Australian dollars over a longer period. During the last 10 years there has been a steady increase in the price and its volatility is not as large as it was in the 1970s and 1980s.

Australian gold production has increased steadily from 2008 and could pass the 300 tonnes/year mark in 2019 if the production continues to increase at a similar rate. There does not appear to be a strong correlation between gold price and exploration investment, but it is good to see the steep rise in the exploration effort during the last six years.

Australia remains second in the world table of gold producers for 2017 (<https://www.gold.org/goldhub/data/historical-mine-production>). The 2018 data will not be available until later in 2019. The total annual global gold production in 2017 was 3247 tonnes and the top 10 producers are shown in Table 2.

It is most unlikely that Australia will overtake China in the foreseeable future, but in 1970 South African production peaked 1000 tonnes and in 2017 it only produced 157; as a result of depleting reserves and aging infrastructure.

It's not clear whether Australia has reached its peak annual production, but based on the increased exploration activity, particularly in Western Australia, it would not be surprising if it produced over 300 tonnes in 2019. That would be worth over \$US 12 billion.

They say that all that glitters is not gold, but if you have the gold you don't need the glitter!

Table 2. Top 10 global gold producers 2017

Country	Tonnes
China	429.4
Australia	289.0
Russia	272.3
United States	243.6
Canada	171.2
Peru	166.6
South Africa	156.9
Finland	130.1
Mexico	122.4
Guyana	114.2

Education matters



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The next two generations of earth scientists II

Last issue (Preview December 2018) I wrote about the next two generations of

earth scientists in the context of theses completed in Australian Universities, and the secondary school Earth Science Western Australia (ESWA) educational programme. This issue we continue the theme by highlighting a very successful programme linking science mentors with high school students in the Australian Capital Territory, plus a report on ASEG prizes and awards to Australian university students.

News of the Science Mentors programme comes from Geoff McNamara AM who has been a science teacher in the ACT for 18 years. He is presently the Convenor for Science Mentors ACT, a programme in which students undertake investigations under the supervision of practising researchers in a wide range of sciences and engineering. He has proved a remarkably innovative teacher, founding the mentors' programme and Canberra's only astronomical teaching facility

for high school students, and gaining multiple awards for teaching excellence, culminating in his being made a Member of the Order of Australia in the General Division, in 2018.

Teaching was not his first career choice; he began as a spectacle maker and teacher of optics. We can perhaps deduce that even at that early stage of his career, his special interest lay with the far-sighted.

I'll take the opportunity to quote from Geoff's article below:

Unless we challenge and inspire young people well before they have to decide on a degree, we won't have the supply of scientists ... needed by the very generation whose future is determined almost entirely by scientific development. But rather than complain, I think it's far more satisfying to be a part of the solution.

Inspiring the next generation of scientists



Geoff McNamara AM
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Imagine if you had the opportunity to inspire a young person to take up a career in science or engineering? Most of us can pin our professional origins on a teacher or other influential person in our youth. But teachers manifest themselves in many ways, not always in the classroom.

For the last 10 years or so, I've run a programme out of a Canberra high school linking students in Years 9 to 12 with practitioners in a wide range of scientific disciplines. Called Science Mentors, my goal was to provide students the opportunity to work

with professionals engaged in the student's preferred field. Each student is assigned their own Mentor who spends an average of an hour a week tutoring the student in contemporary research methods. Over eight months or so, the students conduct their own investigations, gather and analyse their own data, and write up their findings in a formal, referenced and refereed report. The average length of the reports is 5000 words; the longest produced so far was 13 000 words written by a Year 12 student.

In one early investigation, one of my Year 9 students, Charlotte Andersen from Melrose High School, used data from three seismometers, one of which was installed under her classroom, and learned how to locate individual seismic events. She identified 21 tremors ranging from magnitude 1.3 to 3.7, linking most with known fault lines. Unfortunately, she lacked clear evidence of any uncharted faults.

It sounds like a lot of work, and it is: the demands on the student far exceed that needed for a typical high school education. But the telling thing about Science Mentors is the fact the students keep coming back for more. They simply get so very much

out of not only learning more about a branch of science in which they're interested. There's more to it, however. The inspiration of working closely with a professional scientist is irresistible to these curious minds.

The benefit works both ways. Mentors frequently tell me they are themselves inspired and find great satisfaction in being able to help a young person learn their trade. I won't say that they always find it easy: every now and again a new mentor will express the challenge of explaining complex ideas to a student with only Year 8 maths and science behind them. Once over the initial learning experience of their first student, however, mentors normally come back the following year for another student. For them, the attraction is more than working with a willing student prepared to make a sustained effort to understand science. The remarkable intellectual and attitudinal growth that the mentor sees in the student – and the realisation that the growth is due to their efforts – is deeply satisfying.

The programme has grown steadily, and at the end of 2018, 35 students graduated from the programme. As of 2019, the programme is being rolled out

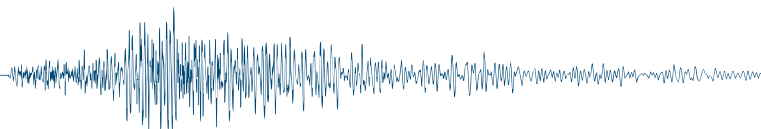


Figure 1. Graphic adapted from the 2018 Science Mentors Awards presentation showing the range of scientific disciplines students have engaged with since 2012. Geology, seismology, and spatial sciences have been highlighted for this article.

across the Canberra region. Students from any government school can now apply for a partnership through Science Mentors ACT. I link the kids with one of the 60 or so scientists and engineers I have on standby.

Most of the investigations are carried out either at the school, in the field, or at an astronomical teaching facility called MSATT I built at Mount Stromlo Observatory. Occasionally, the project calls for specialised facilities of the mentor's home institution. Facilitating

such activities (the students are all minors) is one of my core duties and presents no problems for the mentors. Parental support has been astonishing, and they are just as excited about the prospects for their child, so the partnership becomes four way: student, mentor, teacher, and parent. The result of all this work – most of which the student has to carry out – is a young person not only skilled and experienced in science and science writing. More than that, they are inspired.

The variety of interests of the students is illustrated in [Figure 1](#), which shows the range of sciences covered so far. Each year, a few more branches are added, while staples like the earth sciences remain constant. However, as the programme grows, students such as Emily Bryce ([Figure 2](#)) and Muhammad Abdullah ([Figure 3](#)) need more mentors. If this kind of experience appeals to you, or you want more information, please get in touch.

Beyond the personal experience, there's a larger issue at stake. It's become downright fashionable to talk about the importance of STEM in Australia, and a great deal of attention is focused on the tertiary sector. What needs to be understood, however, is no matter how good STEM education is in our universities (and it is very good indeed), unless we challenge and inspire young people well before they have to decide on a degree, we won't have the supply of scientists – or at least the scientifically literate – needed by the very generation whose future is determined almost entirely by scientific development. But rather than complain, I think it's far more satisfying to be a part of the solution.

All it takes is a little time, a little patient explanation, and your brilliant example as a scientist.



Figure 2. Mentor partnerships involve experienced professionals engaging with intelligent, curious, and hard-working students. Here, Dr Sofia Samper-Carro is tutoring student Emily Bryce in the field of zoo-archaeology at the Australian National University.

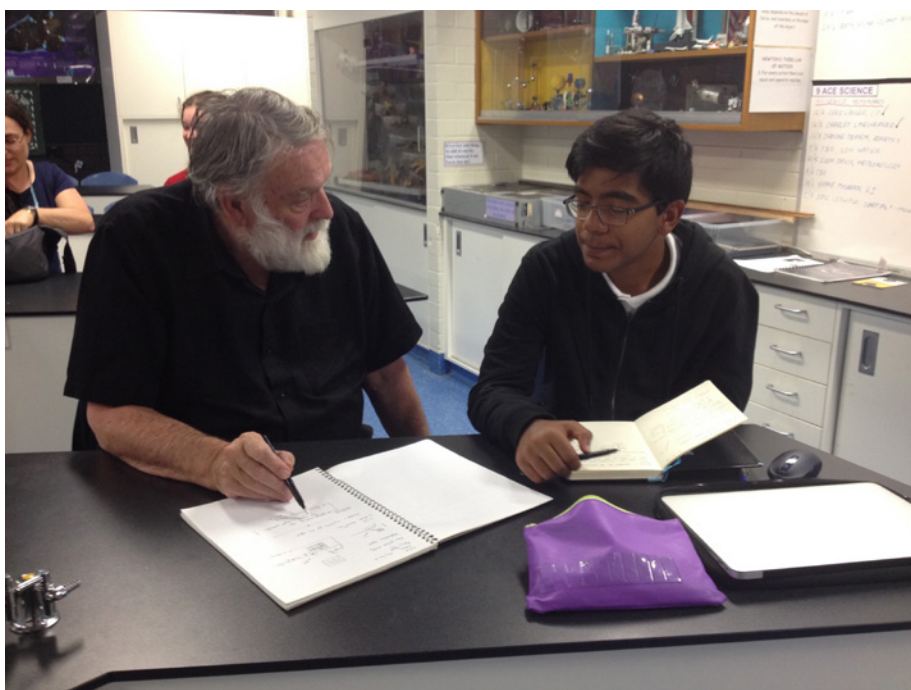


Figure 3. Adjunct Professor John Rayner tutoring Muhammad Abdullah in quantum physics. Muhammad's practical work was conducted at the Science Education Centre, Melrose High School.

2018 ASEG student awards and state branch prizes

WA Student Award

Congratulations to **Alex Costall** (PhD in geophysics, Curtin University, Curtin University) on winning the ASEG WA Student Award for 2018, with the thesis subject “Dynamic Groundwater Flow and Seawater Intrusion in High Quality Coastal Aquifers”. Student Awards are funded by the ASEG Federal Executive and awarded on the recommendation of state branches.



Alex Costall

Alex’s enthusiasm is evident in his description of the subject as follows.

This last year has taken me into the wonderful world of karstic aquifers, numerical groundwater flow – and solute transport – modelling. A “karst” refers to terrain with distinctive structures formed from highly soluble rocks, such as limestone, dolomites, gypsums, etc. Exposure to flowing groundwater causes the rock matrix to dissolve, which can greatly affect the flow of groundwater. Caves, conduits, and fractures all present high-permeability pathways for groundwater to travel.

Some of the highest quality coastal groundwater reserves around the world exist as extensive karstic aquifer systems. At coastal margins, the invisible and ever-looming seawater interface threatens fresh groundwater resources. As the changing climate affects groundwater recharge and growing world population continues to rely on these aquifers for drinkable groundwater, the risk of contamination has implications for millions of peoples worldwide.

Geophysical exploration methods offer unparalleled access to subsurface information, but it is not without flaws. Resistivity imaging is commonly used, but rarely with time-lapse investigation



Presenters at the ASWG WA Branch Student Technical Night. Left to right: Evgenii Sidenko, Heta Lampinen, Alejandro Sanchez, Sean Standen, Mrinal Denis Deane, and Jeremie Giraud.

or optimal acquisition/inversion strategy in mind. Numerical solute transport modelling has potential to aid our understanding, and define the limitations, of both the geophysical and conventional sampling methodology. Outcomes from this research aim to improve groundwater monitoring practices and numerical modelling outcomes with regard to the seawater interface. These outcomes will ultimately aid groundwater management decisions and help to preserve our fresh water resources for future generations.

WA Student Technical Night

The ASEG WA Branch hosted a Student Technical Night on 28 November. Six undergraduate and postgraduate students from the University of Western Australia (UWA) and Curtin University presented their recent work in the field of geophysics. They were:

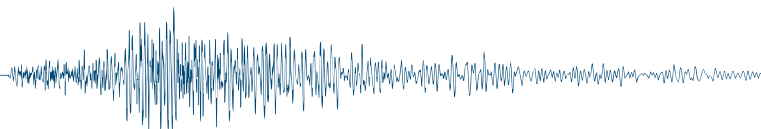
- Mrinal Denis Deane (Curtin) – “Derivation of Seismic Sequence Attributes from VSP Data as Proxy Lithological Parameters For Harvey, WA”
- Jeremie Giraud (UWA) – “Integration of geological uncertainty into geophysical inversion by means of local regularization”
- Heta Lampinen (UWA) – “Basement architecture for the polymetallic sediment-hosted Abra (cadabra)”
- Alejandro Sanchez (Curtin) – “DHI for gas prospecting and lithology discrimination for the Otway Basin, Victoria”

- Evgenii Sidenko (Curtin) – “Application of seismic interferometry to increase 3D VSP illumination”
- Sean Standen (UWA) – “Characterising fault scarps in the south of Western Australia based on underlying pre-existing geological weaknesses to improve the current understanding of past and current seismic release.”

Attendees were asked to vote on the best presentation, and **Alejandro Sanchez**



WA Branch Best Student Presenter 2018, Alejandro Sanchez, with WA Branch President Heather Tompkins.



won the award for 2018. A copy of his abstract appeared in *Preview's* summary of student projects completed in 2018 (December 2018).

SA Student Honours Night

On the evening of 11 December, the SA/NT Branch held its combined Christmas party and Student Honours Night. Two local honours students presented the results of their research work. They were:

- Michael Rieger (Australian School of Petroleum, University of Adelaide) – “Constraining the regional slope of

Western Papua New Guinea: A study of lithospheric flexure”

- Robin Keegan-Treloar (Flinders University) – “A multi-method hydrological study of Wither Swamp, in the Fleurieu Peninsula, South Australia.”

These two talks were both very well done (both received awards for their presentations), and highlighted the breadth of our science. Robin's talk presented high resolution geophysical images over a small but important spring system south of Adelaide, where the study area was on the order of 100×100 m. Michael's work involved examining and modelling stress fields

that covered at least a third of Papua New Guinea. For pictures of these speakers in action see the SA section of the ASEG Branch News in this issue.

NSW Student Technical Night

Four students made presentations the ASEG NSW Student Technical Night in October 2018.

Steph Hawkins and **Alice Van Tilburg** were both awarded ASEG NSW Branch Tertiary Student Scholarships in May 2018. Their project topics were:

- Steph Hawkins (Macquarie University) – “Investigating an igneous dyke swarm using applied field magnetism”
- Alice Van Tilburg (Macquarie University) – “Exploring Lithospheric Scale Structure in the Eastern Yilgarn Craton with 3D Magnetotellurics.”

Copies of their abstracts appeared in *Preview's* summary of student projects completed in 2018 (December 2018).

ACT Student Award

In November, The ACT Branch of the ASEG was delighted to present **Kathryn Hayward** with the 2018 ACT Student Award. Kathryn presented an interesting talk to the Branch that described how pore fluids influence rupture dynamics during earthquakes and discussed the seismological evidence that suggests there is a significant difference in fault behaviour between classic stress-driven earthquakes and those driven by changes in pore fluid pressure.



Student presenters at the NSW ASEG Branch meeting. Left to right: Alice Van Tilburg, Steph Hawkins, Xueyu (Tom) Zhao and Jie Wang. At right – Mark Lackie, NSW Branch President.

Call for nominations for OzSTEP and OzLEAP Distinguished Lecturers

OzSTEP and OzLEAP are the ASEG's Distinguished Lecturer programmes. OzSTEP courses tend to cover entry-level topics and typically last one day. OzLEAP are more specialised, and typically last for at least two days. Selected courses are hosted by state branches around Australia.

The ASEG Education Committee is currently seeking OzSTEP and

OzLEAP lecturer nominations from Members. All nominations are assessed against criteria including: annual Member survey requests; scientific quality; non-commercial; cross-disciplinary appeal; and audience engagement.

Nominations (self-nominations are encouraged!) should be directed to education@aseg.org.au by 1 March 2019. Please supply a:

- seminar/course title and synopsis (a list of major topics covered is fine)
- preferred duration
- brief presenter biography

Please refer to the ASEG OzSTEP/ OzLEAP webpage <https://www.aseg.org.au/continuous-education/ozstepozleap> for additional programme details and list of course topics suggested in the most recent Member survey.

Environmental geophysics



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Evolution not revolution over the past 25 years

Welcome readers to this issue's column on geophysics applied to the environment. I was having some trouble thinking of a topic this month then my wife (a geochemist at the University of Adelaide) got me thinking about how the science/art of geophysics applied to the environment has changed over the last 25 years. She then (being the master of net searches) found a 1994 article by Robert Whiteley in *Exploration Geophysics* titled "Environmental Geophysics: Challenges and Perspectives" (Whiteley 1994). She followed up by finding a second, short 1994 abstract/article by Phillip Romig in the SEG conference archives titled "Environmental Geophysics – Fad or Future" (Romig 1994). These articles were written 25 years ago, and seemed to me to be good starting points for thinking about how environmental geophysics has changed over that time, and where it might be going. They also reminded me about some things that we might usefully revisit from way back then. One article has a more Australian viewpoint, the other has a more American viewpoint.

Let's start with the Romig abstract – while short, it makes several very good points (some that overlap with Bob's article as well). Romig comes at the topic from the viewpoint of a geophysicist contemplating a move from the oil industry to environmental geophysics during one of the oil industry downturns.

He starts by reviewing predictions for the environmental geophysics "industry" – with some observers at the time stating that environmental geophysics could quite soon be bigger than the oil industry; others, of course, claiming that it was nothing more than a fad. In my opinion it still feels as if environmental geophysics is in its infancy (25 years later!), and has a way to go before it becomes a routinely used tool in a geohydrologist's toolbox. More on that later.

Romig also points out that site characterisation (I am thinking of this as "the final product") differs between oil exploration and the environmental industry. Exploration is driven by a "risk-taking, revenue-generation psychology" whereas the environmental industry is more about cost-control and risk minimisation. His final point is on the source and quantity of available money for this type of work in these respective industries. Oil exploration is directly funded by the oil companies – their success at finding oil, at a lower cost than producing the oil, is sufficient justification for using geophysics (in my possibly oversimplified view). As Romig says: "No such simple cause-and-effect relationships exist in the environmental business".

The economic issues that Romig highlights are, for me, a big part of the problem. In exploration even a slight improvement in drilling success based on geophysical information can be worth the investment in geophysics. My feeling when talking to professionals in the environmental industry is that geophysics is seen as too expensive and not worth the effort – possibly given the (occasionally?, frequently?) ambiguous results. I think that this attitude is starting to change, but we will need to keep improving our outputs to close the gap between perception and reality.

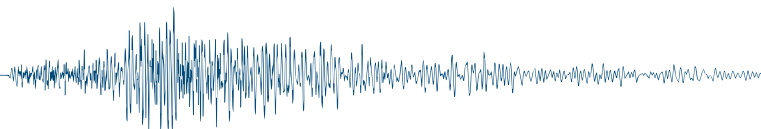
Bob Whiteley's article gives two examples of environmental problems that were current 25 years ago – at least in the Australian setting. The first is still a huge issue over here: dryland salinity. His main point (that I got anyway) is that as environmental geophysicists we cannot just make maps that show the locations of reflectors, or conductive features, etc. We need to produce maps that show parameters that actually mean something to a hydrologist or engineer.

He describes the painstaking process of converting conductivity data collected using a typical earth conductivity meter into actual soil conductivity by regressing the geophysical data against lab-measured soil parameters so that, for example, the total volume of salt stored in the top 5 m of soil could be estimated over a project area. The original conductivity map is likely to look similar to this final product, but actual salt content will not be "correct" without understanding local conditions, specifically clay distribution in the soils.

The second example given by Whiteley is also still a major issue: contaminant leakage (specifically LNAPLs and DNAPLs) into groundwater. Direct detection of these contaminants is very difficult, even though electrical contrasts between the contaminant and the host can be large. In my limited experience, which is only two or three surveys in the last 25 years, it is the urban setting that is the problem. Surveys can run over, for example, concrete pads reinforced with metal rebar that can make most electrical data nearly useless. There are often power lines and other noise sources that also make the use of electrical techniques in these settings difficult. Seismic techniques, in turn, are affected by, for example, local traffic that introduces vibrational noise into those data sets. Unfortunately we have not yet worked out how to see past such urban noise.

So what is different (better?) about environmental geophysics these days? To me there isn't any development that has been truly revolutionary, with most only evolutionary. But we are getting there. One of the most important improvements is the incorporation of GPS information into most data sets, so that we really do know exactly where we are over most survey areas. Our ability to get down to centimetre accuracy with only moderate effort has also made a big difference. In addition, our ability to make the data "real" has improved – here I am thinking of the nearly routine inversion of most of the data that we collect, as well as the improvement in inversion quality. I think that this is a major step toward making our data sets more accessible to others who need to use this information but are not geophysicists.

Along with these developments I think that we are finally starting to make progress removing some of the inherent



ambiguity that we see in some of our data sets that make the use of, for example, electrical geophysics less appealing to non-geophysicists (is that conductive feature a sandy unit in highly saline groundwater, or is it a clay unit?). We are also starting to improve the quality of our products by better incorporating ancillary data. I have rambled on before about the use of NMR in groundwater work to help with this discrimination process, and foresee this as becoming more common - even though NMR is still an expensive technique to run. I am hoping to see more joint inversion of various data sets to produce maps of, what to me is one of the holy grails of the geo-hydrological world - hydraulic permeability (as well as other parameters that are of interest to engineers, etc.).

An area of research that was not really on the radar 25 years ago is the study of uncertainty, and its propagation

through to the various products that we generate. This is looking like a "growth industry" in the environmental field in general. I also think that there are now research/work opportunities that could not possibly have been foreseen in the mid-nineties: the growth of non-conventional energy sources and the often contentious fracking process. We need to do more to improve our ability to image hazards that have the potential to affect the integrity of the fracked well, thereby making the process safer and even, possibly, help to improve the public's perception of the unconventional gas producing process.

And finally Bob, in his article, reminded me of two technological aspects that I think are interesting and could usefully be revisited in environmental geophysics. The first is the careful correlation of soil types with response from, for example, "simple" terrain conductivity metres like

the Geonics EM-38. I don't do enough of this myself, but I suspect that correlations could be improved with the use of well-inverted data sets. The second is the Radiowave Electromagnetic Methods that were of interest in the mid to late 1990s. Coincidentally, I was recently reminded of this research in discussions with another group, and am motivated to look further into these methods and to see why we don't hear much about them these days. Stay tuned!

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Minerals geophysics



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Holiday reflections

I'm writing this on Boxing Day while on holiday in the Cederberg Mountains, Western Cape, South Africa, and I'm in a reflective mood. As well as South Africa, I've been fortunate enough to spend time in Chile and Argentina during the past year. Like Australia, all three countries have important mineral and/or energy resources sectors that contribute significantly to their respective economies. In contrast to Australia, where mining and energy exploitation often meet with well-publicised opposition, my impression is that these three countries view their resource sectors in a more positive light, and there is a greater appreciation of the contribution that the resources sectors make to their respective country's economies. Chile, in particular, with its long history of copper and nitrate mining, proudly celebrates its mineral resources sector.

Why this difference? The Australian resources sector by and large is very well run, takes its environmental responsibilities very seriously, and its continued success is vital to Australia's economy. Yet, in the media, mining is too often depicted as wanton exploitation

of the public-owned assets by greedy overseas corporations, often with the inference that all the minerals will soon be exhausted and we'll be left with nothing but huge holes in the ground. The general public has little idea of how the mining industry functions. The low likelihood of success in mineral exploration, the sheer persistence and sometimes brilliant technology that is needed to find new deposits, and the huge amounts of risk capital involved in developing those deposits are all generally unknown. Even the contributions that the mining industry and related science and technology make to our everyday lives (just about everything we use!) go largely unacknowledged. It strikes me as a bit rich to criticise mining while blithely enjoying all the benefits that mining brings.

Does it really matter that the mining industry suffers from bad press?

Well, yes it does. University graduate numbers are dropping (particularly in mining engineering) as the resources sector is increasingly seen as a less desirable career option. Australia is no longer a net exporter of geoscience professionals to the world. Access to land for exploration and mining is becoming increasingly difficult, both through an increase in governmental regulatory controls and in the face of well-publicised public opposition; some states have taken to the complete banning of exploration for some commodities in designated areas. Australia is at risk of being seen as a less desirable place to explore for minerals and invest in resource development.

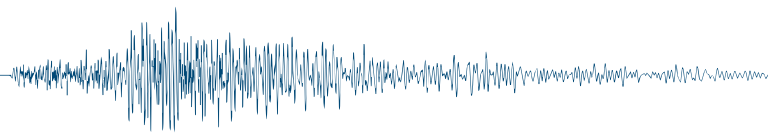
How did this happen? Perhaps the mining industry itself must share some of the blame. There's been good co-operation between the resources

industry and tertiary institutions in educating geoscientists and in designing and funding industry-specific research. But, as an industry, we've done little to educate and inform the general public directly, instead relying on the media to tell our stories. In popular entertainment, mining suffers from a dreadful image: if we're not mining a planet to destruction with slave labour, mad geoscientists are poisoning the ground water with ill-advised exploitation.

But, to my mind, the stand-out omission by the mining industry is in the education of the educators and through them, the children. Arguably, the image of the mining industry currently presented in the education program is not balanced. Listening to my grandchildren, it's clear that their educators have a negative and uninformed view of mining. I appreciate that any contribution to education by the mining industry would be viewed with deep suspicion in some quarters, but surely that should not be a barrier to education? And while we're at it, how about a mining industry-financed program to teach children how to think, rather than what to think, i.e., cause and effect, two sides to an argument, the importance of scientific evidence, the need to research and verify, etc.

I've got a rather different take on the future of the mining and exploration industry, more in tune with modern attitudes, which I plan to elaborate on in the April issue of *Preview*.

And finally, something to celebrate. The excitement generated by Rio's apparent base metal exploration success in Western Australia, and by BHP's recent stunning copper intersections on the Stuart Shelf in South Australia, could herald renewed interest in mineral exploration in Australia. Surely, it's these stories of technical brilliance and perseverance that we should be telling to as wide an audience as possible?



Seismic window



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Fracking

Fracking or hydraulic fracture stimulation (Figure 1) has become the latest target for anti-petroleum protest groups. That would be fair enough if the industry was destroying the environment, contaminating schools or polluting ground water as claimed, but more than 14 reports and inquiries in Australia have concluded that the process can be considered to be safe.

The WA Government released its long awaited report on fracking in WA at the end of 2018. This report also concluded that fracking is proven to be safe when properly regulated, but the WA Premier had to contend with vocal constituents who oppose the process. The decision he made was a pragmatic compromise, fracking is allowed on current exploration leases and 98% banned everywhere else.

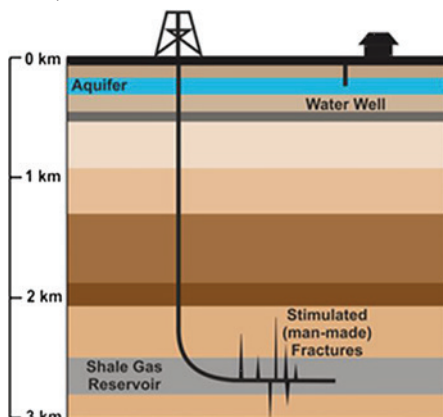


Figure 1. Simplified diagram of hydraulic fracturing (fracking) for shale gas. A well is drilled down into the shale gas reservoir. At the target horizon, high-pressure fluids are injected into the shale. This produces man-made fractures that enable gas to flow from the shale into the well. Source: ReFINE fact sheet.

The “fracking” debate is typically emotion vs science, obfuscation vs clarity, and the dramatic vs the accurate. Any reasonable argument based on facts and science is ignored and, despite the studies and research, a typical internet comment is “there should be no fracking done anywhere. It’s an environmental disaster”.

To add to the debate, here are my five facts about fracking:

Fact 1: Artificial fracture stimulation has been conducted in Australia for more than 50 years without incident

Fracking is a well-established process and has been safely carried out in Australia for decades.

Santos has used artificial stimulation to produce oil and gas for almost 50 years in South Australia and Queensland, while in the Northern Territory, fracking was first used in 1967.

More than 600 wells have been fracked in Western Australia since 1958, the first being Goldwyer-1. On Barrow Island, an A class reserve, 563 wells have been fracked since 1965.

Fact 2: The longest recorded artificial fracture is less than 600 m

A few years ago, Durham University in the UK compiled a database of natural and artificial fractures that was available for download. It has since disappeared, but researchers, under the auspices of the ReFINE (Researching Fracking in Europe) Consortium, have published this:

Our study examined thousands of natural and stimulated hydraulic fractures. For **natural fractures**, analysis of 1170 examples from offshore Norway, West Africa and Namibia showed the maximum reported height to be 1106 m. For thousands of **stimulated** hydraulic fractures in shale gas fields the maximum reported height was 588 m. Mathematical analysis of the datasets indicates that the likelihood of a natural hydraulic fracture extending vertically more than 350 m is about 33%. For hydraulic fractures stimulated by shale gas fracking, the likelihood of them extending more than 350 m is less than 1%.

Fact 3: No drinking water aquifers have been contaminated by fracking

The WA Health Department completed its own review of fracking. It noted

that targeted gas reserves were located between 2 and 4 km below the ground – well below the potable ground water sources – and found that fracking could be done safely.

And the view of Australia’s Chief Scientist, Dr Alan Finkel? “The evidence is not there that it’s dangerous,” he told the ABC in 2015. “In fact, the evidence is that, if properly regulated, it’s completely safe.”

But what about the secret chemicals in fracking fluid? There are additives, but they are not very secret – you can get a list of these here:

<https://www.appea.com.au/wp-content/uploads/2014/08/CSG-fracking-chemicals.pdf>

An interesting exercise is to look under your kitchen sink and compare what you have there with items on the fracking list.

Fact 4: The *Gasland* movie is fiction

The anti-fracking movement gained considerable support and momentum following the release of the *Gasland* movie. It has since been found that the movie was contrived and deceptive and has been discredited. The water supply to the spectacular flaming faucet was indeed burning methane from the aquifer. This methane was determined to be either biogenic or naturally occurring gas two years before the movie’s release. In *Gasland II*, a garden hose was deliberately attached to a gas supply point before the nozzle end was lit. It was all a stunt.

Fact 5: No one will listen to you

The above facts should put you in the box seat at your next family gathering, but from my experience, you will be met by relatives with fingers in their ears and making a LA LA LA sound. I suggest you talk about religion, politics or the weather (not climate) instead.

Some interesting websites:

<http://www.refine.org.uk/>

<http://www.refine.org.uk/media/sites/researchwebsites/1refine/frackingsummaryrb/Fracking%20Summary%20RB%202.0.pdf>

https://frackinginquiry.wa.gov.au/sites/default/files/final_report.pdf

<http://www.refine.org.uk/media/sites/researchwebsites/1refine/framingfrackingrb/Framing%20Fracking%20RB%20English.pdf>

Data trends



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Passive seismic file formats continued

Passive seismic file formats continue to be the theme of this column, as I explore the files that industry is

generating, and what we can do with them.

Discussions that were sparked by this column in the last issue of *Preview* have focused on the two well established formats, SEED and SAC. The general consensus seemed to be that while exporting in the active format of SEG-Y rev 2 is possible, the format is not a natural fit for certain passive seismic data. However, the conversation is continuing around points of specificity and upcoming exchange formats.

The most common exploration datasets at the moment are from Tromino devices and those datasets are most easily shared between Tromino users in ASCII time series format. Since the format ticks the time series and ASCII boxes, further deliberations on an acceptable ASCII format for data exchange, akin to other ground surveys, would cater for this large and growing user base.

It has also been pointed out that the Adaptive Seismic Data Format (ASDF5),

a HDF5 variant, is expected to supersede miniSEED for data exchange in the near future. Rooted in the passive data collection of astronomy, the hierarchical data format is a database-like file that has occasionally been mooted as a rival for increasingly large survey files of all types. The format has wide support in many programming languages and ASDF5 has various open source read/write options available through their website and Github repository (<https://seismic-data.org/>).

EDI file format

I am also garnering opinions on the EDI (Electrical Data Interchange) file format. Admittedly my personal experience is limited to David E. Wright's easy to read 1988 SEG presentation on the format, and some minor parsing. I have heard that some geophysicists have their own interpretation of the standard. Have you used EDI and have you found consistency problems? Please send your comments and suggestions/ideas to me at technical-standards@aseg.org.au.

Magnetic pole on the move

Alanna Mitchell in her latest book "The Spinning Magnet" (Mitchell 2018), which is reviewed in this issue of *Preview* (Henderson 2019), said "The north pole is on the run" and also, "each version [of the World Magnetic Model] is out of date by the time the new one is made". These remarks seem to be particularly apposite, judging by the very latest news about the sudden acceleration of the north pole's position, and the

consequent changes in the shape of the Earth's magnetic field.

The following is extracted from an article by Alexandra Whitze in *Nature*, 9 January 2019, titled, "Earth's magnetic field is acting up and geologists don't know why".

Earth's north magnetic pole has been skittering away from Canada and towards Siberia (Figure 1), apparently driven by liquid iron sloshing within the planet's core.

The most recent version of the World Magnetic Model came out in 2015, and was supposed to last until 2020 – but the magnetic field is changing so rapidly that researchers will have to fix the model as soon as possible.

The problem lies partly with the moving pole, and partly with other shifts deep within the planet. Liquid churning in Earth's core generates most of the magnetic field, which varies over time as the deep flows change. In 2016, for instance, part of the magnetic field temporarily accelerated deep under northern South America and the eastern Pacific

Ocean. Satellites such as the European Space Agency's Swarm mission tracked the shift.

Scientists are working to understand why the magnetic field is changing so dramatically. Geomagnetic pulses, like the one that happened in 2016 beneath South America, might be traced back to "hydromagnetic" waves arising from deep in the core. And the fast motion of the north magnetic pole could be linked to a high-speed jet of liquid iron beneath Canada.

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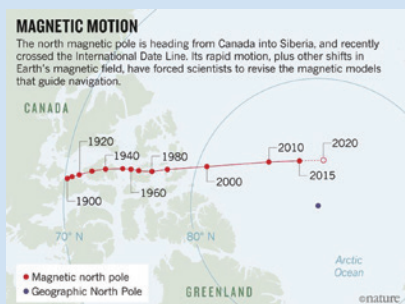
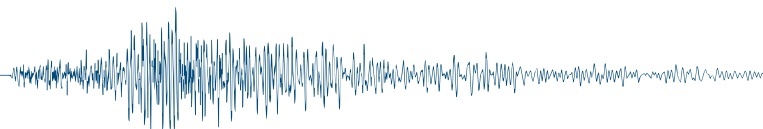
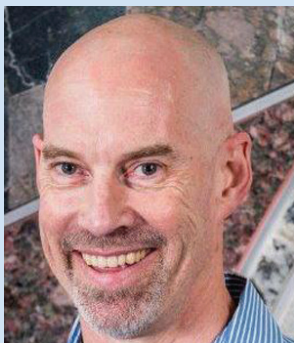


Figure 1. Movement of the magnetic north pole. Source: Whitze (2019).



Webwaves



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Encryption

This is the first *Webwaves* column for 2019, and Members should see requests-to-view *Exploration Geophysics* papers and *Preview* articles served from the ASEG's new publisher, Taylor & Francis, rather than CSIRO. Access is much simpler in 2019, since tokens are not required to be passed to the publisher from the website. After (renewing membership and) logging in, Members should navigate to <https://www.aseg.org.au/publications/publications-members-only> and follow the link https://www.aseg.org.au/publications_tnf. Naturally, should Members run into issues, please send an email to webmaster@aseg.org.au

describing what you were trying to do so that problems can be addressed.

The main theme of this *Webwaves* is encryption, which is the process of encoding a message or information in such a way that only authorised parties can access it, and those who are not authorised cannot (Wikipedia 2019a). Although they are somewhat related, encryption differs from data protection in that while data may be acquired by unauthorised parties, strong encryption can protect that data whereas weak (or no ...) encryption cannot.

These differences are recognised by Australia's NDB regulations, which were enacted 12 months ago. Users are not required to be notified if there is no danger, for example, because data are strongly encrypted. It should be noted that "strong" simply means that the method of encryption can resist attacks long enough to protect the encrypted information for a useful length of time. It does not mean "uncrackable" since advances in cryptography (or computer hardware) can substantially reduce the effort required to decrypt data.

Late in 2018, the Australian Parliament passed a bill (The Access and Assistance Bill, detailed at <https://bit.ly/2Aml0ct>) designed to give intelligence agencies more power to access individual's encrypted conversations. Where a warrant has been issued to intercept telecommunications, the head of an

interception agency can issue a "technical assistance notice" for a company to help decrypt said device. Such notices are interpreted to mean that companies providing telecommunication services pro-actively work to build mechanisms to help authorities collect information, in other words, intentionally weaken encryption.

Much communication, commercial and personal, nowadays takes place through virtual private networks (VPN), which is an encrypted tunnelling protocol. Indeed, Australia's last Prime Minister famously used WhatsApp which sets up a VPN between parties. VPN's are used because they offer secure communication so that business can be kept confidential. For this reason, attempts to weaken encryption will have the opposite effect, and businesses will move to stronger encryption algorithms (Schneier 2012). Indeed, a major feature of Apple's iPhone is the ability to encrypt data strongly enough to thwart the USA's FBI (Wikipedia 2019b). Contrary to Turnbull's (ZDNet 2017) assertion (reminiscent of the Indiana Pi Bill of 1897) that "the laws of Australia will trump the laws of mathematics", weak encryption will be considered a bug, and cease to be used. Rather than weaken encryption algorithms, Munroe (2019) suggests the alternative in Figure 1.

While the debate around encryption plays out, the ASEG will continue to try to protect Member's data, and ensure that, after logging in, ideally using strong passwords (Annetts 2018), they have access to all Member publications.

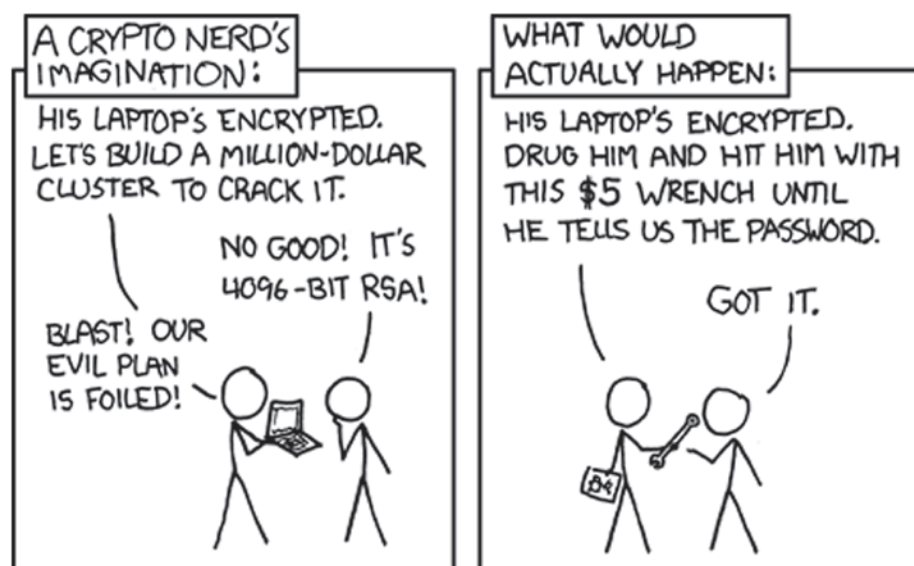
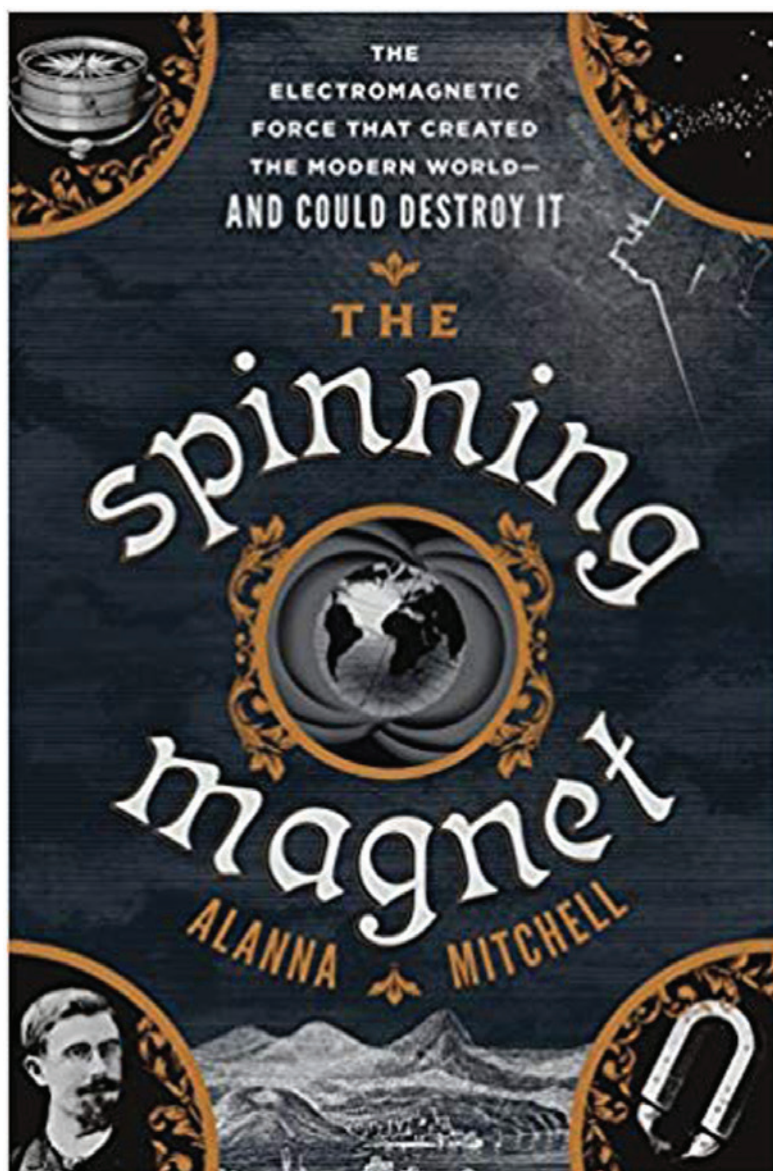


Figure 1. Idealised vs practical decryption (Munroe, 2019).

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Book review



The spinning magnet: the force that created the modern world – and could destroy it, by Alanna Mitchell, London, Oneworld Publications, 2018, 323 pp., RRP US\$28.00, ISBN: 978-1101985168

The subject of this new book is the Earth's magnetic field, with special reference to the reversals of the poles and their consequences. It is told in a very engaging and sometimes informal way. In the author's own words, "What you are about to read is a translation of some ideas from science into journalism". Alanna Mitchell is an acclaimed science journalist, having won prizes and awards for her work,

and, in October 2018, Mitchell was guest speaker at one of the monthly meetings of KEGS, the Canadian Exploration Geophysical Society.

Previous reviewers have said that this book is "a spellbinding scientific detective story", gives "explanations of complex physics in easily understandable terms", and "Mitchell puts magnetism on the map!". My assessment is that the book is a diverting introduction to the subject, and a pleasant review for those who know the traditional history and are keen to know the latest (there are references to publications up to 2017).

This book is not a textbook in the standard sense, as it is without diagrams or equations, although it has a good index and bibliography. To this end, the story is not always told in a logical sequence or without distractions. In this regard, it is instructive to compare it with a more academic study on the same subject, "North Pole South Pole" written by Gillian Turner, a scientist specialising in the subject. However, Turner's book is current only to 2010.¹

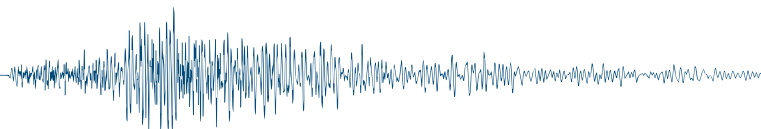
Apart from a Preface, which explains how the author became interested in the subject, the book has four parts: Magnet, Current, Core and Switch. The first two parts deal with the discovery of magnetism, and its association with electricity as a classical physics subject. They include the standard protagonists from Pliny the Elder to Maxwell, including Gilbert, Faraday and many others. Once introduced, most of these individuals reappear in later chapters as if old friends.

While the standard theoretical story of the Earth's magnetic field can easily be found on the web (for example, https://en.wikipedia.org/wiki/Magnetic_field), to the reader familiar with the subject it is the more recent developments, and the researchers that Mitchell has got to know, that are of interest. These appear in Parts 3 and 4, Part 3 dealing more specifically with the internal geophysics of the geodynamo, and Part 4 dealing with solar activity and its effects of a possible diminishing of the field's strength, if not its cessation.

The chapters in each part (totalling 10, 7, 8 & 6 respectively) are, with only one exception, fewer than 10 pages in length. Perhaps this is to make for an easy read. The chapter titles are often seemingly obscure, and not easily relatable to their subject. One called "Pharaohs, fairies, and a tar-paper shack", refers to Mitchell's way of referring to "ferros" and "ferris" types of magnetism.

This book has the most annoying way of providing endnotes. Instead of superscript numbers in the text, which would apparently detract from

¹ North Pole South Pole was reviewed by Ted Lilley in *Preview*, Oct 2010.



the novel style, "Notes" are listed by chapter and page number at the end of the book, with a phrase from the text reproduced instead of a superscript. The problem with this approach is that you don't see these notes when reading the chapter. There are 276 such "notes".

Chapters on classical theory (perhaps considered too "dry") are interspersed with less formal chapters, presumably to retain the attention of the reader. For example, in the first serious chapter, on atomic structure, we are urged on by the words "if we can *wade through* a few more points here, you'll get to one of the ideas that lies at the heart of magnetism". In addition, the author admits to not understanding electron orbits, with "To me it sounds like *gobbledygook*" (my italics).

Even though it is not an academic book, in my opinion it could have benefitted from some illustrations. Turner, by way of contrast, has 56 illustrations including detailed sketches of the prominent players that brings them alive. Mitchell's alternative to this is graphic, sometimes personal, descriptions of the protagonists. One of many examples of this are four pages devoted to the life of Inge Lehmann (as compared to one page by Turner).

As a way of making the story more real and personal, some of these famous contributors to the subject are introduced by present-day advocates whom Mitchell has met in their offices, or at a conference in Nantes. Generally, these "guides" to protagonists are described in surprisingly familiar detail. The name of one of these advocates, Jacques Kornprobst, is the first two words of Chapter 1. He was "sporting a thick, off-white cable-knit sweater the same hue as his rakish hair, ...". He is the "guide" for Bernard Brunhes, who was the first to uncover evidence of pole reversals. The story of Brunhes is told in five typically short, alternating chapters; numbers 1, 3, 5, 7, and 9. While they can be read as one continuous story they are, however, interspersed with chapters on various theoretical and unconnected

topics. This is one of the author's apparent efforts to present the theory in small chunks so as to make it more palatable.

Mitchell's views on geophysicists, say by way of contrast to her descriptions of particle physicists and astrophysicists, is that many geophysicists seem "to be as much at home hacking a piece of rock ... as crunching complex numerical simulations through supercomputers". She does recognise other branches of the profession such as seismology, volcanology, etc.

Insurance against the risk to civilisation posed by disruption of the magnetic field is given a chapter. This is an appropriate consideration at this time, and one which is not likely to be dealt with in a more academic book such as Turner's. The second-last chapter titled "Trout Noses and Pigeon Beaks" discusses magneto-reception, the study of what enables animals to navigate using the magnetic field. As this is a subject of personal interest, I can attest that it is well summarised. Mitchell's references in the (worrisome) "Notes" range only up to the year 2009 on this subject, but research in this area continues to the present day.

Apart from the above two extra short chapters, the remaining four in Part 4 are concerned mainly with NASA projects as described to Mitchell by Daniel Baker, who is "tall and broad-shouldered with straw-straight, gingery hair". These are the projects designed to improve understanding of the external magnetic field. The closing chapter discusses the effects of possible increased radiation on humans from a weakening field.

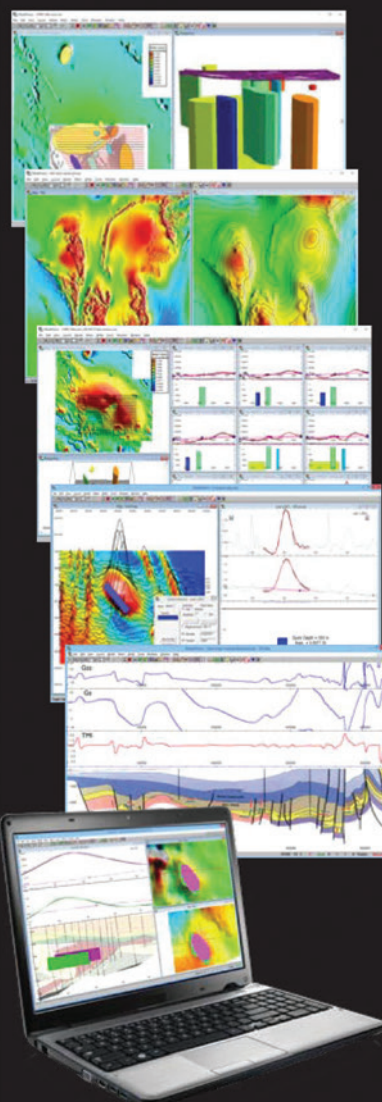
As a result of all her discussions with Baker and many others, Mitchell is left to contemplate the effects of "All these mysterious goings-on below the surface of this spinning magnet we live on". An entertaining read!

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The second lecturer in exploration geophysics in Australia – later to become Surveyor General of India



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The first lecturer in exploration geophysics in Australia, Dr Thirlaway, only held the position at the University of Sydney for 18 months, from October 1949 to April 1951 (Henderson 2016). He left Australia to establish a geophysical observatory in Quetta in Pakistan. Dr Hari Narain, who became the second lecturer in exploration geophysics in Australia, replaced Dr Thirlaway in 1952. At first, he was a Teaching Fellow, then a Temporary Lecturer (1953–1955), and finally Lecturer (1955–1956). Dr Narain completed a PhD in exploration geophysics at the University of Sydney in 1955. His PhD was the first PhD awarded in geophysics in Australia.

Dr Narain's appointment is of interest for a number of reasons. He came to Sydney on a UNESCO fellowship from Allahabad, India, where he had already received a PhD in physics and geophysics. At the University of Sydney, he lectured on all fields of geophysics, but focused his research on regional potential fields. The PhD thesis he completed in Sydney reported on a large number of field surveys with a gravity meter (Figure 1), and the interpretation of the results in terms of geological and crustal structure (Narain 1955).

Narain's thesis work was the basis of a Department of Geology and Geophysics Memoir co-authored by the then Head of Department, Prof C. E. Marshall (Marshall and Narain 1954). This memoir reports on more than 900 gravity observations along a total of 16 000 km of traverses. Over 16 traverses were plotted as Bouguer and Residual gravity anomaly profiles with elevation and geological sections plus the route on geology maps. Figure 2 is an example of one of these plots.

Dr Narain was held in high regard in Australia because of his survey work and was well known as a consultant to private companies (Figures 3 and 4).

During his six and a half years in Australia Dr Narain showed an interest in politics and foreign affairs, especially in relation to Australia and his homeland, and he became Secretary of

the India League of Australia, Sydney. He did not shy away from public debate. In a 208-word letter to the Editor of *The Age* newspaper of 28 March 1953 (*The Age* 1953), Dr Narain, writing in his capacity as Secretary of the India League of Australia, appears to question the claims of a letter from the Press Attaché of the Pakistan High Commission in Australia. Readers will remember that Pakistan was formed by the partition of India in 1947 and was almost an entirely Muslim nation. The period from 1947 to 1956, which overlapped with Dr Narain's time in Australia, was a time of political turmoil in Pakistan.

On 18 May 1953, Dr Narain was the guest speaker at the Newcastle Rotary Club, where he suggested in a 442 word speech that 'Communism was only a passing phase in China' (*sic!*) (*Newcastle Morning Herald and Miner's Advocate* 1953). He claimed that China's 'urge for freedom of spirit' would not permit 'mental regimentation' of its people. At the time of this speech there was much controversy regarding communism in Australia. In 1951 an attempt that was made by the Australian government, under PM Menzies, to ban the Communist Party of Australia was ruled constitutionally invalid by the High Court.

In June 1956, Dr Hari Narain returned to India with his wife and baby son to become a senior geophysicist with the Oil and Natural Gas Directorate of the Department of Natural Resources. Later in his career he would become the Director of India's National Geophysics Research Institute, and then, India's 41st Surveyor General. He held the position of Surveyor General from May 1972 until March 1976. Some of his publications in India include *Political Map of India* (Narain 1972), *Road Map of India* (Narain 1973) and *Scientific Research in India: progress in earth sciences* (Narain 1988).



Figure 1. Dr Narain, wearing a tie, shown reading what is possibly a Worden gravity meter. The other item is possibly a fluxgate magnetometer. His assistant is unidentified. Source: National Archives of Australia.

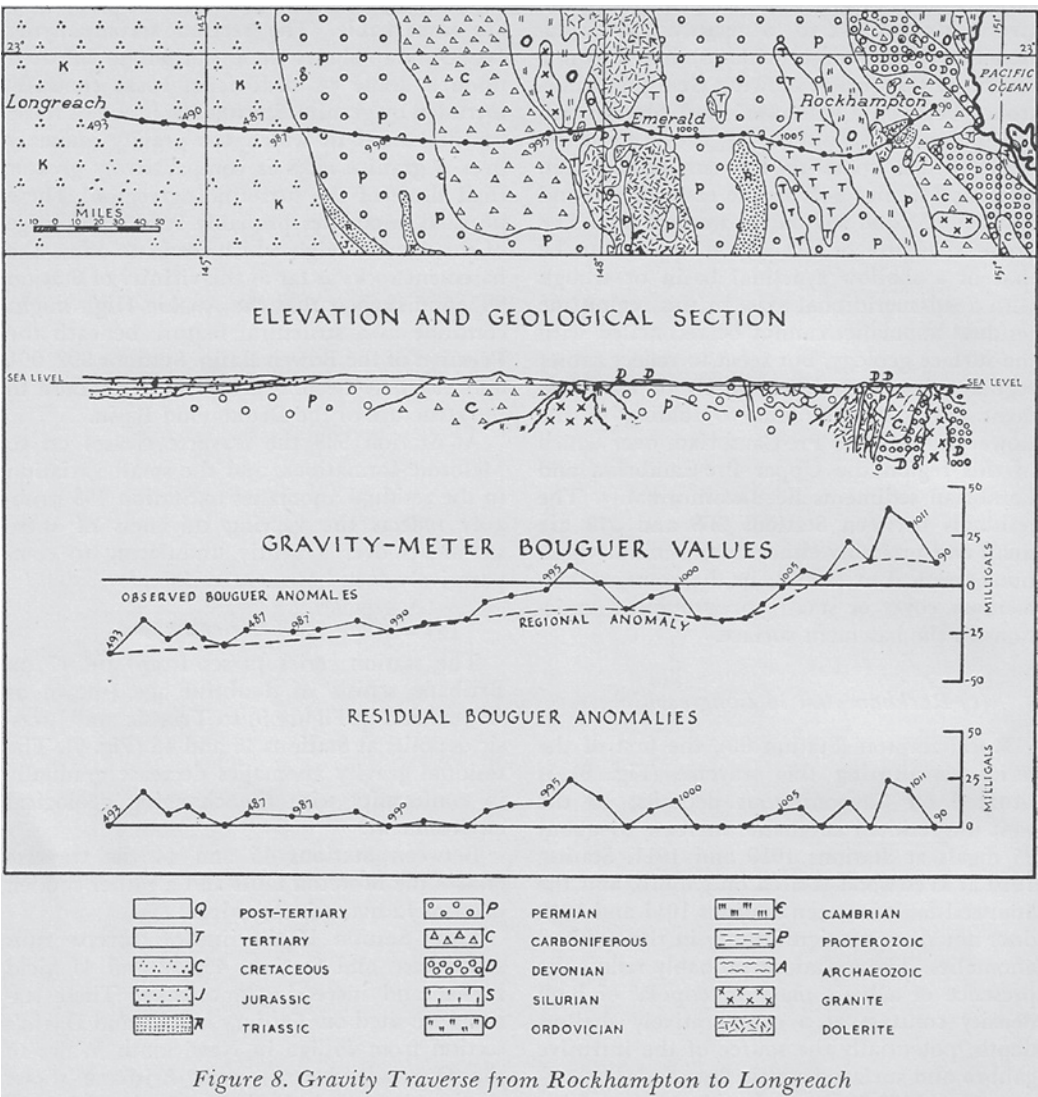
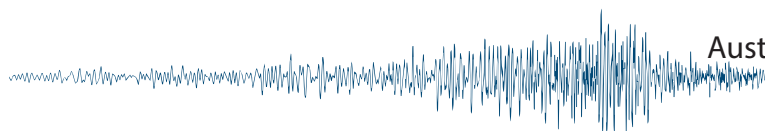


Figure 2. An example plot of one of the gravity traverses from Marshall and Narain (1954).





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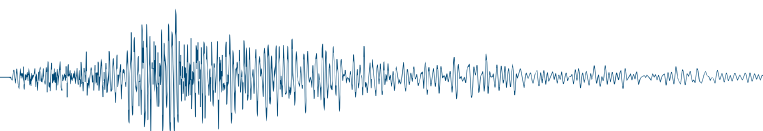


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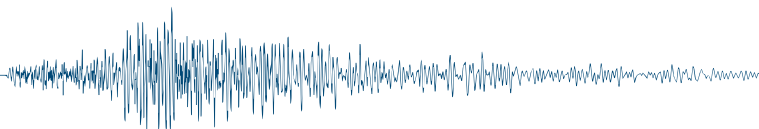
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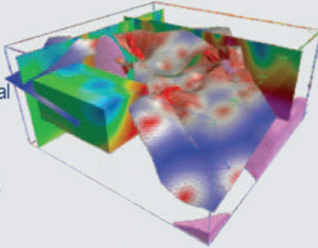
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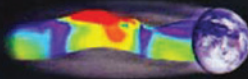
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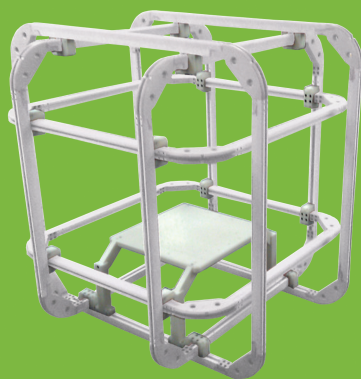
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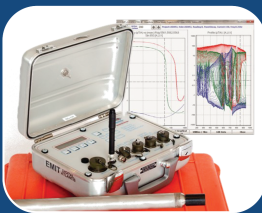
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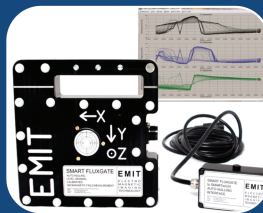
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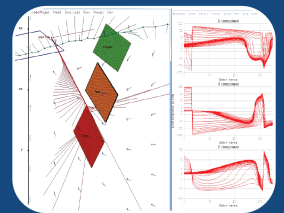
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