Australian Society of
Exploration Geophysicists

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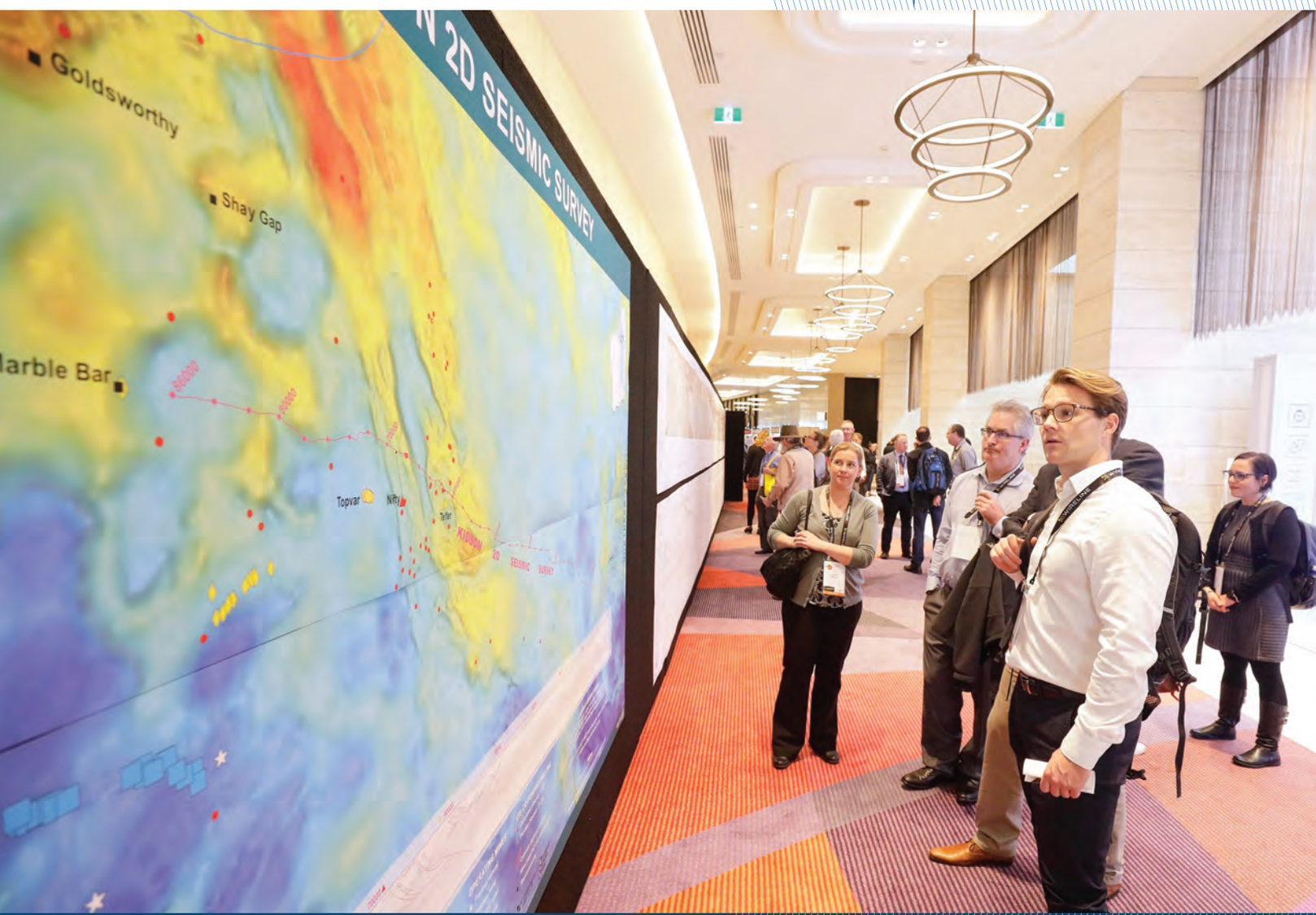
PREVIEW



NEWS AND COMMENTARY

FEATURE

AEGC 2019. Photo montage by David Annetts. All photos taken by David Broadway created by David Annetts

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FRONT COVER

AEGC 2019. Photo by David Broadway

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Editor's desk

This post-conference issue of *Preview* features reflections on the second Australasian Exploration Geoscience Conference (AEGC 2019), as well as details of the conference and exhibition awards, and the ASEG Honours and Awards. In addition, we feature the *Space rocks on display at Geoscience Australia*.

All our usual commentators have also stepped up to the plate. David Denham (*Canberra observed*) reflects on the AEGC before reviewing the latest minerals and petroleum exploration investment figures. Michael Asten (*Education matters*) reports on the progress of current ASEG Research Foundation projects. Mike Hatch (*Environmental geophysics*) takes a look at Grace mapping of terrestrial water storage. Terry Harvey (*Minerals geophysics*) joins David Denham in reflecting on the AEGC that was. Mick Micenko (*Seismic window*) sounds off about Labour's enquiry into seismic surveys. Tim Keeping (*Data trends*) reviews surveying with drones, and Ian James (*Webwaves*) advises readers to adopt *Essential 8* steps to protect themselves and their data.

As many of you already know, not long after the AEGC I set sail for Ethiopia – in a metaphorical sense of course – and I am writing this Editor's desk on the shores of Lake Tana (the source of the Blue Nile). I would like to say that I have a gin and tonic in hand, but unfortunately it would seem that there is a national shortage of tonic water. I have had to make do with the local beer, which is very good but not quite the same!

Ethiopia's mineral potential is still poorly understood and whilst the Ministry of Mines and Petroleum and the Geological Survey of Ethiopia are keen to assist explorers, I have found that there is a dearth of regional geological, geochemical and, particularly, geophysical data. The collection of airborne geophysical data over Proterozoic terrains that include prospective greenstone belts was seen as a priority by the World Bank in a 2014 report on their Strategic assessment of the Ethiopian mineral sector and I expect that when that data does become available it will be of particular interest to gold explorers and producers.

The Editor in the Blue Nile Gorge, Ethiopia.

Metallic minerals aside, I was surprised to learn that Ethiopia is hoping to rival Australia as a producer of opal. Opal was only recently discovered, with the most important discoveries being made in the north Wollo Province in 2008 and 2013. Most of the opal mining is artisanal and the opal is hosted in rhyolitic ignimbrite. The most valuable opal has an orange, yellow or reddish body colour and has been described as precious fire opal. I am hoping to bring some samples back to Australia for Don Emerson, but that is proving to be a bit tricky because Ethiopian opal is often hydrophane and is sometimes "doctored" by dye, smoke, and sugar/acid treatments - difficult to pick with naked eye in a dusty market place!

Speaking of Don Emerson, he is currently putting the final touches on our Christmas treat – an article on pyrite in his inimitable and unbeatable style. Be prepared to settle back, relax and enjoy!

As usual, our Christmas issue will also feature summaries of student research projects in geophysics completed over the past 12 months. All students who have recently completed a thesis in geophysics in Australia are invited to submit a short summary (a couple of paragraphs) together with a short bio (a couple of sentences) and a self-portrait (preferably doing something geophysical) to previeweditor@aseg.org.au. As a bonus, the best student photo will be selected for the cover.

Cheers!!

Lisa Worrall
Preview Editor
previeweditor@aseg.org.au

Call for summaries of student theses completed in 2019

As you complete your thesis and plan your future, please ensure you provide a summary of your thesis to *Preview* (previeweditor@aseg.org.au). Every December *Preview* publishes summaries of student work completed in the preceding year (cf https://www.publish.csiro.au/pv/issue/9305). Not only is this a marvellous opportunity to publicise your work, it is also your chance to catch the eye some future employer – in industry or government, national and internationally!

Letter to the Editor

Dear Lisa

I have just returned from the AEGC 2019 in Perth and wish to congratulate the organisers on a very successful conference. Having been on the AEGC 2018 committee I am well aware of the effort that went into AEGC 2019 and I am sure that the committee are enjoying a well-earned rest and the warm feeling that comes from success. Well done! Brisbane – your turn next!

Unfortunately, I have one complaint about this conference. This is to do with its timing on a variable date every 18 months.

The AEGC is now run in association with both PESA and AIG and it is important that its timing does not clash with other conferences, particularly ones run by the same organisations. The Mines and Wines Conference (M+W), which is a significant Eastern Australian exploration conference, is hosted by AIG. I have been on the committee for this event multiple times, but this year I will be unable to attend because it will be held just a couple of weeks from the AEGC 2019. Also, the "Africa Down Under" conference started on the Wednesday of the same week as the AEGC. I know of several non-attendees at AEGC due to the overlap.

This clash of times makes it impossible for many delegates, including myself, to go to two conferences that they would otherwise like to attend. This is a particular problem for small or medium sized exhibitors, as they simply cannot afford to be at many overlapping conferences.

For the AEGC 2018 the main problem was the proximity to the PDAC in Canada. Many international exhibitors and delegates did not attend AEGC 2018 because of this problem. Also, the AEGC 2018 clashed with school holidays and Chinese New Year, which is a different but related problem. This is counterproductive for the AEGC.

It could be argued that the final dates for AEGC 2019 were set before, for instance, the M+W conference, but the latter is every two years within a couple of weeks of the end of September. We know when it will be and can plan appropriately. The AEGC can be anytime and is impossible to synchronise with.

When the ASEG conference started it was every two years. It became every 18 months to take advantage of the America's Cup in Perth 1983 and, when that was a financial success, stayed at that timing interval to maximise the financial input to the ASEG. However, with the increasing size of the Conference and the inclusion of PESA and AIG, the 18 month variable timing has become a liability and, as a result, will be reducing the possible financial gain to the ASEG from each conference. It is also annoying to many delegates and exhibitors. It is impossible for other conferences to synchronise with this to the detriment of all.

I have canvassed some of the organisers of PESA and AIG on this issue and in every case got the answer that these organisations would be happy with fixed one or two year intervals. Since there would be a revolt from exhibitors if the timing were to be changed to yearly, it seems to me that two year intervals for the AEGC is the only sensible solution. A reasonable time for such a change would be after the 2022 conference due to the long planning time for these events.

I propose that the timing of the AEGC be changed to every two years at approximately the same date. I suggest that any others who have strong feelings on this subject, in either direction, make their feelings known publicly so we can resolve this problem.

Steve Collins
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Non-members of the ASEG can now subscribe to *Preview* online via the ASEG website. Subscription is free. Just go to https://www.aseg.org.au/publications/PVCurrent to sign up. You will receive an email alert as soon a new issue of *Preview* becomes available. Stay informed and keep up-to-date by subscribing now!!

NB: ASEG Members don't need to subscribe as they automatically receive an email alert whenever a new issue of Preview *is published.*

President's piece

The 2nd Australasian Exploration Geoscience Conference and Exhibition in Perth was an overwhelming success!

Our AEGC 2019 Co-Chairs Tim Dean and John Gorter and the Conference Organising Committee, in partnership with Encanta Event Management, worked tirelessly to bring together the high quality and diverse technical programme and social events and a really impressive exploration geoscience exhibition.

Huge congratulations to the organising teams and the chairs of the technical sessions and workshops on the standard of the Technical Program and Trade Exhibition, Workshops (both pre- and post-Conference) and the great social events hosted at Crown Convention Centre.

It has been a pleasure collaborating and co-hosting AEGC 2019 with the Petroleum Exploration Society of Australia (PESA), President, Nathan Parker, and the PESA Executive, and with the Australian Institute of Geoscientists (AIG), President Andrew Waltho, and the AIG Executive. The three societies worked very well together throughout this event.

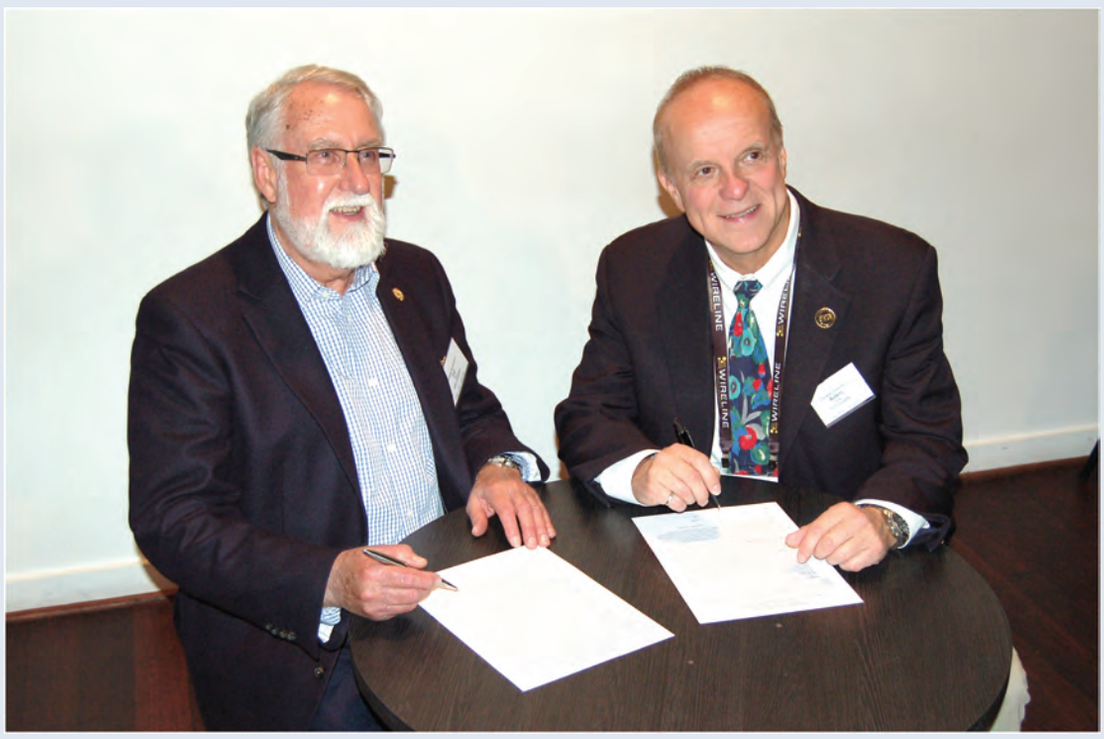
The imperatives for advancing the integration and application of contemporary exploration geoscience, leading to successful discovery, is the underpinning for the ASEG-PESA-AIG partnership model for AEGC conventions. Our three societies are now turning our joint focus to AEGC 2021 Brisbane with planning and supporting the Brisbane Conference Organising Committee, co-chaired by Rachel Kieft and Eric Battig.

Several of the many highlights for me during AEGC included the announcement of the start of the ASEG's 50th anniversary year of celebrations, and also the privilege of announcing and conferring the ASEG Honours and Awards for 2019, details of which are included with some great photos later in this issue of *Preview*. I congratulate all of the recipients of these prestigious awards for their contributions to the science of exploration geophysics and to our Society, and I thank the ASEG Honours and Awards Committee for their exacting work throughout the past year in assessing nominations. A personal congratulation to Dr David Clark for the award of ASEG Gold Medal, which recognises David's exceptional and distinguished contributions to the profession, both in Australia and internationally, through his leading research, publications and presentations in magnetic petrophysics and its application to magnetic field survey design, over a 40-year period.

A further highlight for me and our Federal Executive was co-hosting Rob Stewart, President of SEG, and Yogaani Bhatia, SEG Middle East Office at AEGC, and together working on positive business collaborations as well as enjoying the technical programme, exhibition and social activities. I mentioned in *Preview* Issue 201 that, in our recent exchanges with the SEG leadership, there has been a positive view towards re-energising our partnership and collaborating more closely at future SEG and AEGC conferences. The photo below shows us signing a new SEG-ASEG Memorandum of Understanding, which provides the platform for new collaborative initiatives between our societies.

In 2020 the SEG, our longest standing affiliate society, will celebrate its 90th anniversary, in the same year that the ASEG will be celebrating our 50th anniversary – there will be much to celebrate together!

Ted Tyne
ASEG President
president@aseg.org.au



Dr Ted Tyne, ASEG President, and Professor Rob Stewart, SEG President, signing the SEG-ASEG MoU 2019.

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Executive brief

The Federal Executive of the ASEG (FedEx) is the governing body of the ASEG. It meets once a month, via teleconference, to see to the administration of the Society. This brief reports on the monthly meeting that was held in September 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 August 2019:

Year to date income: $212 395

Year to date expenditure: $204 866

Net Assets: $781 804

Membership

At the time of this report, the Society had 927 Members compared to 970 at this time last year. The ASEG currently has 4 Australian Corporate Members, 2 Corporate Plus Members and one International Corporate Member. Thanks to all our renewed Members and Corporate Members for their continued support in 2019. There are many avenues to stay connected with ASEG including this brilliant magazine, our fantastic website and our wonderful newsletter. You can also follow us on social media – search for Australian Society of Exploration Geophysics. We are on LinkedIn, Twitter and Facebook. Please also remember early and midcareer Members can join the ASEG Young Professional Network www.aseg.org.au/about-aseg/aseg-youngprofessionals

The results of the 2019 Member Survey have been compiled and will be published in the December of *Preview*.

As previously advised (*Preview* 200) the FedEx has welcomed four new Members. They are Jim Austin (Conference Advisory Committee Representative), Mark Duffett (Technical Standards Committee Representative), Ian James (Web Committee Chair) and Tim Dean (Education Committee Chair). Photos and short biographies of these new members follow.

Megan Nightingale
ASEG Secretary
fedsec@aseg.org.au

Biographies of new members of the ASEG Federal Executive

Jim Austin

Jim Austin is a geophysicist, petrophysicist and structural geologist, and is the Team Leader of Potential Fields Geophysics in CSIRO. In his nine years at CSIRO Jim has been focussed on the development of magnetic methods for IOCG, Sedex, VMS, BHT and Magmatic Nickel-PGE systems. Prior to joining the CSIRO, Jim worked on the Australian Geographic Editorial Team, then completed his PhD in the Predictive Mineral Discovery CRC, cut his teeth in industry with Perilya and Pangaea Resources, and worked as a GIS/Geophysics consultant with Encom-MapInfo. He has worked in Mount Isa Inlier, Broken Hill, the Musgraves, Arunta, Albany-Fraser, Capricorn, Kimberley, Thomson, Arnhem Land and Papua New Guinea, and has authored numerous publications on applied geophysics, structural geology and mineral systems.

Mark Duffett

After undergraduate study in geology and geophysics at the University of Adelaide, Mark Duffett came to the University of Tasmania in 1992 to do Honours in geophysics, supervised by the late David Leaman. He stayed until 1998, eventually gaining a PhD in geophysics and GIS applied to the sediment-hosted base metal deposits of the Mt Isa and McArthur Basins. Following completion of his PhD he variously researched, taught and otherwise worked at Charles Darwin University, the Northern Territory Geological Survey and CODES; on projects ranging from saltwater crocodile nesting habitat and prospectivity mapping to airborne survey oversight to regional potential field acquisition and interpretation, from central Australia to the African Copperbelt. Since 2009 he has been Senior Geophysicist at Mineral Resources Tasmania, maintaining interests in regional geophysics, integrated 3D modelling and rock physical properties.

Ian James

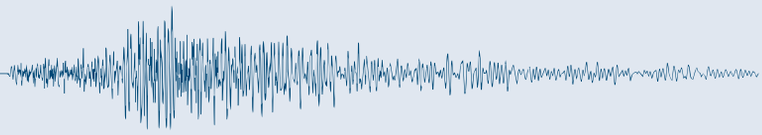
Ian graduated with an Honours degree in geophysics from Southampton

University before emigrating to Australia. Ian has worked in the near-surface, oil and gas and minerals industries using a variety of geophysical techniques. Initially employed by Geoforce, he left to help start ASST and his own business, Terraspect, where he consulted primarily to the seismic industry and worked on projects across six continents. In 2017 he joined HiSeis as a Senior Geophysicist, where he helps mining companies explore more effectively using seismic methods.

Tim Dean

Tim has an Honours degree in geophysics from Curtin University and a PhD in physics from the University of New South Wales. He spent more than twelve years working for WesternGeco and Schlumberger in a variety of roles related to surface and borehole seismic acquisition including field operations, software development and research located in Saudi Arabia, England, Norway and Australia. After leaving Schlumberger Tim worked as a sports technology Project Advisor at Hawk-eye innovations (a division of Sony). He joined the Department of Exploration Geophysics at Curtin University as a Research Fellow in August 2016 and left in August 2019 to join BHP.

Megan Nightingale, ASEG Secretary, and colleagues enjoying AEGC 2019. Photo taken by David Broadway.



Welcome to new Members

The ASEG extends a warm welcome to 49 new Members approved by the Federal Executive at it's June, July, August and September meetings (see Table).

First name	Last name	Organisation	State	Country	Membership type
Michael	Adamson	Southern Geoscience Consultants	WA	Australia	Active
Richard	Allpike	Atlas Geophysics	WA	Australia	Active
Mehdi	Asgharzadeh	Curtin University	WA	Australia	Active
Charles	Baylis	University of Melbourne	VIC	Australia	Student
Andreas	Bjork	CSIRO	ACT	Australia	Active
Benjamin	Boland	Rio Tinto	WA	Australia	Active
Matthew	Boyd	Geological Survey of Victoria	VIC	Australia	Active
James	Brown	University of Adelaide	SA	Australia	Student
Fionnuala	Campbell	University of Tasmania	TAS	Australia	Student
Pablo	Carrillo	Curtin University	WA	Australia	Student
Robindra	Chatterjee	The University of Queensland	QLD	Australia	Student
Min Lee	Chua	CGG	WA	Australia	Associate
Andre	Coffa		VIC	Australia	Active
Ashby	Cooper	Odyssey Geophysics Pty Ltd	NSW	Australia	Active
James	Ewart	University of Melbourne	VIC	Australia	Student
Aaron	Flint	Macquarie University	NSW	Australia	Student
Isabelle	Gartside	University of Melbourne	VIC	Australia	Student
Daniel	Gibbins	Vintage Energy	SA/NT	Australia	Active
Thomas	Harding	Independence Group	WA	Australia	Active
Wei Xuen	Heng	University of Tasmania	TAS	Australia	Student
Jeremy	Hill	Douglas Partners	NSW	Australia	Active
Cathy	Hochwald	Santos	SA	Australia	Active
Thomas	Hoskin	Moombarriga Geoscience	WA	Australia	Active
Roman	Isaenkov	Curtin University	WA	Australia	Student
Kewei	Li	University of Melbourne	VIC	Australia	Student
Lin	Li	University of Melbourne	VIC	Australia	Student
Daniel	Lindsey	Independence Group	WA	Australia	Active
Jason	McKenna	Beach Energy	SA	Australia	Active
Jenna	McKenzie	Ronacher McKenzie Geoscience	Ontario	Canada	Associate
Keely	McMahon	University of Melbourne	VIC	Australia	Student
Renjini	Nair	Rio Tinto Iron Ore	WA	Australia	Active
Catherine	Peryer	University of Melbourne	VIC	Australia	Student
Aruni	Rajanayake	Curtin University	WA	Australia	Student
Thorkild	Rasmussen	Luleå University of Technology	Luleå	Sweden	Active
Anandaroop	Ray	Geoscience Australia	ACT	Australia	Active
Brendan	Ray	Santos	SA	Australia	Active
Nigel	Rees	National Computational Infrastructure	ACT	Australia	Active
Yuxi	Ren	University of Melbourne	VIC	Australia	Student
Mikayla	Sambrooks	University of Melbourne	VIC	Australia	Student
Saini	Samim	University of Melbourne	VIC	Australia	Student
Ranjit	Shaw	CGG Services India	Maharashtra	India	Active
Noah	Stonall	University of Adelaide	SA	Australia	Student
Manlio	Torres	Curtin University	WA	Australia	Student
Dolen	Vogel	University of Melbourne	VIC	Australia	Student
Nicholas	White	University of Melbourne	VIC	Australia	Student
Simon	Willcocks	University of Adelaide	SA	Australia	Student
Taylor	Willick	GBG Australia	NSW	Australia	Active
Adam	Wright	Queensland University of Technology	QLD	Australia	Student
Sasha	Ziramov	Curtin University	WA	Australia	Student

ASEG Branch news

South Australia & Northern Territory

On 27 August the ASEG and SEG hosted **Dr Manika Prasad** from the Colorado School of Mines. She presented her Distinguished Instructor Short Course (DISC) on "Physics and Mechanics of Rocks: A Practical Approach." Ten participants enjoyed an informative and well-taught course by Manika.

On Friday 13 September we held another student night at the University of Adelaide, and it was great to sign up a few new Members.

Looking forward, **Laz Katona** from the Geological Survey of South Australia will be giving a lunchtime presentation on 10 October, "Which anomaly should I drill? Using spatial statistics to inform exploration in covered IOCG terranes." On 22 October we will be co-hosting our second (hopefully annual) Spring Fling event with PESA, SPE and Young Petroleum Professionals at the Havelock Hotel, and taking expressions of interest for the 2020 Mentoring programme. Last year this was a very successful networking event with over 50 attendees, and we are excited to repeat this event with our fellow societies. On 5 November we will be hosting a Melbourne Cup Luncheon sponsored by Terrex and Vintage Energy at the Gallery Hotel on Waymouth St. Join us for a fun day with prizes for best dressed and a Calcutta sweep.

We look forward to a busy end of year, look out for emails to your inbox or by checking the www.aseg.org.au/events. In the last part of the year we have our annual student honours night, Christmas party, and more technical events to round the year off. If you are reading this and you are not a Member, please do come along to one of our events, we would love to see you there and there is usually something for everyone!

Kate Robertson
sa-ntpresident@aseg.org.au

Tasmania

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

Activity at the Victorian Branch of the ASEG was effectively 'put on ice' during the Melbourne winter – no pun intended. Your committee members searched with abandonment for highly contentious and provocative topics of interest with which to shock Branch members, but the search was to no avail. Also, unfortunately, none of the potential speakers that we harassed would agree to wear a sponsored bear suit whilst presenting at a technical meeting.

Our search extended to this year's joint ASEG-PESA-SPE Winter Social event that was held on 28 August at the perennial home of socials; Henry and The Fox. The last gasp of this year's dreadful Melbourne winter was on show that night, as attendees were ushered into a private room at the back of the venue to continue the festivities. The social was very well attended. No drinks were spilt, and no squabbling took place. In fact, no engineers were harmed at any stage of the evening, much to everyone's dismay. Otherwise it was, surprisingly, another very successful inter-society social event for 2019. Maybe we should let PESA run our events more often?

To revive our spring series of events, we have managed to secure a couple of acts over the coming months. First cab off the rank on 1 October is **Dr Mark "lamb-shanks" McLean** from the Geological Society of Victoria, who will be speaking about the GSV's full spectrum airborne gravity survey that was acquired over the Otway Basin as part of the Victorian Gas Programme. FYI, Mark may or may not agree to wear a bear suit on the night but please keep an eye out for announcements regarding meeting dates as one of our future speakers may be prepared to do the honours!

Finally, I'd like to take this opportunity to announce that **Greg Walker**, our dear Branch Treasurer, will be stepping down from his role by the end of spring. Greg has humbly served your Victorian Branch since 2016 by regularly "cooking the books". It's alright Greg, the Federal executives still haven't questioned those outrageous expenses … yet. Greg has reluctantly agreed to educate our northern hemisphere contemporaries in his new role as chief geowizard for Newmont Goldcorp. We wish you all the best, mate!

Victorian Branch meetings are generally held on the third Thursday of each month from 17:30 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.

Thong Huynh
vicsecretary@aseg.org.au

Western Australia

Over 50 WA Branch members attended the 14 August Tech Night that featured a presentation by **Andrew Fitzpatrick** from Independence Group on "Geophysics in the search for Ni-Cu deposits – An IGO perspective".

September Branch events were cancelled in lieu of the AEGC 2019, which was held at Crown Burswood from 2 – 5 September. The AEGC 2019 was very well attended with over 1200 professionals, sponsors, exhibitors, and students from the fields of mineral exploration, geophysics, petroleum exploration and production, geology, geochemistry, consulting, and government.

Upcoming WA events include:

- October 3 – Young Professionals Speaker Night
- October 9 – **Mark Lindsay**, "What is that anomaly? Using machine learning to obtain geological knowledge from downhole petrophysical data", Celtic Club, West Perth
- November TBC – Annual student presentation night, Curtin & UWA
- December TBC – AGM and Christmas party

The Tech night schedule is subject to change due to speaker availability.

Andrew Fitzpatrick addresses the August WA Branch Tech night meeting at the Celtic Club, West Perth.

Please check the website for up-to date information.

Heather Tompkins
wapresident@aseg.org.au

Australian Capital Territory

ACT Branch members at Geoscience Australia have been very busy since the last edition of *Preview* preparing for the AEGC conference in Perth. By all reports, their efforts resulted in some excellent displays and presentations. At the conference, two GA scientists were recipients of awards. **Ross Brodie**, from the Mineral Systems Branch, was presented with the prestigious ASEG 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"). Ross received the award for innovation in applied geophysics with high impact on Australian resource exploration and groundwater.

Marina Costelloe was awarded the ASEG Service Medal for her "outstanding and distinguished service by a Member in making major contributions to the shaping and the sustaining of the Society and the conduct of its affairs over many years". Only ten distinguished ASEG Members have received this honour in the past 20 years, and Marina is the first woman to receive the award.

On 15 August, prior to the AEGC, **Dr Andrea Viezoli** of Aarhus Geophysics ApS gave an interesting talk to the ACT Branch at GA entitled "Some insight from Airborne EM applications in the European Union". Andrea presented selected case studies from the EU, ranging from hydrogeological, to geotechnical and mineral exploration applications. Topics discussed included anthropogenic noise and airborne Induced Polarisation.

In mid-September the ACT Branch distributed details of an annual student award for honours or postgraduate students studying geophysics or related subjects and named after the late **Dr Peter Milligan**. It is anticipated that the successful student will deliver a talk to the ACT Branch on their chosen subject at an award ceremony later in the year.

An upcoming event in October is a talk to be presented by **Clive Foss** of CSIRO, on a topic relating to magnetic data and the Gawler Craton Airborne Survey.

Grant Butler
actpresident@aseg.org.au

New South Wales

In July, we held our annual dinner. It was held in a restaurant by the water in Darling Harbour; we ate lots of steak and other excellent food, drank lots of beers, reds and whites, and discussed many geophysical and non-geophysical topics. We had a good turnout and a great time was had by all.

In August, we held two meetings due to the timely visit of a speaker on his way to the AEGC in Perth.

Our first speaker was **Andrea Viezzoli** from Aarhus Geophysics in Denmark who presented a talk entitled "Some insight from Airborne EM applications in the European Union". Andrea spoke about how the challenges in Airborne EM applications vary depending on several factors, including local (hydro)geology and noise conditions. Andrea presented selected case studies from the European Union, ranging from hydrogeological to geotechnical and mineral exploration applications. Andrea also discussed the effects of anthropogenic noise and the value of airborne IP. Much discussion followed; the talk being enjoyed by all.

*Andrea Viezzoli (left) and **Mark Lackie** (right) enjoy the views from Club York.*

Our second speaker (the following Wednesday) was **Leonardo Vital** from the CSIRO and Observatório Nacional (National Observatory) in Brazil. Leonardo presented two mini talks entitled "Radial magnetic inversion to retrieve the geometry of 3D source methods and Magnetic Inversion – the cost of freedom". In his first talk Leo presented the background to a new method to recover the geometry of a geological source by the non-linear inversion of its total-field anomaly. The second talk highlighted the work Leo had been doing in constructing physical models with plaster of Paris and magnetite powder, then mapping the magnetic field at a low elevation. Thus, with this well-known dataset Leo then ran inversions using different inversion packages to see how the different results compared. Leo's talks sparked discussion about the knowns and un-knowns of magnetic inversion.

Clive Foss (left) and his student, Leo Vital (right)

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

Mark Lackie
nswpresident@aseg.org.au

Stephanie Kovach
nswsecretary@aseg.org.au

Queensland

July ended with **David King** of Marine and Earth Sciences presenting on the use of geophysical techniques for geotechnical engineering in the marine environment. This was an insightful talk given to a very attentive and intimate group of Queensland Branch attendees. David presented an introduction to the shallow seismic geophysics marine and earth science uses, and finished his talk by presenting acquired and processed sections through Sydney Harbour, for the tunnel extension and expansion.

Unfortunately, the Queensland ASEG Branch had to cancel the SEG DISC Workshop with **Manika Prasad** scheduled in August due to lack of registrations. We welcome feedback from members on the kinds of events they would like to the committee to organise or support.

One of our members in Charters Towers has contacted the committee about members that are not based in capital cities being unable to attend technical talks. The committee has discussed the possibility of asking presenters to allow their talks to be recorded. Although we haven't taken this step as yet, we'd love to hear from other members about whether they would like to be able to watch recordings of technical talks.

The start of September brought the AEGC conference in Perth, eagerly attended by three UQ students and one QUT student with the help of a grant from the Queensland Branch. The conference at the ornate Crown Casino hosted plenty of our Branch members and the four students all seemed blown away by the size of the conference and number of talks. Branch members made sure to introduce the students to geophysicists from around the world and they seemed to garner understanding about our industry. A number of our members also attended Federally-hosted ASEG meetings. The conference closed with the news that the next AEGC will be in Brisbane in 2021.

The Queensland Branch committee would like to thank **Eric Battig** for his contribution to events and helping out as Treasurer this year; we wish him well with his new volunteer role as the ASEG Co-chair of the 2021 conference. As Eric will be busy with conference preparations, we would also like to thank **Roger Cant** for stepping up to take over the role of Treasurer.

Our final mentoring event of the year, shared between PESA and ASEG is in planning – watch this space for more information.

We are looking for more presenters to give talks towards the end of the year. If you have a burning geophysical topic you would like to present, please get in touch.

Finally, student field trips are busily getting organised; if you have any geophysical gear to demonstrate to university students in Queensland please contact **Nick Josephs**, Nick@energeo.com.au.

James Alderman
qldsecretary@aseg.org.au

ASEG national calendar

Date	Branch	Event	Presenter	Time	Venue
01 Oct	VIC	Tech talk	Mark McLean	18:00	Kelvin Club, Melbourne
08 Oct	SA-NT	Tech talk	Laz Katona	12:15	Rm 4.06, Level 4, ANZ building, 11 Waymouth St, Adelaide
09 Oct	WA	Tech night	Mark Lindsay	17:30	Celtic Club, West Perth
16 Oct	NSW	Tech night	TBA	17:30	99 on York Club, 99 York St, Sydney
22 Oct	SA-NT	Spring fling		18:00	The Havelock Hotel (Balcony – upstairs), 162 Hutt St, Adelaide
23 Oct	WA	IMP	Close out event and wrap up	TBA	TBA
31 Oct	WA	Mentoring workshop	Various	TBA	Engineers Australia, West Perth
Oct	ACT	Tech talk	Clive Foss	TBA	Geoscience Australia, Symonston, Canberra
05 Nov	SA-NT	Melbourne Cup Lunch		TBA	Gallery Hotel, Waymouth St, Adelaide
Nov	WA	Annual Student Presentation Night	Various	17:30	TBA
06 Dec	WA	ASEG-PESA WA 32nd Annual Golf Classic		08:30	Joondalup Resort, Country Club Boulevard, Connolly
11 Dec	NSW	Quiz night	Various	17:30	99 on York Club, 99 York St, Sydney
Dec	WA	AGM and Christmas party	Various	TBA	TBA

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

Vale: Professor Keeva Vozoff (1928 – 2019)

Professor Keeva Vozoff

Professor Keeva Vozoff, a legend in geophysics, passed away on June 25 2019 in Sydney, Australia at the age of 91, after a long and active life.

Keeva was a pioneer of electrical geophysics and an acknowledged authority on the subject. He was an outstanding educator and mentor to students and colleagues throughout his professional life and across the world. He was also an active contributor to national and international scholarly journals, and published several books.

Keeva was born in Minnesota and obtained a degree in physics in 1949, followed by an MSc in geophysics from Pennsylvania State in 1951, and a PhD from MIT in 1956. Keeva was a Professor at the University of Alberta, Canada (1958–64), Macquarie University, Australia (1972–94), the University of California (Berkeley, 1978–80), and at the University of Cologne, Germany (1989–96).

Keeva was active in the SEG and the ASEG from the 1950s, and held various SEG and ASEG positions. He was awarded SEG Honorary Membership in 1985, and, in 2009, the Reginald Fessenden Award for his work on 3D electromagnetic modelling. Keeva became a Member of the ASEG in 1972, after arriving in Australia to take up the inaugural appointment of Professor of Geophysics at Macquarie University. He served on the ASEG Executive Committee as Treasurer in 1975, and then as President in 1976. Keeva was awarded ASEG Honorary Membership in 1989, for his distinguished contribution to the profession of exploration geophysics through his research and teaching.

Keeva's international engagement included serving on *ad-hoc* committees of Soviet-Australia and Indo-Australia scientific and technical cooperation from 1974 to 1975. He was also an Honorary Fellow of the Association of Exploration Geophysicists of India and, between 1992 and 1993, an Alexander von Humboldt Fellow in Germany.

Keeva developed magnetotellurics while at the Massachusetts Institute of Technology (MIT) and subsequently branched into induced polarisation and 3D modelling, leading pioneering work on inversion techniques. He produced his famous publications on joint inversion with David Jupp at Macquarie University in the 1970s. In subsequent years he used controlled-source EM to map carbonate hydrocarbon saturation changes, and applied CSEM (Long-offset transient electromagnetic depth soundings - LOTEM) to reservoir monitoring. He was always integrating disciplines, methods and teams, and was well known for his synergistic approach to bringing about new thinking and ideas. He ventured into seismic several times; in the 1950s at MIT he wrote one of the first computer programmes to compute seismic dispersion curves in a horizontally stratified medium and later, in the 1980s, he guided his group at Macquarie into in-seam seismic.

Keeva established the Centre for Geophysical Exploration Research (CGER), with his characteristic drive and enthusiasm, at Macquarie University in 1981. This institution was unique in Australia at the time. Keeva led the Centre for a decade and his leadership and extraordinary contributions to the Centre's research, innovative teaching and industry workshop programmes are amongst his greatest achievements.

Keeva's students and colleagues remember him as someone who got everyone thinking creatively about new solutions. His own ideas were usually decades ahead of his time. Over his professional career Keeva not only mentored his former students, but many professional colleagues, and was always concerned about the impact of professional decisions on private lives. Unsurprisingly, in a recent ASEG History interview, Keeva reflected that his interaction with colleagues was the most satisfying part of his career

After his retirement in 1994 Keeva worked as a consultant, and was active until a few years ago. He even co-authored four patents, mostly applying his integration concepts to borehole and reservoir applications.

Although not an Australian by birth, Keeva has always been one of the locals, and would welcome each and every one of

Keeva, at the age of 89, with Katherine McKenna (former ASEG President) at an ASEG Branch meeting in 2017

us at our regular ASEG meetings with his characteristic warmth, genuine friendship and that big welcoming smile. Until his 90th year Keeva was a regular attendee at monthly ASEG meetings in Sydney, and invariably asked insightful questions.

Apart from his focus on science, Keeva had an unbeatable sense of humour, and for many of us he was an undrainable reservoir of jokes and funny information.

Australian earth science is richer for Keeva Vozoff's exceptional contributions and legacies in exploration geophysics research, invention, practical application and teaching. A generation of Keeva's students is continuing to take forward his inspiration and passion for our science.

Keeva was happily married since 1957 to the charming and ever supportive Elizabeth, and enjoyed family life in Sydney with four children and six grandchildren.

He will be missed as friend, colleague, mentor and teacher.

Roger Henderson and Ted Tyne with thanks to Kurt Strack and Sven Treitel
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Ted.Tyne@bigpond.com

Geoscience Australia: News

Geoscience Australia is currently active on a number of airborne and terrestrial geophysical fronts in collaboration with the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (Figure 1).

AusAEM2

The Australian Airborne EM surveying programme (AusAEM) over northern Australia will be suspended in October of this year whilst the aircraft undertakes work for the USGS. Commenced in 2018, AusAEM will eventually cover an entire area of 2.56 million km^2, from Hughenden in Queensland to Port Hedland in Western Australia (Figure 1). The 138 700 line km will be completed by the middle of 2020 and is an integral part of the Exploring for the Future (EFTF) campaign, conducted in collaboration with the respective State and Territory geological survey agencies. Acquisition currently stands at 66% complete, with deliverables to include a full suite of inversions and integrated data products for groundwater resource analysis and pre-competitive information for the identification of new mineral resources throughout Northern Australia.

Inversion data for Queensland and NT parts of the programme can already be accessed via the EFTF portal.

GADDS

GA's geophysical archive data delivery system – GADDs, is nearing the end of its working life and will be replaced shortly with a more user-friendly web-based delivery mechanism for both gridded and located government-agency geophysical data. The new system will be attached to the beta-release of the new *Exploring for the Future* data discovery portal (https://portal.ga.gov.au/), and will provide geophysical data discovery and download in two ways:

- Datasets such as national gravity anomaly grids or individual surveys can be displayed by searching for and selecting the required layers from an extensive list. The portal also provides some simple tools to alter and clip colour ramps, and gives a link to the relevant Web Map Service for users to access directly.
- An innovative 'Clip, Zip and Ship' feature lets users select an area of interest and display all the available datasets that overlap with that area. Users can then choose the datasets and formats they wish to download the data in and a one-off link will be sent to their email for downloading at their convenience.

The portal also has a 3D capability currently displaying AEM and reflection seismic data related to the *Exploring for the Future* programme.

The *Exploring for the Future* data discovery portal is a major final product

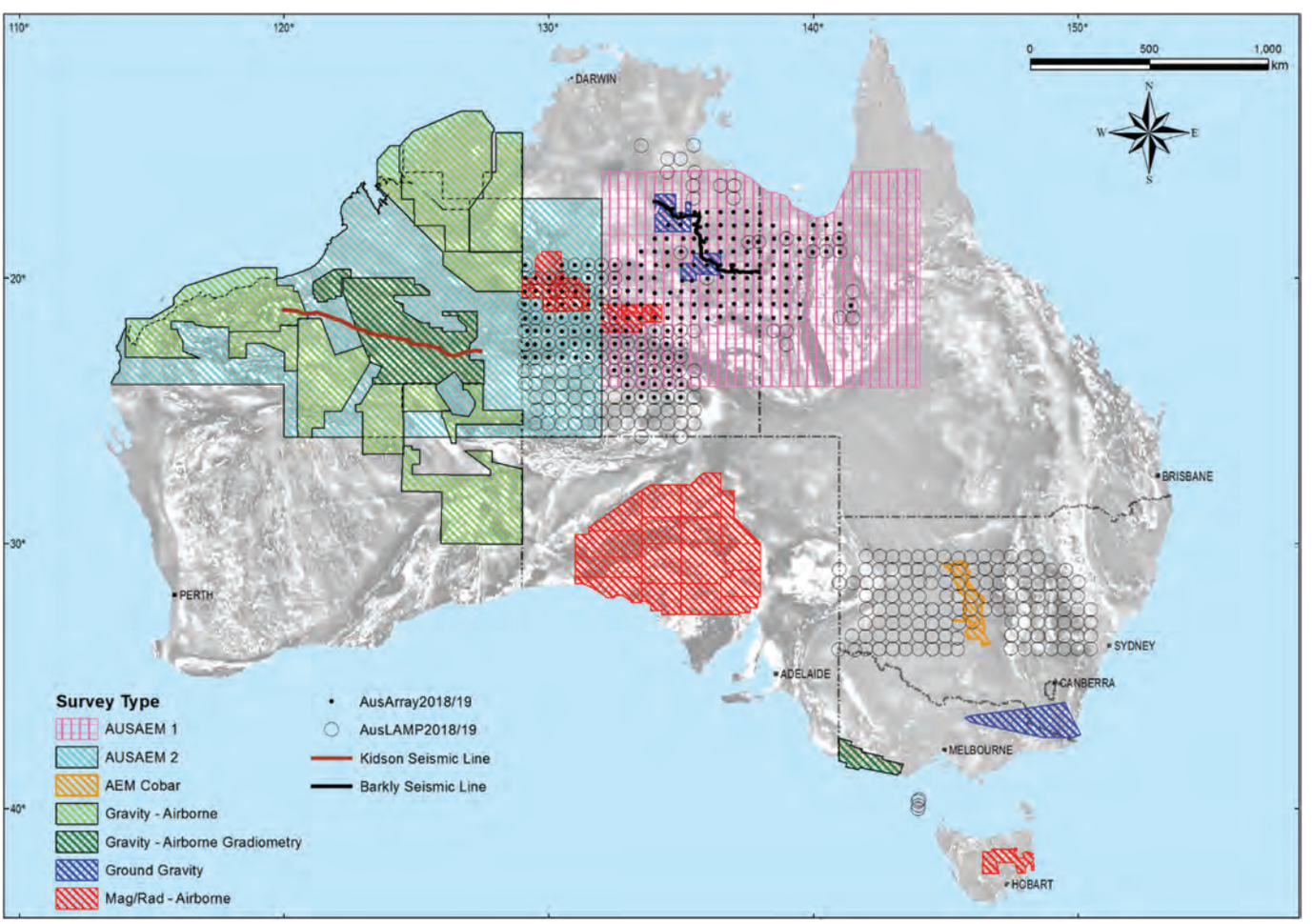


Figure 1. *2018–2020 geophysical surveys – completed, in progress or planned by Geoscience Australia in collaboration with State and Territory agencies.*

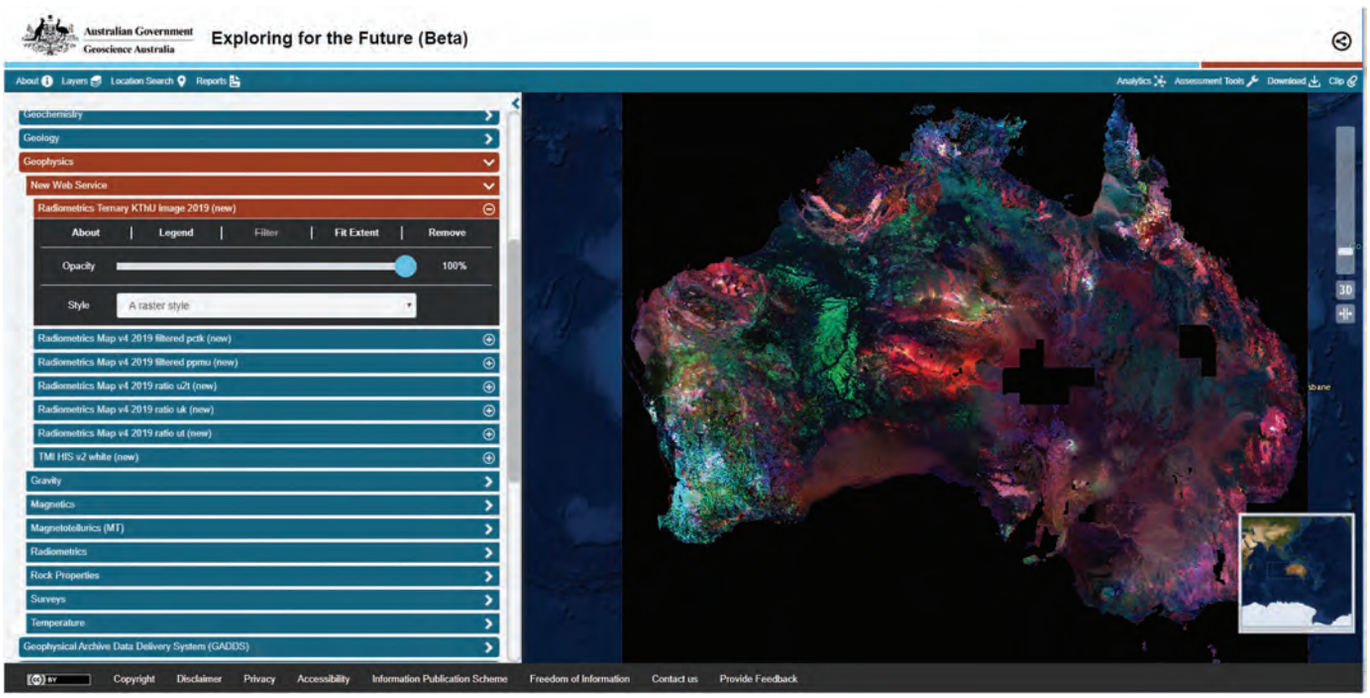


Figure 2. *The GA Exploring for the Future (EFTF) portal showcasing the new 2019 national radiometric compilation as ternary image (Potassium – red, Thorium – green and Uranium – blue).*

out of the four-year programme led by Geoscience Australia. It is designed to better understand the mineral, energy and groundwater resource potential of northern Australia to inform industry, government, and community decision making about exploration opportunities, economic development, and environmental sustainability. As well as displaying data acquired during the programme, development of the portal and underlying web services has provided an opportunity to bring a range of national-scale and legacy datasets together for the first time to support a broad range of users (Figure 2). The portal is currently in beta-release and we are interested in all user feedback – please visit the link and have a go.

For the moment, GADDS will continue to faithfully deliver located datasets for surveys archived before June of this year. For located survey data acquired afterwards, please contact GA's client services clientservices@ga.gov.au or Mike Barlow on mike.barlow@ga.gov.au.

Mike Barlow
mike.barlow@ga.gov.au

The ASEG in social media

The ASEG has just joined Instagram https://www.instagram.com/aseg_news/ – so go on, give us a follow! We'd love to share your photos too, so please email Kate Robertson at communications@aseg.org.au if you have any images you would like featured.

We know not everyone is on Instagram, but you can also find us on a variety of other social media platforms too! We share relevant geoscience articles, events, opportunities and lots more.

Facebook: https://www.facebook.com/AustralianSocietyOfExplorationGeophysicists

LinkedIn company page: https://www.linkedin.com/company/australian-society-of-exploration-geophysicists/

LinkedIn group: https://www.linkedin.com/groups/4337055/

Twitter: https://twitter.com/ASEG_news

Youtube: https://www.youtube.com/channel/UC-dAJx8bXrX5BEudOQp4ThA

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 17 September 2019).

Further information about these surveys is available from Mike Barlow Mike.Barlow@ga.gov.au; (02) 6249 9275 or Laura Gow Laura.Gow@ga.gov.au 02) 6249 9605.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Line spacing Terrain clearance Line direction	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Tasmanian Tiers	MRT	GA	TBA	Jan 2020	Up to an estimated 66 000	200 m 60 m N–S or E–W	11 000	Apr 2020	TBA	TBA	The National Collaborative Framework Agreement between GA and MRT is being updated.
Gawler Craton	GSSA	GA	Various	2017	1 670 000	200 m, various orientations depending on structure	294 000	26 Jun 2019	Aug 2019	http://www.energymining.sa.gov.au/minerals/geoscience/pace_copper/gawler_craton_airborne_survey	Anticipate QC and processing completion by Nov 2019. Will be released shortly afterwards.
Tanami	NTGS	GA	Thomson Aviation	14 Jul 2018	275 216	100/200 m 60 m N–S/E–W	48 267	2 Dec 2018	Jun 2019	195: Aug 2018 p. 16	In process of being released
Mt Peake	NTGS	GA	MAGSPEC	10 Jul 2019	136 576	200 m N-S	24 748	TBA	TBA	Aug 2019	Acquisition at over 80% complete

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 (km²)	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 2018	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	Expected release before the end of Jun 2020
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	Received by Jul 2019	195: Aug 2018 p. 17	Expected release before the end of Jun 2020
Kimberley Basin	GSWA	GA	Sander Geophysics	4 Jun 2018	61 960	2500 m	153 400	15 Jul 2018	Received by Jul 2019	195: Aug 2018 p. 17	Expected release before the end of Jun 2020
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	Received by Jul 2019	195: Aug 2018 p. 17	Expected release before the end of Jun 2020

(*Continued*)

Table 2. Ground and airborne gravity surveys (*Continued*)

Survey name	Client	Project management	Contractor	Start survey	Line km/ no. of stations	Line spacing/ station spacing	Area (km²)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Pilbara	GSWA	GA	Sander Geophysics	23 Apr 2019	69 019	2500 m	170 041	18 Jun 2019	TBA	The survey area is in the Pilbara region in the northwest of Western Australia. Data acquired will be compiled into an update of the gravity anomaly map of Western Australia and help characterise regional geological elements in the area.	Expected release before the end of Jun 2020
SE Lachlan	GSNSW/ GSV	GA	ATLAS Geophysics	May 2019	303.5 km with 762 stations	3 regional traverses	Traverses	Jun 2019	Jul 2019	TBA	Set for incorporation into National database by end Oct 2019
TISA	NTGS	GA	Atlas Geophysics	2 Jul 2019	7821	2 km × 2 km grid	31 285	Sep 2019	Received by Jul 2019	TBA	Expected release before the end of Jun 2020

TBA, to be advised

Table 3. Airborne electromagnetic surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
East Kimberley	GA	GA	SkyTEM Australia	26 May 2017	13 723	Variable	N/A	24 Aug 2017	Nov 2017	TBA	TBA
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
AusAEM2, NT-WA	GA	GA	CGG Tempest	May 2019	59 098 with areas of industry infill	20 km	1 074 500	TBA	TBA	201: Aug 2019 p. 16	At 71% complete. Aircraft shifting to the US in mid Oct before completion of residual
Cobar	GSNSW	GA	NRG Xcite	13 Sep 2019	6701 with areas of industry infill	Variable	NA	TBA	TBA	201: Aug 2019 p. 17	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	166 stations deployed in 2018 - 19	50 km	Long period MT	The survey covers areas of NT and Qld. *Ongoing*
AusLAMP NSW	NSW	AusLAMP NSW	210 stations deployed to date out of 320	50 km	Long period MT	Covering the state of NSW. *Ongoing*
Southeast Lachlan	Vic/ NSW	SE Lachlan	Deployment planned to commence in Feb 2020	~4 km	AMT and BBMT	~160 sites in the Southeast Lachlan
AusLAMP TAS	TAS	King Island MT	4 stations deployed in Jun 2019. Survey completed.	<20 km	Long period MT	Covering King Island
East Tennant	NT	East Tennant MT	131 stations deployed in Aug 2019. Survey completed.	1.5 - 10 km	AMT and BBMT	This survey covers an area northeast of Tennant Creek and is part of the MinEx CRC National Drilling Programme. Data expected to be released in mid 2020.
Cloncurry	QLD	Cloncurry Extension	Survey commenced in Sep 2019.	2 km	AMT and BBMT	This survey covers an area in the eastern concealed margin of the Mount Isa Province and is an extension of the 2016 Cloncurry MT survey.

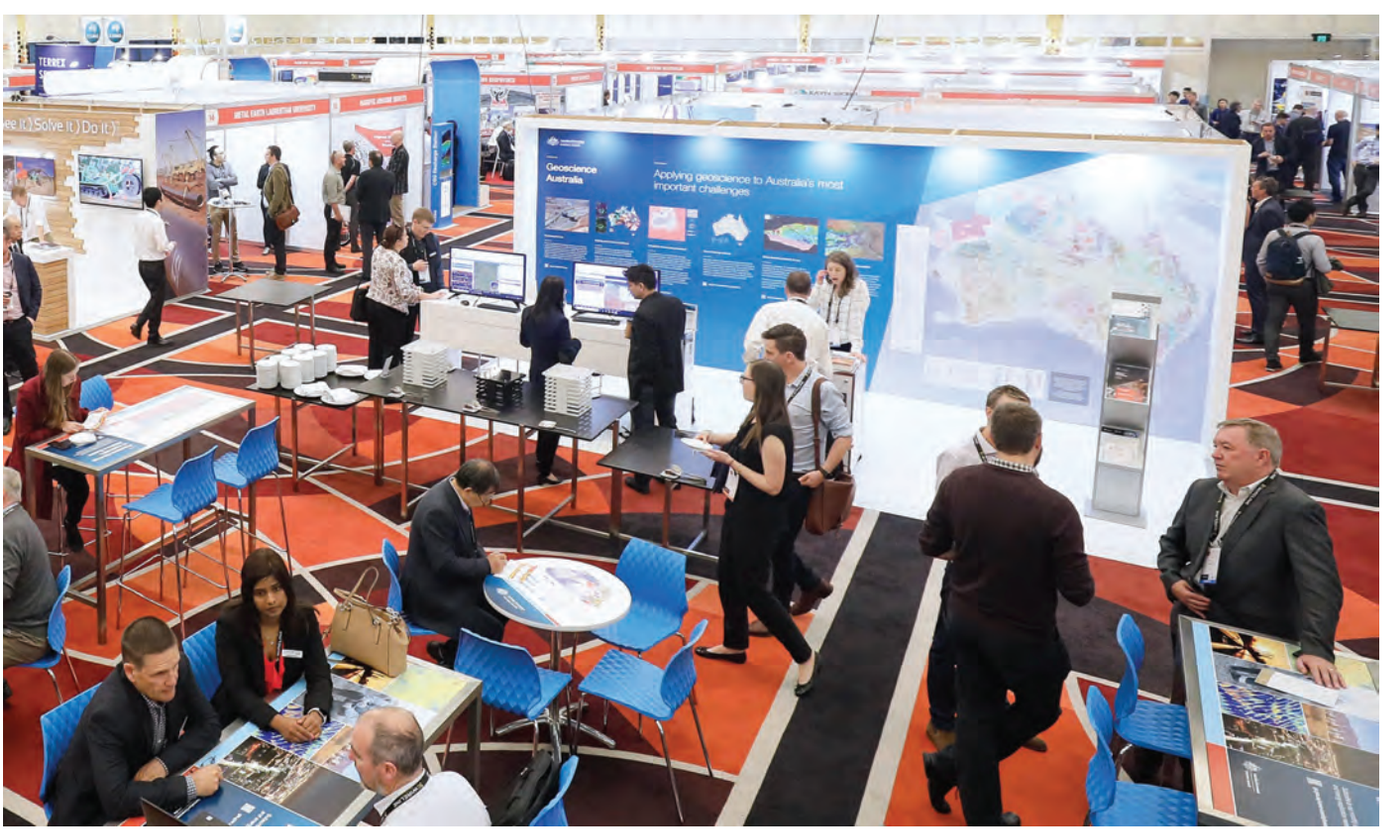
TBA, to be advised

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	629	10 m	40 m	20 s	2D - Deep crustal seismic reflection	This survey covers the Southeast Lachlan Orogen crossing the Victorian-NSW border. Data acquisition was completed in Apr 2018. Raw data and processed seismic data has been released and are available via Geoscience Australia.
Kidson	WA	Kidson Sub-basin	872	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. Data released in May 2019.
Barkly/ Camooweal	NT	Barkly sub-basin	810	10 m	30 m	20 s	2D - Deep crustal seismic reflection	This survey will obtain better coverage and quality of geophysical data over southern McArthur basin to northern Mt Isa western succession. It will also define western extent of the new sub-basin currently informally named as the Barkly sub-basin. Data acquisition commenced in Sep 2019.

Table 6. Passive seismic surveys

Location	Client	State	Survey name	Total number of stations deployed	Spacing	Technique	Comments
Northern Australia	GA	Qld/NT	AusArray Phase 2	About 135 broad-band seismic stations	50 km	Broad-band 1 year observations	The survey covers the area between Tanami - Tennant Creek –Uluru and West Australian Border. The first public release of transportable array data is expected by end 2019. See location map in in *Preview* 201: Aug 2019 p. 16



The GA booth at AEGC 2019. Photo taken by David Broadway

Geological Survey of Western Australia: Data released from Eastern Goldfields 2019 seismic survey

On 26 September 2019, the Geological Survey of Western Australia (GSWA) released final data from its Eastern Goldfields 2019 seismic survey (see *Preview* #200, April 2019).

The survey of an aggregate 305 km on seven traverses along roads and tracks in the area between Broad Arrow and Kambalda (Figure 1) was conducted by Velseis Integrated Seismic Technologies. Data acquisition occurred in March and April; processing was completed in July, and a preliminary interpretation in August.

A download package consisting of a set of stacked time-migrated sections in SEGY format, together with the acquisition, processing, and interpretation reports, is available via GeoVIEW delivery system on the GSWA website at www.dmp.wa.gov.au/geoview ("Simple search" in the "Government Ground Geophysics" layer for "Registered number = 71404").

The complete data package with all raw and processed data, and interpretation products is available on a 2 TB hard drive that must be requested via the online data request form at www.dmp.wa.gov.au/magix. A media charge of $132 applies for the hard drive. Figure 2 is a 3D perspective view of all line sections.

Funding for the survey was provided by the Western Australian Government's Exploration Incentive Scheme.

For more information please email geophysics@dmirs.wa.gov.au

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

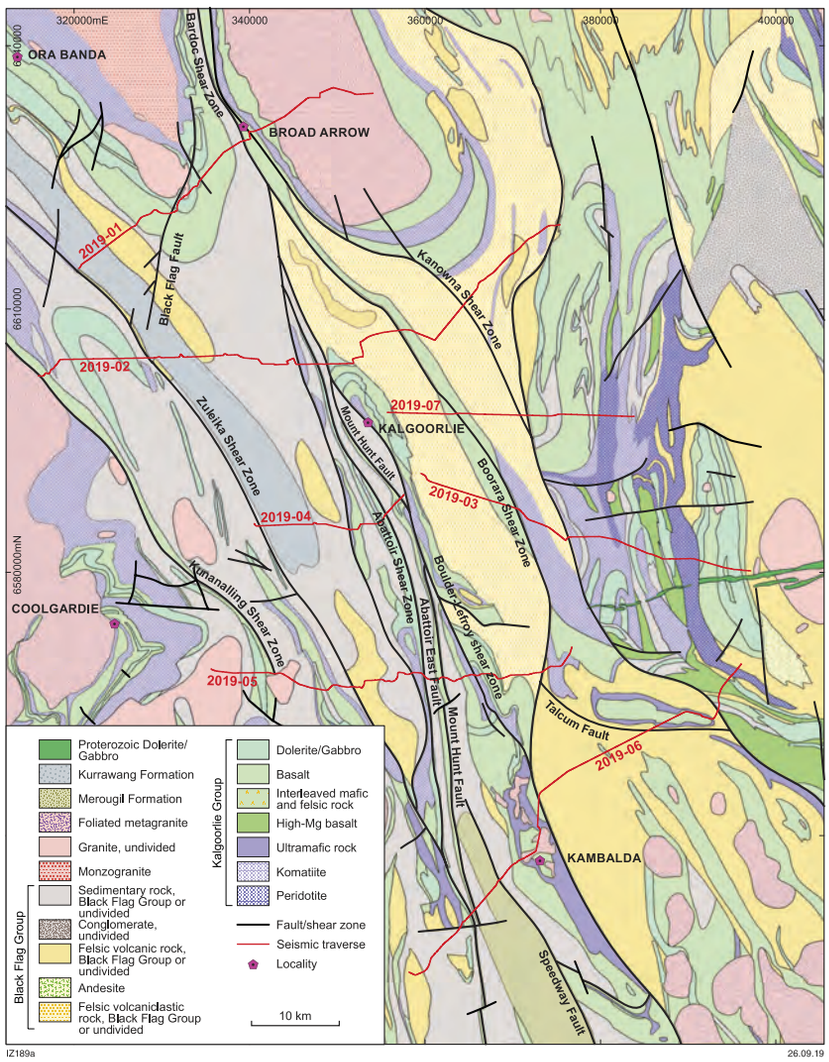


Figure 1. *GSWA Eastern Goldfields 2019 seismic survey. Location of traverses on regional geology. Projection GDA94–MGA51.*

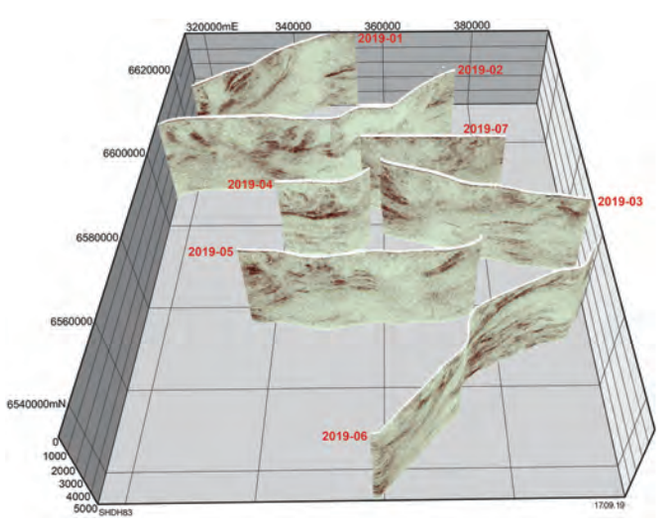


Figure 2. *GSWA Eastern Goldfields 2019 seismic survey. Time-migrated sections.*

Geological Survey of Victoria: Southeast Lachlan Crustal Transect

The Geological Survey of Victoria (GSV), Geological Survey of New South Wales, Geoscience Australia and AuScope (utilising funds provided under the NCRIS programme) have collaborated to acquire new geophysical data across the Southeast Lachlan Crustal Transect in southeast Australia. Deep crustal seismic reflection data were acquired in 2018, detailed ground gravity traverses in 2019 and magnetotelluric surveying is being planned for 2020.

The project partners have worked together (Figure 1) to complete a preliminary interpretation of the processed deep crustal seismic reflection data. The preliminary interpretation was unveiled by Ross Cayley (GSV) at the "Discoveries in the Tasmanides" conference during September 2019.

These new seismic data demonstrate that the rock packages and structures mapped at the surface can be traced through the whole thickness of the crust under the Australian Alps (Figure 2). Interactions between different generations of structures and rock packages are clearly imaged, in ways

Figure 1. *Representatives of Geological Survey of Victoria, Geological Survey of New South Wales and Geoscience Australia at the seismic interpretation workshop held in Melbourne in February 2019.*

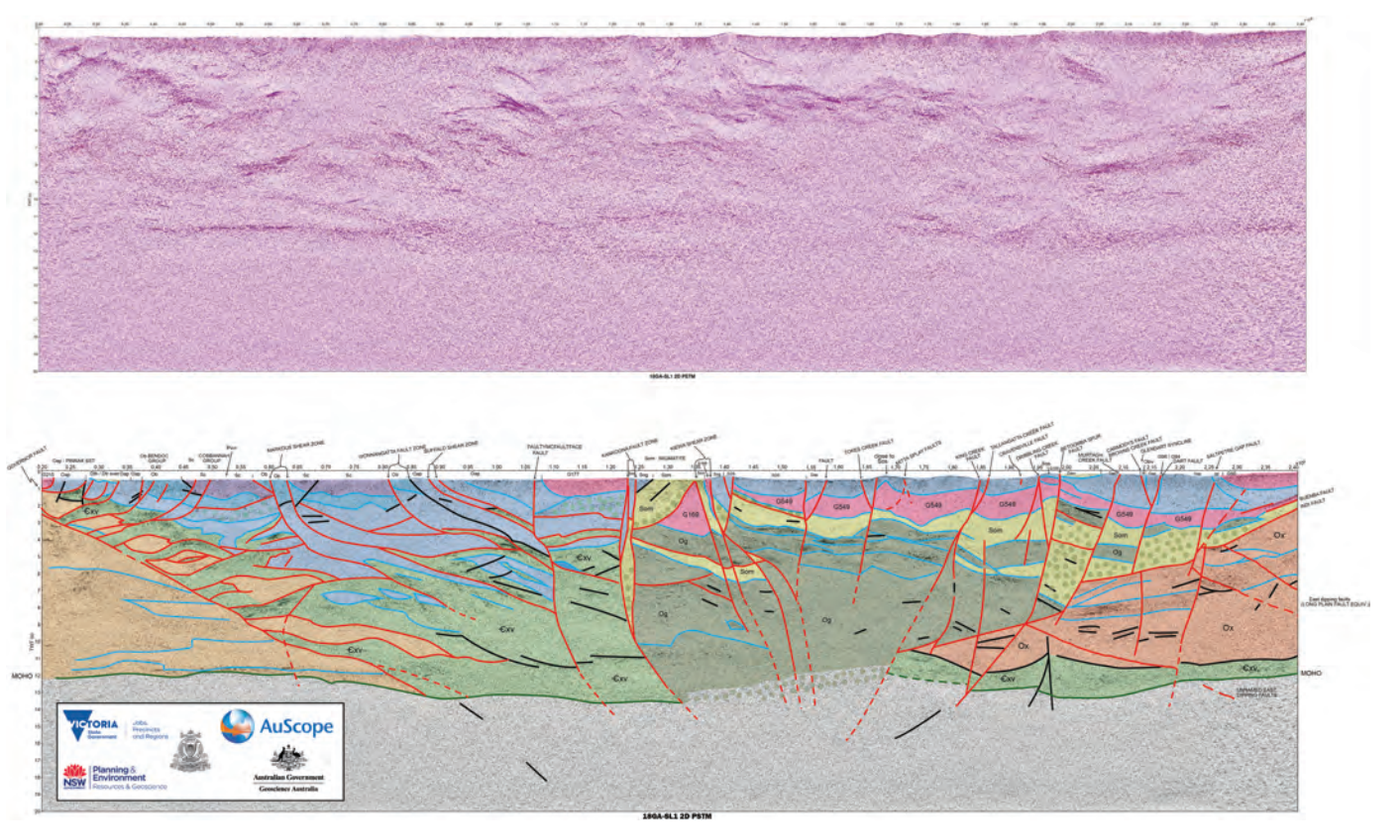


Figure 2. *Southeast Lachlan Deep Crustal Seismic Reflection Survey Line 1 (18GA-SL1) from south of Benalla (left) to west of Tom Groggin (right), see* Preview *201, p.21 for location diagram. Top panel: 2D Pre-Stack Time Migrated data to 20 seconds TWT. Bottom panel: Geological interpretation with faults in red and rock packages as coloured blocks, overlaid on the data shown in the top panel.*

that add immense value to an already rich geological dataset compiled across this region by generations of geologists.

The processed deep crustal seismic reflection data are available from Geoscience Australia as L208 Southeast Lachlan Seismic Survey 2018. A report describing the results of the preliminary interpretation is being published by the project partners as Cayley *et al.* (in prep) and will be available from www.earthresources.vic.gov.au and from the Geological Survey of New South Wales DIGS catalogue: https://www.resourcesandgeoscience.nsw.gov.au/miners-and-explorers/geoscience-information/services/online-services/digs

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Reference

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Henderson byte: Michael Faraday

The SI unit of capacitance, the farad (F), is named in honour of Michael Faraday (1791–1867) who was born and brought up in poor circumstances on the streets of London. He received no formal education beyond age 12, which left him with almost no knowledge of mathematics. However, he taught himself science by reading the books that it was his job to bind as an apprentice bookbinder. By chance, in 1813, he became assistant to Sir Humphry Davy at the Royal Institution in London, where he stayed for the rest of his career. He was to become one of the most influential scientists in history, particularly renowned for his many well-designed experiments that served to illustrate his (non-mathematical) reasoning. In addition, he gave a series of memorable public lectures, explaining the wonders of science to his audiences.

Faraday built the first electric motor by showing that the free end of a rod-like magnet rotated around a current-carrying wire. He also demonstrated the converse, showing that the free end of a current-carrying wire rotated around the pole of a magnet.

He discovered mutual induction when he wrapped two electrically separate coils of wire around an iron ring and found that upon passing a current through one coil, a current was induced in the other coil. By varying the number of turns in each coil he developed the essentials of a transformer.

The relationship Faraday established, that a changing magnetic field produces an electric field, was later modelled mathematically by James Clerk Maxwell as Faraday's law, which subsequently became one of Maxwell's four equations of electromagnetism.

In a presentation to the Royal Society in November 1831 Faraday also described the first working dynamo, a subject later vital to understanding the cause of the Earth's magnetism.

In his work on static electricity Faraday demonstrated that the charge resided only on the exterior of a charged conductor, and that exterior charge had no influence on anything enclosed within a conductor. This shielding effect is used in what is now known as a Faraday cage.

Thus, Faraday's experiments that showed the inter-relationship between magnetics and electricity, resulted in the invention of the electric motor, the transformer, and the electric dynamo or generator.

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Geological Survey of South Australia: An update to the South Australian gravity module

Gravity survey data in South Australia are stored in an Oracle database. The minimum amount of data that can be uploaded are some location information (typically a latitude and longitude), the observed gravity (in either the IsoGal67 or 84 datum), and a height (AHD only). The database takes this information – along with a crustal density defined by a user – to calculate a Bouguer Anomaly. This Bouguer Anomaly is based on the simple slab model, using AHD heights and the Kearey, Brooks, and Hill (1984) theoretical gravity equation. The equation can be written:

$$g_{b(1984)} = obs_{g(1984)} - 978031.8(1 + 0.0053024\sin^2\vartheta - 0.0000059\sin^2 2\vartheta) + (-0.04191*h*\rho) + (0.3086*h)$$

Where ϑ is the latitude (in GDA94), ρ is the crustal density, and h is the AHD height. The gravity module also calculates the Bouguer Anomaly for the 1967 gravity datum. This process is similar to the previous method, but uses a different equation for the theoretical gravity (Sheriff 1991; Blakely 1995; Reynolds 1997):

$$g_{b(1967)} = obs_{g(1967)} - 978049(1 + 0.0052884\sin^2\vartheta - 0.0000059\sin^2 2\vartheta) + (-0.04191*h*\rho) + (0.3086*h)$$

Note that the gravity module uses GDA94 (not AGD66) latitudes in this second equation. Note also that these equations are not using the AAGD07 gravity datum, ellipsoidal heights, or a spherical cap Bouguer calculation.

It is time for an upgrade, and geophysicists at the Geological Survey of South Australia are exploring how to upgrade the gravity module.

The database will need to be populated with ellipsoidal heights, in addition we will need to populate the database with observed gravity in the AAGD07 datum, update the theoretical gravity equation to a more modern formulation (e.g., from Blakely 1995), and incorporate the spherical cap equations as per Kuhn, Featherstone, and Kirby (2009). We anticipate we will retain the slab model Bouguer Anomaly values for completeness.

We don't yet have an anticipated release date for the new and improved gravity module, but stay tuned to *Preview* for future announcements.

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Philip Heath and Christie Gerrard at the GSSA booth at AEGC 2019. Photo taken by David Broadway

Northern Territory Geological Survey: Release of the NTGS Tanami Region Airborne Magnetic, Radiometric and Elevation Survey

Tanami Region survey

The Northern Territory Geological Survey (NTGS) and Geoscience Australia (GA) have recently released the NTGS Tanami Region Airborne Magnetic, Radiometric and Elevation Survey (Figure 1). Over 270 000 line km of high resolution data now provide seamless coverage across 42 000 km^2 of the highly prospective Tanami Desert region extending from the WA border to 300 km west of Tennant Creek. Flown at 60 m clearance and 200 m line spacing, the survey data was acquired over 6 months in late 2018.

This was the first major programme of the NT Government's $26 million

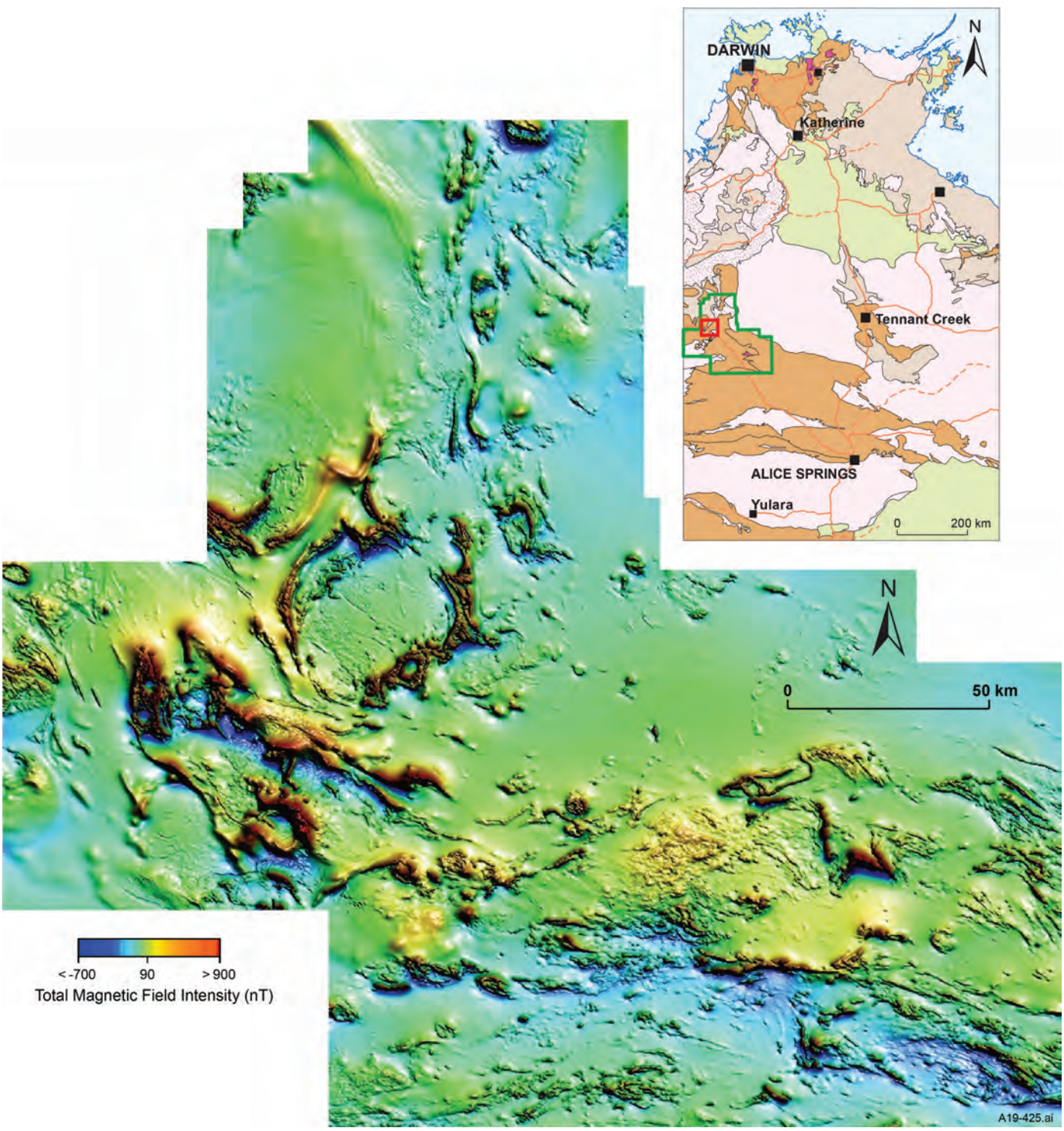

Figure 1. *Shaded relief image of the total magnetic intensity data from the NTGS Tanami Region Airborne Magnetic, Radiometric and Elevation Survey (green outline on inset location diagram). Red box indicates location of detailed image shown in Figure 2.*

investment in minerals exploration under the four-year *Resourcing the Territory* initiative, which runs until 2022. The survey is one of the largest of its kind undertaken in the Territory, and the data produced will help explorers locate mineral deposits they can develop into future mining projects.

A premier exploration destination

The Tanami Region is host to multiple 1 Moz+ gold discoveries including the world-class Callie gold mine. This relatively under-explored province is emerging as a premier gold exploration destination for major gold producers with several projects already at an advanced stage. The new magnetic data will play a crucial role in enabling the mapping and modelling of the bedrock geology beneath the largely sand-covered terrain while the radiometric data will aid in the search for REE mineralisation as well as unconformity-style or palaeochannel-hosted uranium mineralisation (Ahmad, Vandenberg, and Wygralak 2013).

Multi-party collaboration benefits

The survey was also the first NTGS-led multi-party collaborative airborne magnetic and radiometric survey between the NT Government, private companies and GA. Under this arrangement the NTGS, as the primary funding agency, developed the survey design and invited industry to fund infill of their areas of interest at 100 m line spacing. Acquisition contract management and data quality assurance were provided by GA on behalf of NTGS under a National Collaboration Framework agreement. The benefits to industry from infilling NTGS-led programmes include economies of scale, outsourcing of project management and delivery of high-quality products (Dhu, McCoy, and Scrimgeour 2019). On this occasion, industry partners funded the acquisition of 33 000 km of infill data.

A considerable improvement in data quality was achieved compared to the previous regional NTGS Tanami and Granites surveys acquired in the 1980s (Figure 2). This enhancement is due to a number of changes: the closer line spacing (200 m vs 500 m), a lower flight height (60 m vs 90 m), improved flight path navigation (visual/doppler vs differential GPS), increased sensor sensitivities and sampling rates and flight line orientations appropriate for the regional geological trends (E–W lines in the north and N–S lines in the south). Data quality was assured under GA's management of the project with the contractor achieving high technical specifications set out by GA for both the acquisition and processing stages of the survey.

Delivered products

An extensive suite of deliverable products are available for this survey including the industry infill areas (Figure 3). They comprise:

Located data: raw edited and final ASEG GDF2-compliant datasets for elevation, magnetics and radiometrics plus an NASVD-processed spectral radiometric dataset.

Gridded data: In ER Mapper format of magnetics, magnetics reduced-to-the-pole, first vertical derivative of magnetics reduced-to-the-pole, dose rate, potassium, thorium and uranium concentrations, ground elevation from both radar and laser data.

Merged grids: Combining the two main survey blocks flown at different orientations and levelled to the AWAGS based national grids.

Images: GIS ready images in GeoTiff format of the grid data.

Reports: Comprehensive logistics reports and processing documentation.

Data availability

Images of the new geophysical datasets are available on the Geophysical Image Web Server (http://geoscience.nt.gov.au/giws).

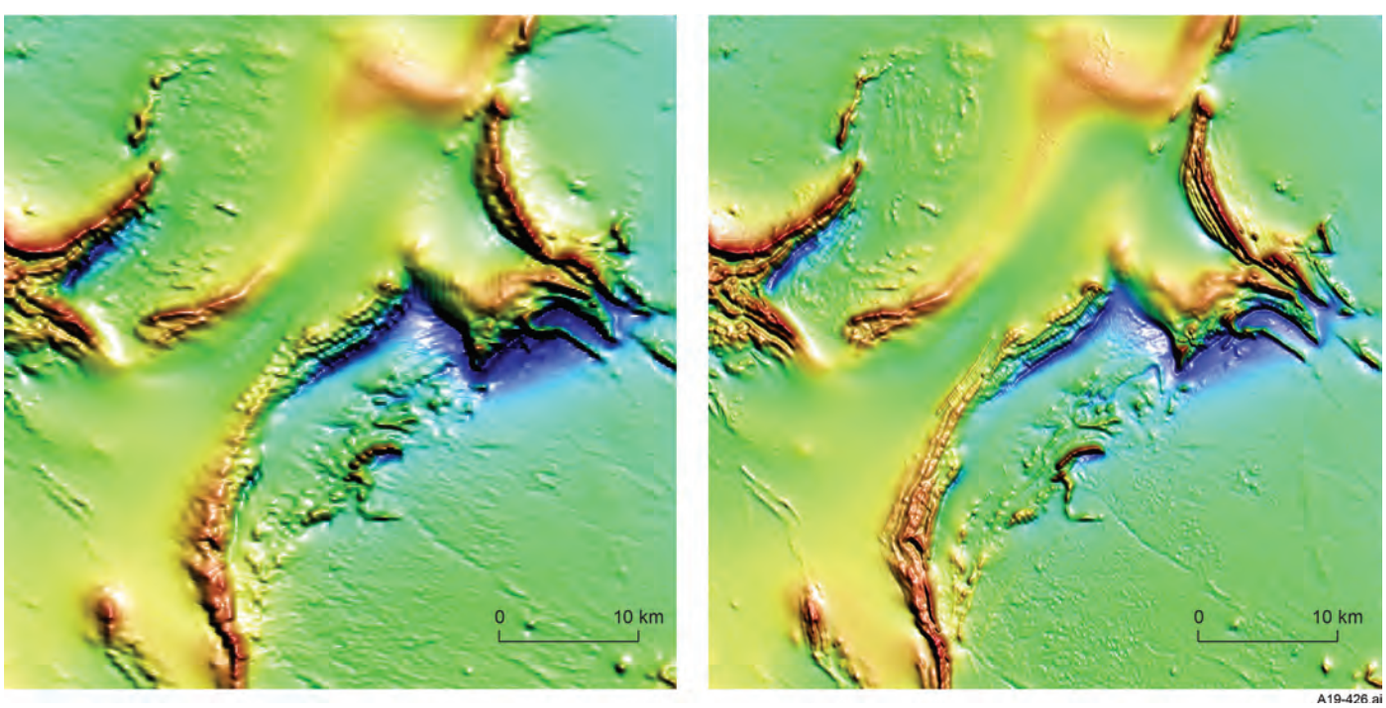

Figure 2. *Example of the improved resolution of thin magnetic features achieved from the current survey (right image) compared to the previous regional survey data (left image).*

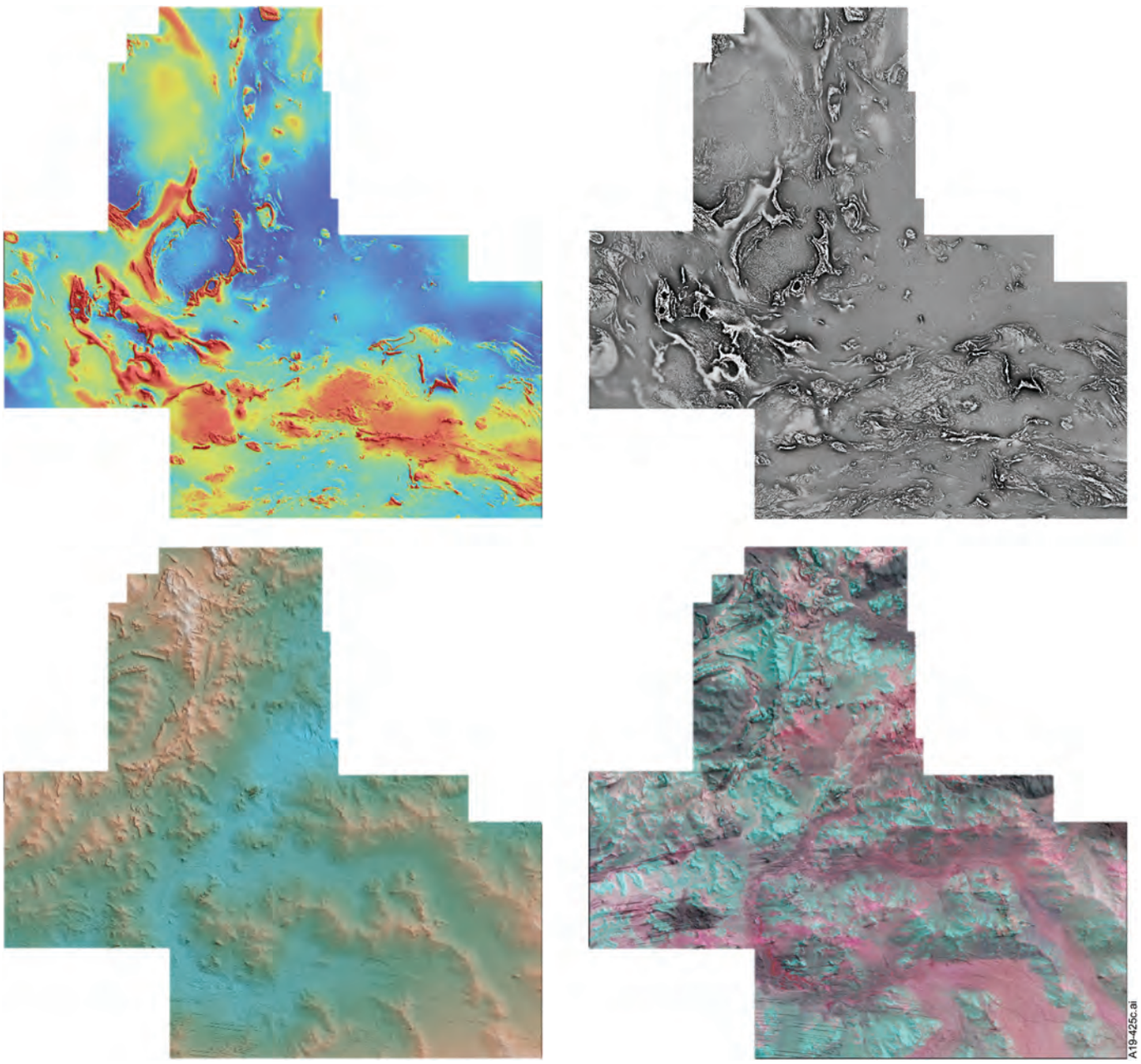

Figure 3. *Examples of images of the merged-grid data provided as part of the product suite. Shown here are the magnetics reduced to the pole (top left), first vertical derivative of magnetics reduced to the pole (top right), ground elevation (bottom left) and ternary radiometrics (bottom right).*

The deliverable products can be requested from the Minerals and Energy InfoCentre (geoscience.info@nt.gov.au).

Survey details and data downloads are also available through Geoscience Australia's Data and Publication web page (https://ecat.ga.gov.au/geonetwork)

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Acknowledgements

The NTGS would like to thank the industry partners for their involvement and would also like to acknowledge the invaluable assistance of collaborative partner, Geoscience Australia.

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AEGC 2019: Reflections

The Second Australasian Exploration Geoscience Conference (AEGC 2019), jointly hosted by the ASEG, the Petroleum Exploration Society of Australia (PESA) and the Australian Institute of Geoscientists (AIG) and incorporating the 27th ASEG Geophysical Conference and Exhibition, and the PESA West Australian Basins Symposia, was a truly clastic event held at Crown Perth from 2 to 5 September 2019.

Spring failed to arrive early in Perth, but the rain failed to dampen anyone's enthusiasm with nearly 1200 delegates attending. Heather Tompkins and Donna Sewell took nothing for granite and organised an outstanding exhibition featuring more than 85 exhibitors. Helen Debenham dug up some outstanding presentations to contribute to an exceptional technical programme featuring more than 280 oral presentations and 80 posters. Shane Mule and Andrew Buffin created a one stop workshop and quartz programme attracting 504 attendees, including one particularly enthusiastic delegate, who clearly seeing no faults in the line-up, attended four separate workshops.

Cameron Adams ensured that the students' apatite for what can be a tuff subject was not diminished with students being well cratered for across by a range of interesting activities. Lendyn Philip ensured the conference dinner audience were well entertained by wacke comedian Peter Rowsthorn. Thanks must also go to the various sub-committee members, too numerous to name, who took on a seis-able amount of work. Expert marshalling by Renee Bennett and her team from Encanta ensured that the conference had many lavas.

It's been a gneiss experience but it's now time to pass the responsibility for organising the next rocking conference to the Brisbane committee. Look forward to seeing you there!

On behalf of the AEGC 2019 Conference Organising Committee, co-chairs Tim Dean (ASEG) and John Gorter (PESA) and treasurer John Warner (AIG)

AEGC 2019: Further reflections

It was with pleasure that I accepted an invitation to reflect on September's AEGC conference. Ted Tyne, in his President's piece, and conference co-chairs Tim Dean and John Gorter in their *Reflections* cover the conference particularly well, making it difficult to identify a niche. And so, it is probably more appropriate, as ASEG President Elect, that I focus on the future.

At the time of writing it is quite soon after the conference, and many members of the Conference Organising Committee (COC) have either taken a well-earned break or returned to work, so full conference statistics have yet to be properly compiled. One set of numbers that has been made available by the COC surrounds the numbers of attendees and their affiliations. Figure 1 presents conference attendance in terms of member society. Of the 1182 unique conference participants, 343 were Members of the ASEG, 227 were Members of PESA, 141 were Members of the AIG and 501 were not identified with any Society. The ASEG could reasonably be regarded as the dominant partner of the triumvirate.

The dominance of geophysics was equally reflected in the exhibition and the technical sessions. Indeed, a number of non-geophysicists (geologists and geochemists) have commented on this dominance. When asked whether there was enough in such a conference to interest them, effectively, whether they would likely consider AEGC 2021, all indicated that they would likely attend. Although the "Unidentified" category from Figure 1 will be dissected in the COC's detailed report to the hosting societies, initial indications suggest that the AEGC has largely identified an appropriate audience viz. the exploration geoscience community. It is therefore critically important that future AEGC conferences continue to address this community.

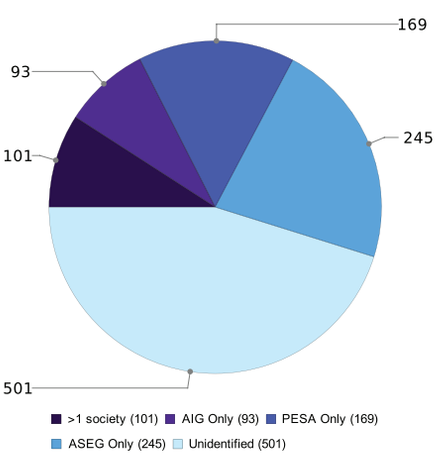

Figure 1. *Conference attendance by society affiliation.*

In the spirit of swings and roundabouts, comments have also been heard around the dilution of the ASEG conference. A quick check of conferences at https://www.aseg.org.au/history/key-dates suggests that dilution has been occurring for some time. Of the 28 conferences that the ASEG has supported, only 14 were solely convened by the ASEG. The remainder were joint ventures, mostly with PESA.

So how to address comments that geophysics is being diluted? One approach is to get involved in future conferences. Attempt to present interesting, relevant results. Case histories are generally very well received. An AEGC context with reduced limits on submission size, might allow a fuller geological explanation in conjunction with relevant geochemistry to give a complete context to the work. Joining the organising committee of the next AEGC is a significant commitment, but one that is equally rewarding.

Another approach to perceptions of dilution might be to work within a specific domain to address needs. Some examples of this are one-day workshops on Airborne Electromagnetics (2012) and Geophysical Inversion (2014), the contents of which are located at https://www.aseg.org.au/continuous-education/workshop-proceedings. The ASEG is always happy to support such initiatives.

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AEGC 2019: Conference and exhibition awards

Laric Hawkins Award: For the most innovative use of a geophysical technique from a paper presented at the (ASEG) conference

Mike McMillan, Jen Fohring, Eldad Haber and Justin Granek

Orogenic gold prospectivity mapping using machine learning

WABS Best paper prize

Darren Ferdinando and Paul Harrison

Shooting for the stars: Unravelling a late Jurassic deepwater petroleum system – frontiers for the next generation of petroleum exploration

Mike McMillan receiving the ASEG Laric Hawkins Award from the AEGC Technical Program Chair, Helen Debenham

AEGC best paper and poster prizes sponsored by First Quantum Minerals

Best oral paper – minerals

David Stannard

Update of the geophysical expression of the Abra sedimentary replacement Pb-Ag-Cu-Au deposit, Western Australia

Best cross- disciplinary oral paper – minerals

Mike McMillan, Jen Fohring, Eldad Haber and Justin Granek

Orogenic gold prospectivity mapping using machine learning

Best oral paper – regional

Tony Marsh

Regional Stratal Slice Imaging of the Northern Carnarvon Basin, Western Australia

Best oral paper – energy

Simon Holford

Structural and lithological controls in the geometry and morphology of igneous intrusions: a 3D seismic case study from the Exmouth sub-basin NW Shelf

Best cross disciplinary paper – energy

Laura Phillips

Faster play-based exploration, Petrel Sub-Basin, Australia

Best oral paper – Near-surface and groundwater

Sharna Riley

Passive seismic HVSR surveying for groundwater exploration at the Chilalo Graphite Project Tanzania

Best student oral paper – minerals

Marija Dmitrijeva

Mineralization signatures of the magnetite dominant Acropolos prospect, Olympic Dam IOCG district, South Australia

Best student oral paper – regional

Xuemei Linda Yang

Gippsland Basin 3D forward modelling in Badlands

Best student oral paper – energy

Liam Olden

Are stromatolites in the northern Perth Basic following the End Permian mass extinction?

Best student oral paper – near-surface and groundwater

Ankita Singh

Investigating rock micro-structure of sandstones by pattern recognition on their X-ray images

Best student poster paper – minerals

Alicia Pollett

A crustal profile of the heat production of the Harts Range Group, Northern Territory

Best student poster paper – energy

Patrick Makuluni

The impact and causes of subsidence in the Exmouth sub-basin, Northern Carnarvon Basin

Best exhibitor stand – shell scheme

Thomson Aviation

Best exhibitor custom stand

IMDEX

Chris Wijns of First Quantum Minerals presenting Alicia Pollett with her award for best student poster paper – minerals. All the conference awards for best oral and poster papers were sponsored by First Quantum Minerals and all the winners were presented with a gold coin.

AEGC 2019: ASEG Honours and Awards

ASEG Gold Medal: David Clark

The ASEG Gold Medal is awarded from time to time for exceptional and highly distinguished contributions to the science and practice of geophysics by a Member, resulting in wide recognition within the geoscientific community. The ASEG President announced at the ASEG Awards Ceremony held at the AEGC in Perth that the ASEG Gold Medal has been awarded in 2019 to David Clark.

This award specifically recognises David's exceptional and distinguished contributions to the profession, both in Australia and internationally, through his leading research, publications and presentations in magnetic petrophysics and its application to magnetic field survey design and magnetic interpretation, over a 40-year period.

After graduating from Sydney University in 1974 with a BSc (First Class Honours) majoring in physics, David took a "gap two years" in London and worked as a scientific staff consultant at the GK Bureau in London, before returning to Australia to work as a Research Assistant in the Department of Geology and Geophysics at the University of Sydney for two years.

In 1978 David joined Ken McCracken's CSIRO Division of Mineral Physics as an Experimental Scientist. It was whilst at Mineral Physics that, through Professor Don Emerson at Sydney University, he became involved in a research project on basic magnetic models incorporating both anisotropy and remanence. Here he achieved much, especially his own development of equations for modelling ellipsoids, on which he was the first to publish in the public domain. He was awarded an MSc in geophysics from Sydney University in 1984 for his thesis topic "Magnetic properties of pyrrhotite -applications to geology and geophysics".

From 1979 to 1992 Dave was the lead researcher for four consecutive three year internationally supported AMIRA projects on the "Applications of Rock Magnetism to Mineral Exploration", projects that served to demystify many magnetic modelling enigmas. For example, the anomalies associated with several mineralised Au-Cu bearing quartz-magnetites in the Eastern Mt Isa Inlier in Queensland give rise to large magnetic anomalies, which significantly perturb the ambient geomagnetic field. Dave showed that the effects of self-demagnetisation from these strongly magnetic bodies originally led to serious errors, particularly in interpreted dip, accounting for the initial mis-targeting of drill holes. Correct dips were calculated after allowing for the self-demagnetisation. This example, and others from this period, served to demonstrate to exploration geophysicists the importance of anisotropy of susceptibility, self-demagnetisation and remanence.

David Clark receiving the Gold Medal from ASEG President Ted Tyne.

In conjunction with this work, Dave took up the role in 1986 of Senior Research Scientist at CSIRO's Exploration Division, where he specialised in magnetic petrophysics and its application to magnetic field survey design and geological interpretation of magnetic surveys.

During the 1990s and early 2000s, Dave played a leading role on further AMIRA projects that integrated petrology and petrophysics through his unique understanding of magnetics, petrology and alteration systems. These projects typified this period of Dave's career and led to a major review of magnetic effects of hydrothermal alteration in porphyry copper and iron-oxide copper-gold systems.

Later David worked with CSIRO on tensor gradiometry in multidisciplinary teams collaborating with DSTO, the US Strategic Environmental Research and Development Program, the Canadian National Research Council and Defence R&D Canada, developing SQUID-based tensor gradiometer systems for submarine detection from airborne platforms. This led to many new mathematical relationships that Dave was able to exploit and bring back into geophysics, including the investigation of multiple-order magnetic gradient tensors for localisation of a magnetic dipole and interpretation of magnetic gradient tensor data using eigenvector analysis and the novel concept of the normalised source strength and a review of methods for determining remanent and total magnetisations of magnetic sources.

In CSIRO Minerals Down Under Flagship projects Dave was intimately involved in two main developments: (i) developing tools for downhole magnetic measurements and (ii) a surface

magnetometer/gradiometer system for remote determination of properties and locations of magnetic sources to aid geological interpretation and drill targeting.

Based on much of this new insight, in 2014 David was awarded a PhD in geophysics from Macquarie University Department of Earth and Planetary Sciences, for his thesis "Integrated Magnetics: Contributions to Improved Processing and Interpretation of Magnetic Gradient Tensor Data, New Methods for Source Location and Estimation of Magnetisation, and Predictive Magnetic Exploration Models".

Through all this time, Dave has remained with the CSIRO in its various guises, both on staff and from 2003 as a consultant to the CSIRO Division of Industrial Physics at Lindfield, Sydney. After a few years, and a name change to the Division of Materials Science and Engineering, Dave was put back on staff where he remains to this day, although currently he works mostly from his home in Kentucky in the US.

Dave has a proven record and renowned reputation internationally in communicating his work to the research community. In his career with CSIRO he has published over 60 peer-reviewed articles, as well as over 60 conference abstracts, four book chapters, and numerous CSIRO reports. As evidence of his standing in the international geophysical community, Dave has been invited to give several keynote addresses/plenary lectures, invited seminars, and to convene sessions at overseas universities and major international conferences.

Additionally, Dave has always made himself freely and willingly available to share his insights and mentor, advise and help students, post-graduates and colleagues in their work on magnetics. He has also been a pro-active supporter of the ASEG, having been a Member since 1977, and a regular presenter and contributor at ASEG conferences and meetings,

David Clark has diligently and effectively devoted his great abilities to magnetics, transforming what was a more-or-less qualitative exploration tool into a sophisticated geophysical technique for the benefit of all geoscientists. For his achievements he is greatly admired both in here and internationally by his peers and colleagues.

This combination of skills and multidisciplinary experience, combined with his proven track record in attracting industry support, his publication record and established international reputation, is perfectly aligned with the goals of the ASEG. It is only appropriate that the profession now recognises David Clark's career-long achievements and contributions to the science and practice of geophysics with the award of the ASEG Gold Medal.

Lindsay Ingall Memorial Award: David Isles and Leigh Rankin

The Lindsay Ingall Memorial Award is intended for an Australian resident or former resident for the promotion of geophysics within the non-geophysical community, including geologists, geochemists, engineers, managers, politicians, the media or the general public. The award honours the memory of an ASEG founder, past President and Honorary Member, the late Lindsay Ingall, for his capacity to cross geoscience boundaries, his ability to relate technically and effectively with other professionals, regardless of their own understanding of the principles of geophysics, and for his enduring commitment to assist geoscientists across Australia. It is awarded generally to an individual who has actively promoted geophysics to the wider community.

In 2019, the award is made jointly to David Isles and Leigh Rankin. David and Leigh together have devoted substantial time and energy in promoting the use of airborne magnetics and aeromagnetic data interpretation to the broader exploration community. This has been achieved through development and presentation for over 25 years in Australia and overseas of the course "Geological Interpretation and Structural Analysis of Aeromagnetic Data".

David completed a BSc (Hons) in 1975 at Melbourne, and subsequently a PhD in 1983 at Adelaide University, where he was guided and strongly influenced in his studies and early career by the late Professor David Boyd. After seven years as a project geophysicist with BHP Minerals in Perth, he joined the airborne contactor World Geoscience, where he was involved in interpretation, training and R&D in aeromagnetics. He was a director and exploration manager of several ASX-listed companies from 1993 to 2016 while continuing to provide technical and training services, and since 2009, he has maintained a strong affiliation with Southern Geoscience Consultants. Dave has been a member of ASEG since 1976 and is also a Member of the Australian Institute of Geoscientists (AIG).

Leigh completed a BSc (Hons) in 1983 at Adelaide University, and joined the Mines Department of South Australia in 1985, where he spent nine years as a geologist in the Regional Mapping Branch. In 1994, he joined World Geoscience, where he spent three years involved with data interpretation, field mapping and training programmes internationally. He has worked as a self-employed exploration consultant since 1997. Leigh is a member of the AIG, SEG and GSA.

In 1991, Dave was encouraged to develop a workshop course for staff of World Geoscience, in order to understand and promote the potential of integrating magnetic data with geology, and to create improved opportunities for the utilisation of such data. From this starting point, the workshop course was developed in conjunction with colleagues at World Geoscience and Monash University, for presentation to the broader exploration audience.

Since 1995 David and Leigh further developed and presented this course on numerous occasions globally, targeted at training exploration geoscientists, of all technical disciplines, in the geological relevance of aeromagnetic data sets. They highlighted the key role it can play in the interpretation of lithology and structure and the controls on mineral deposit setting, be it in hard or soft rock geology.

The significance of the work was acknowledged in 2013 when Dave was made an SEG Honorary Lecturer, Pacific South and presented the lecture "Aeromagnetics – A Driver for Discovery and Development of Earth Resources" at a variety of meetings and universities in Australia, New Zealand and Indonesia.

The subsequent publication of the book based on the course has become a practical manual for aeromagnetic interpretation written primarily for geologists, but often referred to by practicing geophysicists. The book carries comprehensive worked examples of aeromagnetic data and a guide to practical interpretation. It has been widely distributed among the earth science community with over 600 copies sold up to mid-2018 and a further 1026 downloaded from 73 countries once it became available for download from the ASEG website.

Dave and Leigh's endeavours have demonstrated to exploration "decision

makers" that much of the geological story of a region is inherent in the aeromagnetic data. Their demonstration of the value of aeromagnetic data to geological mapping and mineral discovery has helped expand the demand for aeromagnetic coverage and the other airborne methods that followed. Together they have helped to establish aeromagnetics as a primary tool for geological mapping and interpretation throughout Australia, as well as in many other countries. It is no longer a "black art" practiced by only specialised geophysicists, but a valuable basic tool and part of most exploration programmes.

The contributions by David and Leigh to the understanding and interpretation of aeromagnetic data have had a significant influence on generations of geoscientists in Australia and around the world. Their endeavours have no doubt promoted the use of geophysics to the broader geoscience community, and they are worthy recipients of the Lindsay Ingall award.

Dave Isles receiving the Lindsay Ingall award from ASEG President Ted Tyne.

Grahame Sands Award: Ross Brodie

This award is based on an endowment made by Members of the ASEG and the geoscience profession in memory of the late Grahame Sands, who was tragically killed at the prime of his life in an aircraft accident in 1986, whilst developing and testing new equipment for geophysical survey aircraft. Because of Grahame's abilities to turn scientific theory into innovative application, the award is made 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 Grahame Sands Award in 2019 has been awarded to Dr Ross Brodie, in recognition of his development and innovation in geophysical modelling algorithms to provide the Australian exploration industry and government agencies with efficient and practical means to invert and image airborne EM data.

Ross graduated from Queensland University in 1990 with a BApSc (First Class Honours) in geophysics. After a brief stint with Velseis processing seismic refraction data, he joined The Bureau of Mineral Resources (now Geoscience Australia) in 1991, and subsequently followed a distinguished career as an influential government scientist and academic in designing and promoting robust methodologies for processing and displaying airborne EM geophysical data.

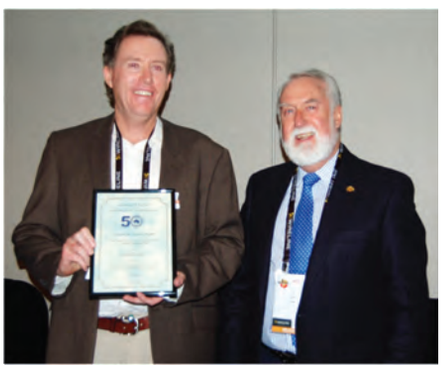
Ross's development of mathematically rigorous airborne EM forward and inversion codes have been instrumental in the AEM community's path toward more quantitative and systematic modelling.

In collaboration with some of Australia's and the world's most recognised EM geophysicists, he has applied his in-depth knowledge of the technique to produce algorithms that take complex time-series number-sets to generate "real-earth" equivalent sections. Not only adopted by industry and contractors, the methodology and process flows have been implemented in other areas, including MT and passive seismic processing.

Ross has over 46 research works and an extensive list of publications focussing on the field of Airborne EM, but also including collaborative works in regional airborne magnetics, radiometrics and other geophysical and data integration approaches. In 2010 he was awarded a PhD with a thesis entitled "Holistic inversion of Airborne Electromagnetic data" by the ANU at the Research School of Earth Sciences, under the supervision of Malcolm Sambridge.

Ross has played a leadership role in Geoscience Australia's pioneering use of Airborne EM as the next generation platform for regional resource and groundwater mapping. His knowledge and skills in the technique have set Australia up as one of the first countries to map and model the earth's conductivity cross-section across entire geological provinces.

Ross' work has established a new standard for the geoscience community in terms of the benefits of open-source code sharing. While Airborne EM surveys grow in physical size and sampling rate, his codes remain robust and continue to take advantage of ever-increasing computer power. Ross's work has provided significant practical benefits to Australian exploration geophysics. For this contribution to the practical application of geophysical methodology in Australia, he is a worthy recipient of the ASEG Grahame Sands award.



Ross Brodie receiving the Grahame Sands award from ASEG President Ted Tyne.

Early Achievement Award: Regis Neroni

The Early Achievement award was inaugurated in 2007 to acknowledge significant contributions to the profession at an early stage in a person's career, by way of publications, professional work or contributions to the ASEG by a Member under 36 years of age.

The Early Achievement award for 2019 is presented to Regis Neroni from the WA Branch, for his outstanding contributions to the ASEG through conference and branch related activities, and through mentoring, community engagement and development and application of new technology within his professional career.

Regis graduated in 2006 with an Honours Degree in Geosciences, Environment and Risks from the Louis Pasteur University in Strasbourg, France. He came to Australia in July 2006 to undertake a hydrogeophysical research project supervised by Dr Graham Heinson at the University of Adelaide. He subsequently gained employment, initially as a field geophysicist undertaking ground electrical geophysical surveys for Zonge Engineering based in Adelaide, and later, with Southern Geoscience Consultants in Perth, supporting large exploration projects globally.

In 2012, Regis joined Rio Tinto Exploration in Perth, providing

geophysical support to various commodity groups within the Australasia region. By this stage of his career, he had gained broad exploration exposure having worked in seven countries across a range of commodities in diverse terrains, culminating in 2014 with his appointment at the age of 30 as Senior Geophysicist with Fortescue Metals Group (FMG), the first geophysicist ever appointed by the company. His challenging role at FMG included exploration strategy and geophysical support to exploration teams, assistance to near-mine hydrological and geotechnical projects, new opportunities assessment and target generation, management of geophysical budget and assets, and staff mentoring and training. His efforts resulted in his promotion to the role of Lead Geophysicist at the age of 33, with responsibilities spanning across Australia, South America and Europe.

Despite his youth, Regis is an industry leader with respect to his work and mentoring junior colleagues both in geophysics and other fields of geoscience. He is an enthusiastic proponent of the promotion of applied geophysics, helping to organise both in-house courses and industry training events, such as the ASEG-affiliated seminar in Perth on "Geophysical Inversion for Mineral Explorers" in 2014.

He has contributed in many ways to the local ASEG WA Branch, as a Branch committee member, as a keen reviewer for journal and conference material, and through the technical sub-committee for the Perth 2019 AEGC conference. He has presented talks at conferences and Branch meetings, and he is the first person to have received awards for best oral paper at two consecutive ASEG conferences; at the 2016 conference in Adelaide (Minerals) and at the 1st AEGC 2018 Conference in Sydney (Near Surface and Groundwater)

Regis is a role model for younger members of the profession, and a worthy recipient of the Early Achievement Award, which includes a $2000 contribution to the recipient in recognition of their achievement. Regis has indicated that he will donate these funds toward a travel grant to assist a Student Member attend the next AEGC conference to be held in Brisbane in 2021, in recognition of the generous people who made his first life-changing visit to Australia possible.

Regis Neroni receiving the Early Achievement award from ASEG President Ted Tyne.

Shanti Rajagopalan Memorial Award: Lachlan Hennessy

The Shanti Rajagopalan Memorial Award, inaugurated in 2013, is presented for the best paper published by a Student Member in *Exploration Geophysics* in the period prior to each ASEG Conference.

The award is named in memory of the late Dr Shanti Rajagopalan, who passed away in 2010 at the prime of her career. Shanti was one of the best known and respected Members of the ASEG and was well known for her outstanding contributions to the geophysical profession.

Shanti was also a major contributor to the ASEG. She was a great supporter of her local branch, served as Victorian Branch President, and was actively involved in the organisation of ASEG conferences in Hobart and Melbourne. She was also Editor of *Exploration Geophysics* in 2000 and 2001.

But it is most noteworthy in the context of this award that, in 1987, as a student Member, Shanti received the inaugural Laric Hawkins Award for the most innovative use of a geophysical technique from a paper presented at the ASEG Conference. It is therefore very appropriate that an award to encourage technical excellence by our student Members is named in honour of Shanti.

The recipient of the Shanti Rajagopalan Memorial Award for 2019 is Lachlan Hennessy, formerly of RMIT University in Melbourne, for his paper co-authored with Jim Macnae entitled "Predicting lightning sourced electromagnetic fields". The paper was published in 2018 in *Exploration Geophysics*, Vol 49:4, pp 425–433. The paper incorporated research work completed as part of his PhD thesis.

Lachlan completed his PhD at RMIT University in 2018. He is currently working as Project Geophysicist for Anglo American Group Discovery and Geosciences in Brisbane. where he will apply lessons learned during his PhD towards the discovery of superior value deposits buried deep under the sedimentary basins of North West Queensland.

Lachlan Hennessy receiving the Shanti Rajagopalan Memorial Award from ASEG President Ted Tyne.

ASEG Service Medal: Marina Costelloe

The ASEG Service Medal is awarded for outstanding and distinguished service to the ASEG over many years. The recipient in 2019 is Marina Costelloe, in recognition of her outstanding service to the ASEG, through contributions to the ASEG Federal Executive and State Branches, for her leadership and promotion of the Society, and for her efforts in fostering education, and diversity within the ASEG.

Marina is well known to most ASEG Members, through her senior leadership role with the Mineral Systems Branch at Geoscience Australia (GA), and through her active involvement with the ACT Branch, and since 2015 on the Federal Executive, including ASEG President in 2018–19.

Marina has 25 years of experience in Science, Technology, Engineering and Mathematics (STEM) fields, including industry experience in contracting, geophysics, resource (groundwater, energy and mineral) management, and information technology. Marina was awarded a BSc and Graduate Diploma of Science in geology and geophysics from Sydney University in 1992, and an MSc from James Cook University in 2004 where she completed an environmental review of the Mary Kathleen Uranium Mine, incorporating geophysics, geochemistry, and policy.

Marina is currently the acting Branch Head, Mineral Systems Branch, at GA. Marina is working in the exploration, resource management and engineering space in Australia, in a complex and changing political and economic framework. She is contributing to the long-term reform agenda for the Australian resource sector using the recently released Australia's National Resources Statement as a framework, and is influencing resource investment policy in future government plans. Since joining GA twelve years ago, she has led highly skilled, dedicated teams in areas such as groundwater, mining, energy, near surface exploration, critical infrastructure, earthquake monitoring, nuclear tests monitoring and space weather.

Marina initially joined the ASEG in the 1990s and was active at a local NSW branch level for several years. After a few years away she re-discovered the ASEG in 2006 and has subsequently devoted much of her time to the management and governance of the Society. She was ACT Branch Secretary from 2007–10 and President from 2011–14, before being appointed to the Federal Executive Committee in 2015. She was Honorary Secretary in 2016, and Federal President in 2018–19.

As a member of the Federal Executive, she has made many significant contributions behind the scenes to the governance, modernisation, and visibility of the ASEG with national and international stakeholders, and on social media, through which she has been invited to represent the ASEG in forums and at leadership meetings that professional societies may not ordinarily be invited to. She has also helped develop a five-year strategic plan (2018–23) for the Society, modernised the Society's Constitution, instigated the new membership newsletter, upgraded and modernised the ASEG website content, upgraded and modernised the ASEG procedures manual, and contributed over many years to the technical standards committee.

Additional to all this, she holds strategic leadership positions on the Australian Geoscience Council and the Science and Technology Australia board, representing over 10 000 geoscience professionals as the Geology and Geography cluster representative.

Marina is also a champion of diversity for the ASEG and the broader science communities. Amongst many achievements in this area, she organised and wrote the ASEG Decadal Plan for Women in STEM submission, and was the Diversity Champion for the Australian Geoscience Council Conference in 2018. Marina has spoken at many events on behalf of the ASEG and has melded science, mentoring and the ASEG story to a broad often non-technical audience.

Marina is not someone who goes about promoting herself, but the rest of the geoscience community is awake to her achievements. It is most fitting that Marina's substantial contributions to the ASEG and the profession are now recognised with the award of the ASEG Service Medal.

Marina Costelloe receiving the Service Medal from ASEG President Ted Tyne.

Honorary membership of the ASEG: Joe Cucuzza

The Award of ASEG Honorary Membership has been conferred upon Joe Cucuzza, in recognition of his significant contributions to the profession through his key roles in AMIRA for over 30 years, and for his significant contributions to the ASEG Executive Committee and the ASEG Research Foundation over many years.

Joe is well known to most ASEG Members having been an active Member and great supporter since 1975. He served as ASEG Federal President in 2007–08 and was a member of the ASEG Research Foundation committee at its inception. He served as Chairman of the Foundation from 1997 to 2001. He has been a regular attendee and contributor at ASEG conferences and is often involved with many ASEG Members through his professional role with AMIRA International in both developing and managing collaborative research projects.

Joe graduated from The University of Melbourne in 1975 with a BSc (Honours) in geophysics. He has also received an MSc (Geology) from ANU in 1992. Apart from these qualifications, he also gained a Master of Business (Enterprise Innovation) from the Centre for Innovation and Enterprise at the Swinburne University of Technology in 1998, and in 2013 he became a Graduate of the Australian Institute of Company Directors.

Joe has had a distinguished professional career, initially as a company geophysicist with Australian Anglo American Corporation, then with Comalco Aluminium in both their Minerals and Petroleum divisions from 1978–1988. In 1988, he joined AMIRA International, as a Research Coordinator. In 1996 he became Business Unit Leader, and later Global Manager - Business Development, and Research Director. In 2012 Joe was appointed Managing Director, only recently announcing that he will be leaving AMIRA International to pursue other interests.

In Joe's role with AMIRA International he has developed and managed many research projects that have involved collaboration between industry geophysicists and researchers in academia, CSIRO and other institutions, as well as individual members of our profession. The collaboration has played a major role in advancing exploration geophysics, particularly in Australia, but also involving many international companies and supporters.

Joe has been proactive over the years in meeting company representatives not only to seek direct support for specified projects but also to publicise the importance and effectiveness of industry-academic research partnerships. This research has usually been focused on advancing Australian geophysics, either by developing or modifying new or existing tools, appropriate for the Australian environment. AMIRA International and the collaborative research projects they have managed have made a major contribution to the widespread use of geophysics in Australian mineral exploration and the geophysical profession.

Joe was closely involved with the CRCAMET which ran from 1992 to 2000 and managed many exploration oriented geophysical research projects, which contributed to the tools in common use today.

More recently, AMIRA International under Joe's leadership, promoted and developed

the Roadmap for Exploration Under Cover, which supports and strengthens the UNCOVER project initiated by the Australian Academy of Science. This project has provided a clear plan for the advancement and development of new or improved methods for mineral exploration beneath the cover.

Many in the industry believe that Joe's leadership of AMIRA International has been instrumental in setting the direction within geoscience research in recent decades. It is very fitting that the ASEG now recognises Joe's outstanding contributions over many years to the profession, and to the ASEG, with the award of Honorary Membership of the ASEG.

Joe Cucuzza receiving his award from ASEG President Ted Tyne.

Honorary membership of the ASEG: Lisa Worrall

ASEG Honorary Membership has been awarded to Lisa Worrall, in recognition of her distinguished professional career, and for her outstanding work for the ASEG over many years as editor for *Preview* and through her mentoring and role modelling women in leadership and STEM. The award also acknowledges her role in modernising and expanding the use of geophysical technologies through CRC LEME to non-traditional users.

Lisa has more than 25 years' experience in the minerals and energy sector, including more than 15 years in senior management roles. She is nationally and internationally recognised as an expert in mineral exploration through cover. She has published in national and international journals and her work has featured in the popular media.

Lisa is currently Managing Director of Protean Geoscience Pty Ltd, a small Australian business based in the Cairns region, delivering geoscientific advice and services to the mineral exploration industry. This followed her role as Chief Geoscientist of Zeus Resources Limited, a junior exploration company that listed on the ASX in 2012.

Prior to this, Lisa Worrall acted as a senior executive leader of the Resources, Advice and Promotions Group in the Onshore Energy and Minerals Division of Geoscience Australia (GA). This Group was responsible for providing information and advice to government on mineral resources, as well as promoting investment in the Australian mineral resources industry in collaboration with other Australian government agencies including State and Territory agencies.

Prior to acting in this role at GA, Lisa was the Chief Executive Officer of the Cooperative Research Centre for Landscape, Environments and Mineral Exploration (CRC LEME). CRC LEME was a highly successful joint venture between public and private sector agencies that was focused on developing effective strategies for exploring in Australia's extensive areas of cover and for managing Australia's natural resources; particularly soils and groundwater. CRC LEME had 135 staff members and a budget of nearly $135 million over a seven-year life span. Lisa was the senior executive leader of CRC LEME's Regolith Geoscience Program for five years before being appointed CEO. Through this role her key contribution was the modernisation and expansion of how geophysics could be used to understand regolith in Australia.

Lisa is a Graduate Member of the Australian Institute of Company Directors and has more than ten years of experience as an executive director, non-executive director and chair of boards and management committees in the for-profit and not-for-profit sectors including the board of a childcare centre, sporting club, and various academic and professional organisations.

Lisa joined the ASEG in 1995, after her first ASEG conference experience. Since 2014, she has been the honorary editor of *Preview*, the magazine published bi-monthly by the ASEG for members and a more general readership. In the last two years, this role has had a special challenge in facilitating and managing a change of publisher.

Lisa has also spoken at numerous ASEG conferences, mentored and supported many early and mid-career geophysicists, and peer reviewed many abstracts, papers and articles for the ASEG. She received the award for the best environmental geotechnical presentation at the ASEG Conference in Perth in 2007.

Lisa has inspired and guided decision-makers in the Federal and State policy areas about the relevance and contribution of research to the economic future of Australia and the use of pre competitive geophysics to be used as an evidence base for these decisions, in particular the multi-use of airborne EM for water, agriculture, salinity mapping and uncover work. To acknowledge these outstanding contributions to the profession and the ASEG over many years, the ASEG is pleased to confer the award of Honorary Membership to Lisa Worrall. Lisa also becomes the first female recipient of Honorary Membership within the ASEG.

Lisa Worrall receiving her award from ASEG President Ted Tyne.

Honorary membership of the ASEG: Michael Micenko

ASEG Honorary Membership has been awarded to Western Australian Branch Member Michael (Mick) Micenko, in recognition of his significant contributions to the ASEG at many levels over several decades, as well as his notable professional contributions to the oil and gas exploration industry for over 40 years.

Mick graduated with a BSc (Hons) from Flinders University, South Australia in 1976 and subsequently completed an MSc in geophysics at the University of Durham UK in 1977. In the following years he has had a successful career in oil and gas exploration culminating in his role as Chief Geophysicist at Mitsui E&P Australia.

News

His outstanding contributions to the profession include the recognition of the oil potential of the Queensland Eromanga Basin which led to the discovery of the Jackson Field in SW Queensland, Australia's largest onshore oil field at the time. The discovery led to an expansion of successful oil exploration in an area previously regarded as gas-prone.

Later in his career he developed ideas on stratigraphic trapping of hydrocarbons in the Exmouth Sub-basin and proposed the location for Ravensworth-1, the discovery well for the Pyrenees trend oil fields offshore WA. This discovery was awarded the Most Significant Discovery Award by APPEA in 2003.

Mick is acknowledged for introducing the latest in leading-edge geophysics to the places he worked, with some of the ground breaking examples being:

- the use of synthetic seismograms in the 1980s to model changes in seismic character related to good quality reservoir trends
- introduction of AVO to discriminate between reservoir fluids in the early 1990s,
- in the 2000s recognising and measuring azimuthal anisotropy of seismic velocity so acquisition footprint and borehole stresses could be reduced
- developing the "rave" plot to highlight amplitude conformance with structure
- using densely spaced point receivers in onshore seismic acquisition which allowed noise to be modelled and removed from seismic data

Mick's expertise as an interpretation geophysicist is evidenced by almost 50 articles published in *Preview* between 1998 and the present. He also taught the Seismic Interpretation course at Curtin University for seven years. Several of the students from his course are now in senior positions with exploration companies and service providers.

Mick Micenko receiving his award from ASEG President Ted Tyne.

Since becoming an ASEG Member in 1975, Mick has been an active supporter of the ASEG and has made many outstanding contributions to the success of the Society for over 40 years. His involvement with the ASEG has included contributions on three State Branch committees, Victorian Branch Secretary, Treasurer for ASEG conferences in 1981 and 1989, a member of the Federal Executive and Business Manager. But to most Members he is best known for his exceptional contributions as Associate Editor, Petroleum for *Preview* since 1998 – and still going.

To acknowledge these outstanding contributions to the profession and to the ASEG over many years, the ASEG is pleased to confer the award of Honorary Membership to Michael Micenko.

Canberra observed

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AEGC 2019 a great success, but how will it contribute to more discoveries?

With more than 1000 delegates from over 20 countries, the Perth conference was a big success. There were over 400 contributions as either poster or oral presentations, and the subject scope was huge. It ranged from a detailed seismic survey to locate an old gun emplacement, through to continent-wide EM, magnetic, gravity and radiometric surveys and their interpretations, to the 872 km land seismic line from Kiwirrkurra to Marble Bar over the Kidson Basin.

You can only attend a few of the papers presented, but I was impressed by two that analysed the evolution and prospectivity of the Bight Basin. Using gravity and seismic information they derived models of the tectonic history, structure and morphology of a 600 km cross-section. The interpretation covered the time window from when Antarctica broke away from the Australian continent about 100 Ma to the present-day. A masterly display of extracting the most from the available geophysical data.

As expected, AI and machine learning techniques were more prominent than in the 2018 meeting. There were presentations on 3D stochastic geological modelling; machine learning techniques on airborne geophysical data for mineral resources exploration; mineralisation predictive targeting using tensor-flow deep neural networks and many more. It will obviously be some time before AI successfully identifies drill sites for new mineral deposits, but if these machines can beat humans at Chess and Go we can expect greater use of AI as an exploration tool in the near future.

Explorers have to face the reality that, in Australia, most of the "easy-to-find-deposits" have already been found. It's just going to get harder to discover more resources and we are going to need new ideas and better skills to do it. Conferences such as AEGC 2019 have a crucial role in that regard. They provide opportunities to network, collaborate and generate ideas. And that is how conferences such as this one will contribute to discoveries yet to be made. But it is not going to be easy.

Petroleum exploration investment stagnates

The petroleum sector shows no sign of recovery, and investment levels are now approximately 20% of what they were between 2013 and 2015 (Figure 1). It was, therefore, good to see that the Government recently released 64 areas for offshore oil and gas exploration. Bidding is open until 5 March 2020 and this release should provide a welcome boost to our exploration effort.

The release areas are in five basins: Bonaparte Basin (15), Browse Basin (3), Northern Carnarvon Basin (39), Otway Basin (2) and Gippsland Basin (5). Figure 2 shows their locations.

Minerals exploration investment continues to increase

Meanwhile, the rebound of the minerals sector shows no sign of slowing down. Investment is now more than double what it was in the 2016 March quarter. The drilling numbers (Figure 3) are a useful indicator of the health of the sector, and with over 2.5 km drilled in the June quarter it is clear that the upward trend is continuing.

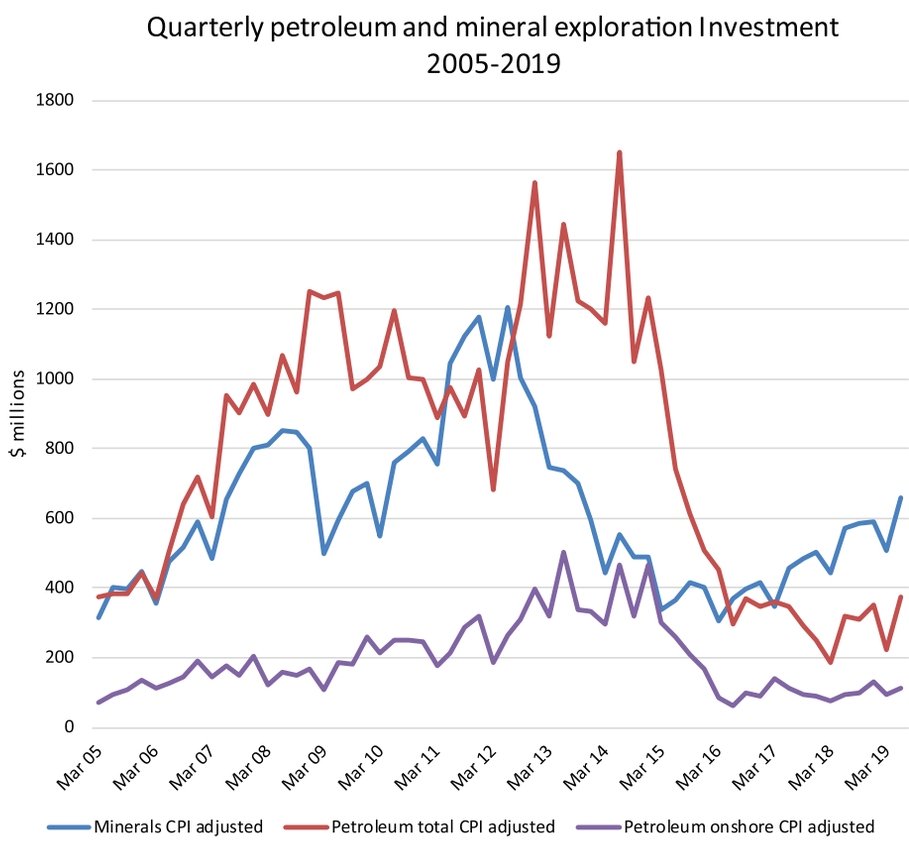

Figure 1. *Quarterly petroleum and mineral exploration investment 2005-2019. Investment in minerals is now gradually increasing, but petroleum expenditure is stagnating. Data from the Australian Bureau of Statistics.*

Figure 2. *Map showing the locations of the 64 acreage release areas in 2019 (in dark yellow). See https://www.industry.gov.au/strategies-for-the-future/investing-in-offshore-petroleum-exploration for more information.*

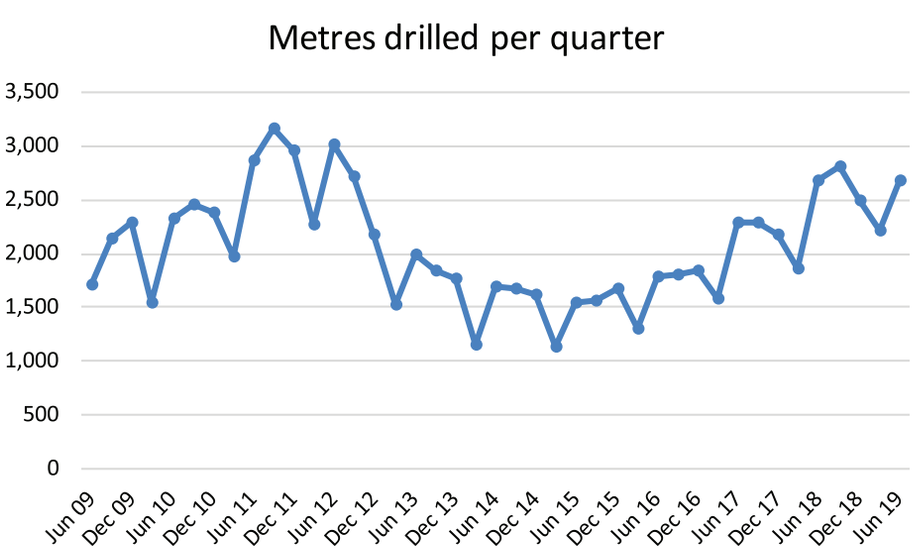

Figure 3. *Metres drilled per quarter from 2009-2019, from data supplied by the ABS https://www.abs.gov.au/ausstats/abs@.nsf/mf/8412.0*

To summarise, it appears that the minerals sector is performing well but the petroleum sector urgently needs a boost, otherwise our import bill for petroleum products will get even worse.

In 2010/11 we produced 25 bl and imported 49.2 bl, and in 2017/18 we produced 15.7 bl and imported 58.7 bl. So, the shortfall increased from 24.2 bl to 43.0 bl in seven years (see https://www.energy.gov.au/publications/australian-petroleum-statistics-2018).

Not good – we must find more oil!

Education matters

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ASEG Research Foundation supports four new projects

The Research Foundation of the ASEG (ASEG RF) reported at the AEGC conference last month that a further four student projects were being supported this year. ASEG RF Secretary Doug Roberts said that the projects at Curtin University, University of Melbourne, Monash University and the University of Adelaide are supporting two multi-year PhD projects and two BSc (honours) projects in 2019. These are in addition to support commenced in past years for two continuing PhD projects at Curtin and Adelaide.

Students working on ASEG RF funded projects tend to be global scientists; Curtin PhD student Snezana Petrovic has already scheduled conference presentations in Perth (WA) and Manchester (UK), plus software training in Paris. PhD candidate Michael Curtis at the University of Adelaide while working on the Carnarvon Basin (north-west WA) has scheduled complementary field-work in analogous rocks of north-west Scotland. We wish all our students on ASEG RF projects great success; may they repay our ASEG RF donors with a lifetime of new insights into our exploration technology.

Applications for ASEG Research Foundation grants for 2020 projects open in December 2019, with a deadline for submission at end February. Details of the application process are on the ASEG's website.

ASEG Research Foundation mid-year project reports

Mid-year reports for four current projects give an insight into the type of projects being supported.

RF19M01 "Elemental analysis via prompt gamma neutron activation for diamond drilling". PhD candidate **Snezana Petrovic** at Curtin University writes of her first six months since starting the project:

I obtained the licence for the MCNP6.2 CLOUD software and registered for the software training programme scheduled for 7–11 October in Paris, France. With my supervisors I completed shielding design for a neutron generator laboratory, and ordered additional shielding material needed. We obtained four quarter-core samples from the Perth core library which will be used for our initial laboratory experiments with the neutron generator.

At a later stage of our research, we will order more samples from the core library. In accordance with the research agreement with the Geological Survey of Western Australia, we are required to provide results of a full suite of analyses (major and trace element suites) on these samples, hence we have obtained a quote from an analytical laboratory to perform these assays. Finally, we have purchased an Amptek DP5G digital pulse processor designed for use in scintillation spectroscopy systems.

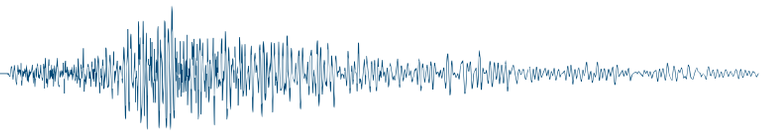
We presented a poster paper at the AEGC conference in September 2019, titled "MCNP modelling of a neutron generator and its shielding for PGNAA in mineral exploration", and have submitted a further abstract for the NSS/MIC – 2019 IEEE Conference (Manchester UK).

RF19M02 "Characterising the depth to basement using HVSR passive seismic in the Murray Basin: Implications for gold exploration undercover". BSc (honours) student **Matthew Luke Sultani** at the University of Melbourne writes:

Many geophysical methods have been employed to characterise the depth to basement in Victoria, including Naudy depth to magnetic source, and 2.5D modelling of gravity and magnetic data. The Horizontal-to-Vertical-Spectral Ratio (HVSR) passive seismic method employs ambient seismic noise generated passively in the environment, by things such as wind and ocean waves to highlight regions of high acoustic impedance contrasts in the subsurface. In the Bendigo Zone, acoustic impedance contrasts could represent the transition from the Murray Basin to the Ordovician Castlemaine Group basement which is prospective for orogenic gold. The Castlemaine Group however, is obscured beneath the Cainozoic sedimentary cover of the Murray Basin, as well as a poorly understood, variable distribution of Permian tillite. It is estimated that a further 75 Moz of gold is potentially untapped below these cover units, which are difficult to penetrate with traditional geophysical methods, especially in the case of the Permian tillite. This research aims to determine depth to basement in the northern Bendigo Zone using the HVSR passive seismic method and drillhole calibration provided by Chalice Gold Mines Limited.

A passive seismic survey was undertaken in Serpentine, Victoria in June 2019. Measurements at 153 stations were taken using three Tromino seismometers along three roadside traverses totalling 11 km in length. A nominal spacing of 100 m across the traverses was obtained, reducing down to 25 m spacing in areas of interest. A total of 42 drillholes were used not only to calibrate the HVSR data, but also to assess the effectiveness of the method's ability to image observed basement depths.

In the study area, prominent and laterally consistent stratigraphic horizons can be interpreted from the HVSR data, due to significant acoustic impedance contrasts in the subsurface. Preliminary results suggest that these contrasts are caused by the transition from Murray Basin cover either



to the top of the Ordovician basement or the Permian tillite – whichever occurs first directly below the site of measurement. The HVSR data is unable to distinguish between the Ordovician or Permian rocks. Faulting is also evident in HVSR data. The HVSR method can be used to accurately determine depth to basement in areas which lack Permian tillite. This technique could be used to reduce exploration expenditure by allowing the targeting of basement highs, to optimise drillhole placement.

RF19M03 "Using analogue interpretations of geophysics to understand geology hiding undercover: A case study from the Mount Isa Inlier". BSc (honours) student **Hannah Williamson** of Monash University writes:

The objectives of this project were to interpret the 3D structural architecture of an outcropping region south of Mt Isa, using potential field geophysics combined with field data and high-resolution digital data. This interpretation will then be applied to understand the continuation of the same geology at depth beneath the Georgina Basin. The expected outcomes will be a greater understanding of the tectonic evolution of a poorly studied portion of the Mt Isa Inlier, as well as recommendations for regions of exploration focus that Anglo American should more closely target in their Exploration Lease.

The project is coming along well and I have undertaken three weeks of field work where there is ground truth in the study area to constrain critical structural geology relationships, particularly along the Wonomo Fault and surrounds, which is interpreted as a potential along strike equivalent of the mineralised Mt Isa Fault System.

During this field season magnetic susceptibility data was collected for all major rock packages exposed. These data have been used to construct an integrated structural and lithological geological map based on geology and aeromagnetic expression of the area. This map has illustrated areas where the geology has not been correctly mapped. Rock property data is also used to constrain two long forward models of the geology. These forward models are constructed and illustrate the geology of the region and the 3D architecture. They will be used to simulate buried geology to the south of the Mount Isa inlier and inform the geophysical expressions of major exploration targets to the south, which will be the final phase of the project.

RF19PO1 "The impact of magmatism on petroleum systems of the Carnarvon Basin". PhD candidate **Michael Curtis** at the University of Adelaide writes of his first six months since starting the project:

The primary aim of this project is to improve knowledge of the timing and distribution of rift-related igneous activity in this important petroliferous basin, and to assess the impacts of this activity on petroleum exploration and development issues.

The project has commenced with a detailed interpretation of the distribution of intrusive igneous rocks present in the Exmouth Sub-basin and the western Exmouth Plateau using open file 3D seismic reflection surveys. Their extent ranges from (and likely continues beyond) the Coverack 3D seismic reflection survey in the south of the Exmouth Sub-basin to the Bonaventure 3D survey in the north-western Exmouth Plateau. In the region of the Coverack Survey, where intrusives often terminate less than a km below the seafloor, they can easily be identified on magnetic data. These igneous rocks are the result of significant magmatism underlying the location of later Cretaceous rift axes that were active while Greater India broke away from the Australasian continent during the Valanginian, c. 140 Ma.

Our mapping reveals intrusions in the Northern Carnarvon Basin have various morphologies that we have categorised in a scheme developed by Plankeet *et al.* (2005): 'Saucer sills' are disc shaped, and climb gently upwards from their centres. These intrusions tend to be isolated, situated several hundred metres below the palaeo-seabed, and generally 2–3 km in diameter. 'Layer parallel sills' are sub-horizontal, tens of km in length, are generally confined to depths of a few km, and act as conduits for magma across large distances. Layer parallel sills are particularly apparent at depth in the Scarborough and Bonaventure 3D surveys.

Magma ascends from deep in the basin by way of 'transgressive sills' and 'climbing saucersills'. Transgressive sills are planar in nature, and progress steeply through stratigraphy as high-angle sheets. Climbing saucer sills fan outwards and upwards in the direction of magma transport and are commonly observed in the Coverack 3D survey. The diameter of these sill types varies from 2 km to >10 km. In addition to the isolated sills we have also identified many large, interconnected complexes of stacked sills, which are present in the Scarborough, Bonaventure and Charon 3D surveys. We have also observed sills exploiting faults as magma pathways, especially in the Indian 2000 3D survey.

We have constrained the timing of igneous activity in several 3D seismic surveys by dating stratigraphy onto which magma extrudes, stratigraphy deformed by injection of magma beneath, and stratigraphy on which cooling-related vent structures are identified. For example, in the HC93 3D Survey, we identified a volcano that has erupted lava onto sediments of the Lower Barrow Group (c. 145Ma – Early Cretaceous); further south, in the Coverack survey, we have mapped intrusions terminating in Aptian age sedimentary rocks (c. 120 Ma –Mid Cretaceous). This shows younging of magmatism to the south, and that the magmatic system was active both during and after breakup on the Cuvier Margin.

To date we have identified six wells that penetrate igneous material. We have compiled their well log data, to gain an understanding of the identifiable petrophysical properties of ash fall deposits, lava flows, volcanoes and intrusions in the Carnarvon Basin. We note that ashfall deposits penetrated in Enfield-3, Enfield-4 and Stybarrow-2 are of similar age to the volcano interpreted in the HC93 3D survey and suggest they may be related.

The next stage of the project will evaluate this data with respect to the Carnarvon Basin petroleum systems, with particular focus on regional heating effects of intrusions on source rocks, reservoir compartmentalisation, and potential trap formation in fold structures generated by intrusion. Fieldwork is planned on the Isle of Skye in Scotland for mid-September 2019, in order to conduct 3D drone scanning of world class exposures of intrusions hosted in a variety of clastic lithologies, analogous to intruded host rocks in the Carnarvon Basin. Data related to intrusion thicknesses in clastic host rocks will be collected. Gaining a better understanding of the relative number of small, seismically undetectable (thinner than 40 m) intrusions compared to larger intrusions will assist in estimating their overall impact on petroleum systems in the Carnarvon Basin. This fieldwork will be followed up with a four-week study placement at the University of Aberdeen, alongside project co-supervisor Dr Nick Schofield, a world expert on the impact of magmatism on petroleum systems.

Environmental geophysics

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Grace mapping of terrestrial water storage

Welcome readers to this issue's column on geophysics applied to the environment. This column is dedicated to the recent Australasian Exploration Geoscience Conference (AEGC), held from September 2 to 5 in Perth.

Actually, in this column I'm going to review one of the most interesting papers that I have seen in years – which I found in the process of doing research for one of my talks at the AEGC. The paper is from *Nature* in 2018 by Dr Matthew Rodell from the Hydrological Sciences Lab at the NASA Goddard Space Flight Centre and six others (Rodell *et al*. 2018). In this article, Rodell and his co-authors interpret 14 years of Grace Satellite data, from launch in 2002 to nearly the end of the mission in 2016, and attribute the observed changes in gravity to changes in water budget around the world – more below.

For those of you who don't know (and I didn't until I researched the project as part of my talk and yes, it is true some of this information is sourced from Wikipedia) the Grace Satellites are a pair of satellites that were in very close to N-S polar orbit, at approximately 500 km altitude. At this altitude and attitude the pair of satellites collected a complete set of global data every 30 days. The pair were separated by about 220 km – and this is the amazing part – the distance between them was known to better than 10 microns. So, this pair of satellites acted as a big gravimeter, with the changing distance between the satellites (after a "few" corrections) being directly related to gravity variation under the track of the satellites. By repeating the data sets every 30 days, the system measured the change in gravity of all in its path over and over again for 14 years. The pixel size from system ranges from about 300 x 300 km at the poles to about 450 by 450 km at the equator, so yes the scale is pretty coarse.

I am aware that I am using the past tense for the Grace data sets – Grace 2 (the second in the pair) burned up on re-entry to the Earth's atmosphere in 2017. The good news is that the all new and improved Grace FO pair were launched in 2018 – so there will be more data like this to look at for the foreseeable future.

Rodell and his team processed the data from the system, looking for gravity changes that could be attributed (mostly) to change in Terrestrial Water Storage (TWS) – at any given location. TWS is the content sum of the groundwater, soil moisture, surface water, snow and ice at a given location. They then categorised the observed change patterns over the surface of the Earth, in conjunction with additional data from other sources that allowed them to "decide" what caused the change in gravity. These additional data sources included long-term rainfall records, Landsat imagery, reports on water use, etc.

Thirty-four trends were identified worldwide, (Figure 1 is from the paper). Changes were divided into five categories: Probable and possible trends caused by climate change (8 of 34 responses), probable and possible trends caused by direct human impact (think groundwater use, dam building, etc. - 14 of 34 responses), and probable trends caused by natural variation (12 of 34).

I could study Figure 1 for hours, looking for trends; the analysis that they provide is very interesting and worth spending time with. The numbering of each trend is related to approximate "importance" of that trend. The largest changes observed (Regions 1 to 5) are all related to changes in ice content at high latitudes. In the groundwater world (just to pick one example), I found it very interesting that this work identified one area, Region 11, west of Urumqi in China, where the change to the TWS has not been previously documented, and was attributed in this paper largely to intense local irrigation not until now appreciated for the sheer magnitude of its effect.

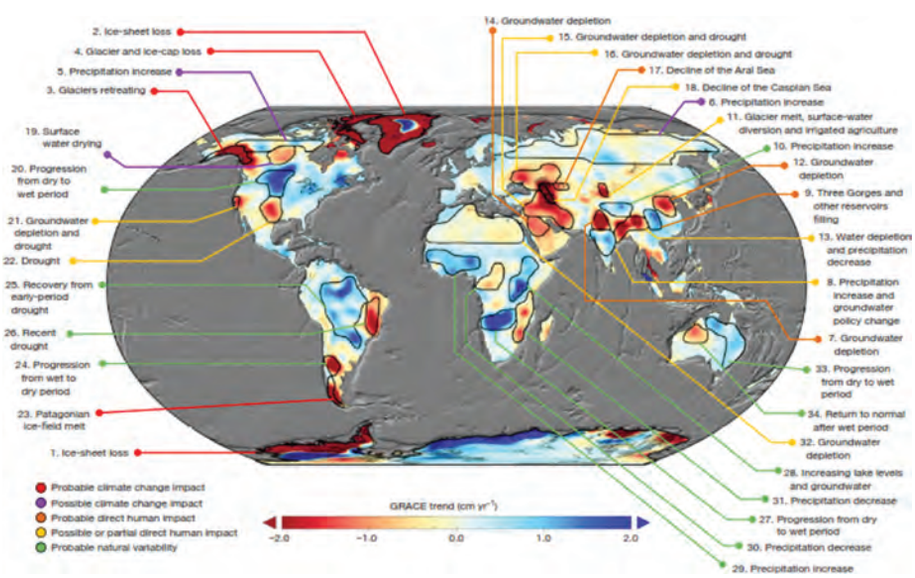

Figure 1. *Annotated map of TWS trends taken from Rodell et al. 2018. Trends in TWS (in cms per year) obtained on the basis of GRACE observations from April 2002 to March 2016. The cause of the trend in each outlined study region is briefly explained and colour-coded by category. The trend map was smoothed with a 150-km-radius Gaussian filter for the purpose of visualization: however, all calculations were performed at the native 3° resolution of the data product.*

From an Australian perspective it is interesting to look at the map of Australia – and note that data do not reflect the drought that is affecting eastern Australia so strongly. This study uses data collected through 2016 - BOM states that the start of the drought was 2017, so this work doesn't reflect the beginning of this event.

Examining the figure, I (cleverly?) wondered what was happening on the Malay Peninsula as there is a large negative there that was not "identified" in the figure. Interestingly, this is discussed in the paper and is not attributed to change in water balance. Rather, this feature is recognised as a dipolar feature (the other pole is to the west in Sumatra) and is attributed to the Sumatra-Andaman earthquake of 2004. The observed gravity change is attributed to the shifting of the ground from the earthquake. Wow!

The results, while fascinating, are also important. The data show clear trends that transcend national boundaries and any government's attempts to obscure information on water use. Not every interpretation offered by the authors will be correct, but all deserve further evaluation. The authors, perhaps somewhat idealistically, see these results as the basis for international cooperation on water use. Perhaps they are too idealistic. At least the data (as big as the pixels are) are out there for all to see.

References

Rodell, M., et al. 2018. Emerging trends in global freshwater availability. *Nature* 557, no. 7707: 651–659.

The new LOUPE portable EM profiling system (transmitter and receiver carried separately) being demonstrated at AEGC 2019. Photo taken by David Broadway

Minerals geophysics

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AEGC 2019 Perth

The Perth 2019 "Data to Discovery" conference was the second exploration conference that the ASEG has co-hosted with the Australian Institute of Geoscientists and the Petroleum Exploration Society of Australia.

My opinions on the structure of our conferences haven't changed. The format is spot on, not too short and not too long, with an emphasis on technical quality in presentations and posters, and a broad range of associated workshops. The physical focus around the exhibitors' hall – having session breaks, lunches and end-of-day drinks amongst the exhibitors – greatly enhances the potential for interaction between conference participants and exhibitors. The expanded AEG Conference format continues to be an excellent means for catching up with fellow geoscientists, finding out about the latest developments in geophysical techniques and doing business. And as geophysicists, we benefit from the presence of geoscientists from other disciplines.

The Perth conference continued in this tradition. It was very well organised and well supported, with more than 1200 delegates and an overflowing exhibitors' hall. The breadth of topics tackled in the presentations was impressive, although I would have liked to have seen a few more mineral geophysics papers – some people are never satisfied! The poster rooms were centrally positioned and well patronised, and there was a wide range of workshops on offer both before and after the conference itself.

The conference also provided an opportunity for the *Preview* contributing editors to get together and exchange ideas. One topic the editorial group thought might be of interest to *Preview* readers was the state of geophysics in countries outside Australia. So, if you are spending time overseas and would like to let our Members know what is going on in your part of the world, please get in touch. Continuing the overseas theme, articles from geophysical contractors or consultants detailing significant or innovative surveys could be of interest to our readers and would serve to showcase your expertise. We felt that *Preview* was an appropriate vehicle for this type of contribution.

And a thank you to the Conference attendees who caught up with me to discuss past *Preview* articles and offer suggestions and contributions for future issues. Your interest in and enthusiasm for *Preview* and mineral geophysics are most appreciated, and the content of future issues will benefit accordingly.

Finally, to the conference papers themselves. This is necessarily a rather personal view focussing mainly on mineral and ground water geophysics. However, the sometimes widely differing approaches to a diversity of subject matter within individual conference streams produced some interesting paper juxtapositions. I've omitted any specific references – extended abstracts of papers and posters were made available to all conference attendees, and it is hoped that the extended abstracts will be published in due course.

With respect to geophysical techniques, the increasing and evolving use of 3D seismics in hard rock environments attracted attention, as did the continued improvements in understanding IP effects in airborne EM. Passive seismics is now in routine use, as evidenced by papers on its application in exploration programmes for heavy mineral sands, iron ore and ground water. In new developments, one paper updated progress on investigations into the biased heterodyne technique, and in another details of an upgraded helicopter EM system were outlined. MT and IP also had their own dedicated conference streams with some thought provoking papers.

Considerable attention was directed to regional geophysics, with papers addressing operational and interpretational aspects of regional airborne gravity, magnetics and electromagnetics surveys, error identification and correction in large data-sets, and organisational mechanisms for collaborative surveys between federal and state governments and industry. Various aspects of the huge Northern Australian AusEM airborne EM survey were considered, and one paper looked in detail at target detection implications for the very wide flight line spacings used in this style of regional survey.

The geophysical Mineral Case Studies streams covered a range of deposit styles and techniques. Topics ranged from single method successes to comparative studies of a series of geophysical techniques, with some interesting papers delving into the exploration strategy as well as technical aspects of the methodology. For something a little different, I also sat in on several of the industrial and strategic minerals case studies; not surprisingly some of the geological settings were quite exotic.

One aspect of papers presented at the conference that did set me thinking was contrasts in content and styles. Papers ranged from the very detailed, elaborating on the intricacies of the processes under discussion (at least one paper supplied computer code), to the very general, perhaps only touching on the evidence and processes, and focussing on the main conclusions. Where appropriate, either style can be valid and very effective. Both have their place. Sometimes details are essential to properly illustrate a process or to provide confidence that every aspect has been fully considered. In other cases, the details may become a distraction, shifting focus away from the important conclusions being drawn. I found both styles of papers to be relevant – it just depended on the subject matter and the aims of the speaker. Yet another illustration that in our business more than one approach path can be valid.

Seismic window

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Labor's enquiry into seismic surveys

I read today that Australia's Labor party has voted to support the Greens to establish an inquiry into offshore seismic surveying. What is the basis for this enquiry? Well all I could find when researching this article was quotes from various "pioneers of whatever seafood industry" whose concerns were printed beneath pictures displaying factory workers opening and gutting scallops or similar. Poor scallops. So, I will pose a question for my readers to ponder as they read further "What is the biggest cause of repetitive, loud noise in the ocean?"

Seismic surveys have been acquired for decades and no one until now has suggested they have brought about the extinction of life in the ocean. In fact, seismic boats operate under strict regulations, which are in place to protect marine life. There are far worse industries in the marine environment, and while that is not a good argument to support seismic surveying it does question the motives of the Greens and Labor. Let's take shipping for example. Who hasn't seen a picture of an unfortunate whale that ventured too close to a propeller that gouged vertical gashes into its body from head to tail? I would add the picture here, but I don't want to infringe copyright rules by grabbing something off the internet without permission. Imagine if ships had to stop if a whale was spotted within two, three or five km by one of a team of observers who continually monitor the ocean around the boat. And just to make sure the whale is not lurking nearby; the ship could not restart until an hour after the last whale sighting.

Or how about fishing? I attended a workshop some time ago and was intrigued by the logic of a Swedish fisherman who complained that seismic surveys should be banned because they make it harder to catch fish. Apparently, the fish swim deeper or shallower for a short time after a seismic vessel passes and therefore they avoid the nets which are trawled at a pre-set depth. I suppose those Swedish fish had a lucky escape from the frying pan as well as a change of scenery.

Plankton researchers a year or so ago (see *Preview* June 2018) decided to study the effects of seismic acquisition on plankton. I'm guessing they figured they could get a grant to support this research. I am led to believe the resultant publications were based on poor science because their methods were discredited by environmental scientists and APPEA within a week. A lot of whales eat plankton and their numbers are going up not down, which suggests that surely there is enough plankton floating in the ocean. The APPEA research indicated plankton levels rebound rapidly.

Lobsters are the latest animals to be dragged into the anti-seismic fight, with recent research suggesting that seismic blasting gives lobsters a balance problem that prevents them from righting themselves if they are put on their back. These lobsters are destined for the dinner table, but who wants to eat an unbalanced crayfish?

Opponents of seismic acquisition use the term "seismic blasting"; an emotive phrase designed to mislead. The days of blasting using an explosive source like dynamite are long gone. Today's sources release compressed air to create a pressure pulse. The pressure is about the same as that created by the "Karcher" in my garage. And the answer to my opening question – the largest source of repetitive, loud noise in the ocean is pile driving for wind farms (Matuschek and Betke 2009). Little wonder the Greens have gone off wind turbines.

Reference

Matushcshek, R., and Betke, K., 2009. Measurements of construction noise during pile driving of offshore research platforms and wind farms. https://tethys.pnnl.gov/sites/default/files/publications/Matuschek_and_Betke_2009.pdf.

Data trends

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Surveying with drones

If you don't have a drone then you have probably flown one in a mate's backyard. They seem simple, are clearly a growing method in exploration and look like a logical successor to certain ground surveys, but what details should we know about drone surveys? I sat down with a licensed drone operator who specialises in ground imagery of mines to get tips on the world of Remote Operator Certificate (ReOC) and Remote Operator Pilot Licence (RePL).

The obvious is, can I do it all myself?

If you are a business you must have the necessary licenses and certificates. Even "flying for fun" will soon need accreditation for anything over 250 g and mandatory drone registration is planned by CASA (Civil Aviation Safety Authority).

Is it as (legally) simple to run as a ground survey?

An important clarification is that drone surveys incur regulation of both CASA and your local Mining Act. Airspace is anything in the air and while surveys may appear harmless there are rules that must be followed. Drone surveys are viewed as airborne surveys by most states, who expect to be properly notified in advanced. In addition, while grey in writing, it is always best stakeholder/explorer relationship practice to notify the land owner (including government departments).

What are ReOC and RePL

The business needs the certificate and the pilot needs the license. The certificate holder must nominate a qualified Chief Remote Pilot. The Chief Pilot does not have to be present, but signs off flight plans and is essentially acting as a record keeper for CASA.

Do you use survey control, such as RTK base stations?

Yes, but drone flights are increasingly using new base stations, of which the most widely known at the moment is *Aeropoints©*. An hour before survey the flat, tile like GPS units are placed around the perimeter of the survey and one in the centre for similar results to traditional RTK techniques. They can also be placed at different heights to increase height resolution.

Typical pre-survey preparations?

Survey design is so easy with the various free apps and programmes that you barely have to type, however you should use programmes such as Google Earth to check elevation profiles to understand your terrain issues and carry out an onsite recon to confirm. Pre-flight logistics planning includes managing the number of batteries required, locating launch areas and identifying sensitive flora and fauna to avoid (e.g. scouting for eagles). Try to fly along "strike" with the terrain instead of across/up and over to avoid climb issues. A tale from photogrammetry involved flying over a hill in one direction and unavoidably being left above the legal limit on the other side. The solution was to simply split the survey into two, which is not an onerous problem when you consider batteries often need changing every half to one hour anyway.

How does weather affect surveys?

Besides rain and dim light conditions for photography, flights for the small drones are often restricted by winds above 20–30 km/h. Even though geophysics drones may be heavier, the extra hardware attached means there is more surface area for the winds to buffet.

More information

General information: https://www.casa.gov.au/droneflyer

Find out if you in a no fly zone? https://casa.dronecomplier.com/external

Webwaves

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Essential 8

In this issue of *Preview* I am going to be looking at viruses, malware and other security vulnerabilities on modern electronic devices, and some best practices for protecting you and your data.

Heartbleed, Spectre, Meltdown. No, I'm not listing Bond films or villains. These are some of the names of vulnerabilities that have been found on computers in the past decade. Some of these exploit the microprocessors used in our devices. Others, like Heartbleed, are vulnerabilities in OpenSSL, used by some of the most popular websites. Every Intel processor that has been released since 1995 is affected by Meltdown. Spectre can exploit a wide variety of devices including smartphones, and has been verified on Intel, AMD and ARM processors.

The Australian Government has a series of recommendations for ensuring cyber security and protecting you and your business from threats (and avoiding the virus aquarium shown in the cartoon). In 2019, the ACSC (Australian Cyber Security Centre) updated their Essential 8 guidelines, originally released in February 2017. These provide eight strategies designed to mitigate cyber security incidents and represent a prioritised list of mitigation strategies. This can be viewed in full online (https://www.cyber.gov.au/publications/essential-eight-explained) and an abridged version is published below.

The Essential 8 are grouped into three sections; to prevent malware, limit the extent of malware, and recover data.

Mitigation strategies to prevent malware delivery and execution

Application whitelisting

To prevent non-approved applications and malicious code from executing, it is recommended to only allow trusted and approved programmes to run.

Patch applications

Software should be regularly updated. Any security patches should be applied within 48 hours of release. Security patches and updates are designed to fix vulnerabilities in software that can be used to execute malicious code.

Configure Microsoft Office macro settings

While you are ideally operating a Unix/Linux environment, for those running Microsoft applications it is highly recommended that only vetted macros from trusted locations are allowed to run. Macros can be used to execute malicious code.

User application hardening

Web browsers should be configured to block ads and Java, and Flash should be uninstalled. Additionally, unneeded features in Microsoft Office should be disabled. Flash, ads and Java are popular ways to deliver and execute malicious code.

Mitigation strategies to limit the extent of cyber security incidents

Restrict administrative privileges

Users should not be running with an admin account. Elevated privileges should be dropped when not needed. They allow full access to the system for any code that is run.

Patch operating systems

Don't use unsupported versions of operating systems and patch your operating system within 48 hours of extreme risk vulnerabilities. These vulnerabilities can be used to compromise the system.

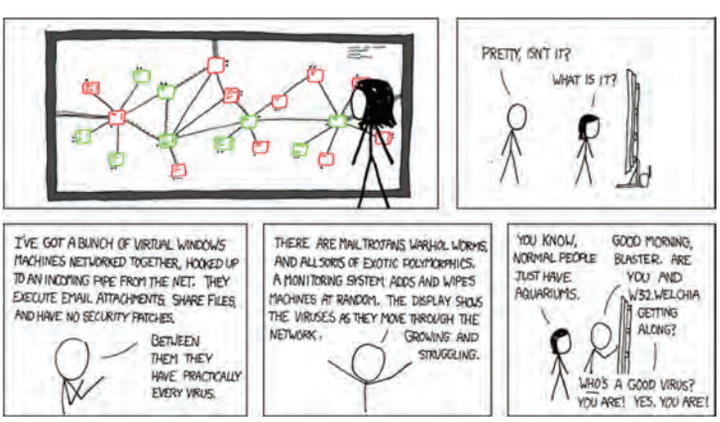
Multifactor Authentication

If performing a privileged action, or accessing highly sensitive data, multifactor authentication should be used. Think withdrawing money from a bank account: you need both your card (something you have) and your PIN (something you know).

Mitigation strategies to recover data and system availability

Daily backups

Users should keep daily (or more frequent) backups of important or changed data. Restoration should be tested on a regular basis and when IT infrastructure changes. This prevents ransomware incidents.



A virus aquarium (https://www.xkcd.com/350)

Breaking news

Non-members of the ASEG can now sign up for email reminders for the latest issue of *Preview*. Head over to https://www.aseg.org.au/publications/PVCurrent and simply sign up to receive email notifications every time an issue of *Preview* is released. Members of ASEG will continue to receive email notifications when new issues are published.

There are other works in the pipeline for the website that will improve the user experience and add additional features. If you'd like to help out with the website, please email webmaster@aseg.org.au.

Space rocks on display at Geoscience Australia

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Introduction

Geoscience Australia recently opened a new public display of space rocks to commemorate the 50th anniversary of the Apollo 11 landing on the Moon (Figure 1). The centrepiece is a touch sample collected from the Moon by Jack Schmitt, the only geologist to visit another world, on the Apollo 17 mission, the last time anyone went to the Moon. Two other samples are particularly noteworthy; meteorites from Mars and the Moon. There are also a number of other meteorites on view, representing all the significant classes.

Apollo 17 sample 70215

This sample came from approximately 60 km east of the Apollo 17 lunar module (LM), *Challenger* (Figure 2). It's unusually dark and massive appearance called Jack Schmitt's attention during previous extravehicular activity (EVA 2) and he took the opportunity to collect it during EVA 3. The transcript can be read at the Apollo Lunar surface Journal (2015).

Sample 70215 (or, to give it it's full name of 70215,396, making it the 396th piece from the sample) was described as a medium dark grey, brownish tinted, fine-grained basalt containing micrometeorite pits on all faces. Rare vughs up to 3 mm in diameter are also present. The shape is blocky to subangular with one flat surface slicken-sided. Under the microscope the vughs contain projecting plates and prisms of ilmenite and pyroxene. The fabric is intersertal (containing glass between larger crystals) to intergranular. Different thin sections reveal 70215 as a fine grained, sub-variolitic basalt with microphenocrysts of ilmenite, olivine, and clinopyroxene. Localised sheafs of plagioclase laths are present. Chemically 70215 contains 13% titanium and thus belongs to the lunar high Ti basalt province. The sample has been successfully dated using Ar-Ar and K-Ar methods, with a whole-rock plateau age of 3.84 ± 0.04 Ga and an exposure age of 100 ± 12 Ma (Apollo 17 sample catalog 2016, and references therein).

At 8.1 kg, sample 70215 is the largest rock brought back by Apollo 17, many of the offcuts have been distributed to various institutions to allow the public to touch. It is the only lunar sample which the public can access in this way.

NWA 11273 – lunar feldspathic breccia

The second lunar sample on display is a lunaite, a meteorite that originated from the Moon. Its full sample ID is 11273-19-015. All lunar meteorites have been ejected following impact, because of the low lunar gravity (0.17 G) any crater larger than a few km is likely to impart velocities in excess of the lunar escape velocity to some of its' ejecta (Head et al. 2002). Although lunar meteorites are likely to have been falling on Earth throughout geologic time, all those known were ejected in the past 20 million years and some as recently as a few hundred years ago (Gladman and Burns 1996, Nishiizumi et al. 2005). Such meteorites were not found until after the Apollo missions, the first being discovered in Antarctica in 1979.

At the time of writing (22/7/19) 405 lunar meteorite samples are known, many of these are paired samples, that is, samples from a single parent body that have fragmented either during their atmospheric passage or on impact. Lunaites are significant not only because they add significantly to the mass of lunar material available for study but because they originate from different parts of the Moon than were visited

Figure 1. *Opening of the display. Left to right Steve Petkovski (GA), Anthony Murfett (Deputy Head of the Australian Space Agency), Badri Younes (Deputy Associate Administrator, NASA), and Steve Hill (GA). They are standing behind the display of the Apollo 17 touchstone the and lunar and Martian meteorites.*

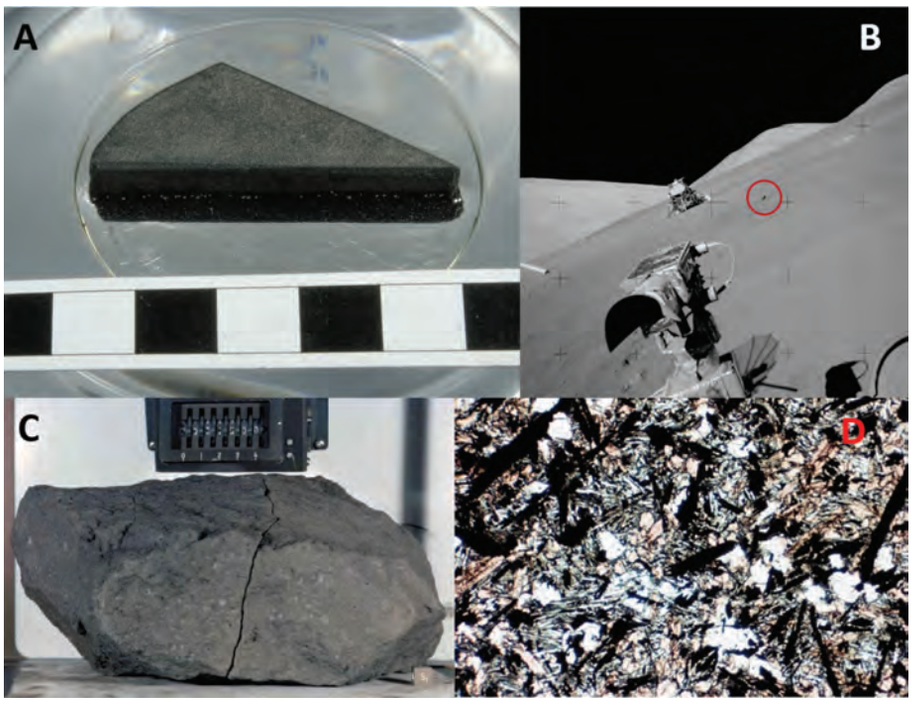

Figure 2. *The story of the Apollo sample 70215. A) Close up of Apollo 17 sample 70215,396, a 3.84 Gya high Ti lunar basalt. B) Sample 70215 (circled) on the Moon. Lunar module Challenger in background, the Apollo Lunar Module Roving Vehicle TV camera in foreground (NASA image). Not every photograph taken on the Moon was perfectly composed, as this example, taken by Harrison Schmitt, shows. C) Intact specimen, over 8 kg in mass, in the laboratory (LPI image, Apollo 17 sample catalog 2016). D) Thin section image, width 2.5 mm, transmitted light, crossed polars (LPI image, Apollo 17 sample catalog 2016).*

by the six Apollo and the three Luna unmanned sample return missions. A useful online introduction to lunarites is Korotev (2018).

North West Africa 11273 was found buried in Algeria in 2017 and had an original mass of 2.81 kg. It is a feldspathic breccia with prominent white clasts of anorthosite, the dominant rock type of the lunar highlands (Figure 3). Petrography reveals that in addition to the anorthite comprising the anorthosite clasts, olivine, exsolved pigeonite, pigeonite, augite, chromite, Ti-Cr-Fe spinel, kamacite, taenite and troilite are present in a fine-grained matrix containing small vesicles and minor barite. Rare basalt clasts and glass fragments are also present (Meteorite Bulletin database 2019a).

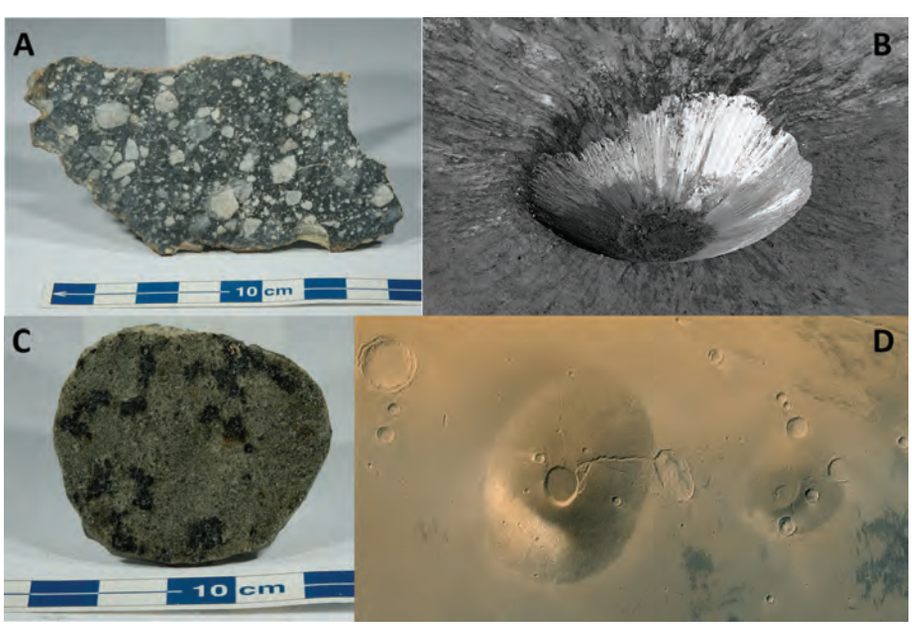

Figure 3. *Lunar and Martian meteorites. A) Lunar meteorite NWA 11273, composed of a feldspathic breccia. B) Hell Q crater, a very young, 3.4 km diameter crater on the Moon, an event of this size would eject lunar material with sufficient velocity for some to end up on Earth as lunar meteorites (NASA LROC image). C) A Martian meteorite, NWA 8657. Dark areas are shocked plagioclase glass. D) Ceraunius Tholus (left), and Uranius Tholus, two "small" volcanoes in the Tharsis Ridge region. The caldera of Ceraunius Tholus is approximately 24 km across. NWA 8657 would have been ejected by an impact into a relatively young (150-200 Mya) volcanic province such as this within the last few million years (NASA/MSSS image).*

NWA 8657 "diabasic" shergottite

As with lunaites, impacts on Mars can ejecta material with sufficient velocity to escape the planet and put it into Earth crossing orbits, where some may eventually fall as meteorites. Much larger impacts are needed to eject material from Mars than from the Moon, due to the greater Martian gravity (0.38 G). A small group of meteorites have long been known to form a distinct family known as SNC meteorites, after the original specimens from Shergotty, Nakhala, and Chassigny. At the time of writing (22/7/19), 135 distinct specimens are known, not including paired stones. Demonstrating that the SNC meteorites come from Mars is one of the most remarkable pieces of scientific reasoning in the history of meteoritics. The two Viking spacecraft that landed on Mars in 1976 measured the noble gas isotopic ratios of the Martian atmosphere, these ratios are unique to each planet. In 1983 the SNC meteorites were found to have the same ratios. The most common Mars meteorites are Shergottites (118), the remainder are Nakhalites (11) Chassignite (4), single examples of an orthopyroxenite (the famous ALH84001 with putative evidence for Martian life), and a regolith breccia (Irving 2019).

Geoscience Australia's display specimen is of Northwest Africa 8657 (Figure 3). The meteorite, originally massing 234 g (GA's sample is 8.421 g), was purchased from a Moroccan dealer in 2015. NWA 8657 is described as being predominantly complexly zoned, prismatically-twinned clinopyroxene and maskelynite (shocked plagioclase glass) with accessory ilmenite, ulvöspinel, pyrrhotite, merrillite, chlorapatite and vesicular glass. Minor components are anorthoclase and altered glass. The sample is classed as a diabasic (doleritic) Shergottite (Meteorite Bulletin database 2019b). It is one of 15 individual specimens linked to the same event (Irving 2019). The meteorite is enriched in incompatible elements (Howarth et al. 2017), indicating it formed from a fractionated basaltic magma. The Martian source of dated enriched diabasic Shergottites were formed between 200 and 150 Ma, they were ejected by a number of impacts between 3.7 and 0.73 Ma. NWA 8657 and its pairs have not themselves been dated (Irving 2018).

Other meteorites on display

Meteorites are fragments of naturally occurring space material that have fallen to any planetary surface through natural processes. Collisions between asteroids and between asteroids and larger bodies such as the Moon and planets, can send fragments into Earth-crossing orbits, some of these can fall as meteorites (McSween et al. 1987). They can be linked spectroscopically. In addition to Earth, meteoritic material has been found on the Moon (Anders et al. 1973) and Mars (Schröder et al. 2008). A probable terrestrial rock has been found on the Moon in one of the samples returned by the Apollo 14 mission (Bellucci et al. 2019). Most meteorites are, however from the asteroid belt (McSween et al. 1987). Figure 4 shows a number of asteroids visited or about to be visited by space missions that represent the most common asteroid classes.

The Geoscience Australia display (Figure 5) has examples of the following meteorites classes:

Type L (low iron) ordinary chondrites: Nine Mile, Kybunga, and Allan Hills A76009. Nine Mile (also known as Menindee 003) is from NSW (Meteorite Bulletin database 2019c), Kybunga from north of Adelaide in South Australia, respectively (Fitzgerald 1979) and Alan Hills A76009 from Antarctica (Meteorite Bulletin database 2019d). Ordinary chondrites are typical of many of the smaller asteroids, known as group S bodies. An example is asteroid Itokawa (Yoshikawa et al. 2006), visited by the Japanese Hayabusa 1 probe in 2005, and with samples returned to Earth at Woomera in 2010. Their name refers to the presence of chondrules, typically millimetre-scale spherical bodies formed as melt droplets in the solar nebula before accreting to form

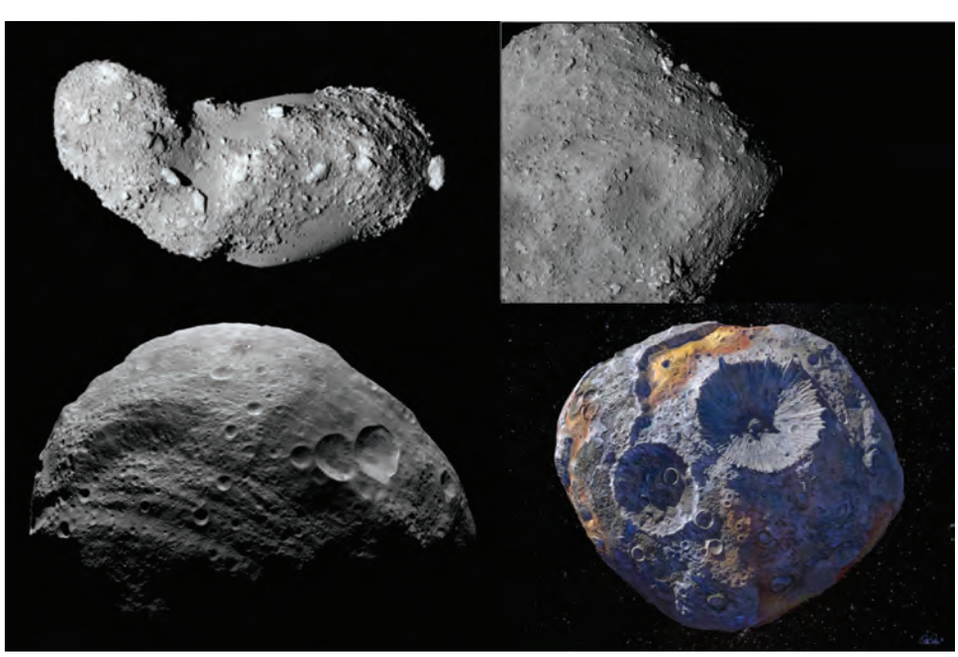

Figure 4. *Example asteroids with compositions representative of different meteorite classes. A) Asteroid Itokawa (535 m long), a typical small asteroid of L ordinary chondritic composition (JAXA image). B) Asteroid Ryugu (1 m diameter), with a carbonaceous chondritic composition (JAXA image). C) Asteroid Vesta (diameter 573 km) visited by the Dawn mission), probably the source of the HED family of meteorites (NASA image). D) Artist's impression of asteroid Psyche (diameter 279 km), to be visited by the forthcoming Psyche orbiter mission to be launched in 2022 for a 2026 arrival (Peter Rubin/NASA image).*

Figure 5. *GA meteorite display.*

meteoroids and asteroids (Figure 6). All three have received some shock metamorphism, The Kybunga meteorite belongs to the L5 type (Meteorite Bulletin database 2019e), with sufficient metamorphism to homogenise olivine and pyroxene, convert all low-Ca pyroxene to orthopyroxene, cause the growth of various secondary minerals, and blur chondrule outlines (Meteorite Bulletin database 2019f). The Nine Mile and Allan Hills specimens represent the slightly more metamorphosed L6 type. These have been metamorphosed under conditions sufficient to homogenise all mineral compositions, convert low-Ca pyroxene to orthopyroxene, coarsen secondary phases textures, and obliterate many chondrule outlines, all without, however, melting the meteorite; no melting has occurred (Meteorite Bulletin database 2019g).

Carbonaceous chondrites: These very primitive meteorites are notable for their relatively high content of organic matter (including amino acids), water, and small calcium rich inclusions (CAIs) that pre-date the formation of the solar system (Figure 6. They are derived from group C asteroids such as Bennu and Ryugu, which are currently being visited by the Osiris-REX and Hayabusa 2 spacecraft respectively (Laurette et al. 2019, Watanabe et al. 2019). Such asteroids are the most common in the asteroid belt but carbonaceous chondrites are rare because of their weak structure and easily weathered mineralogy. The class is represented in the GA display by the Murchison meteorite, which fell in Victoria in 1969.

Achondrites: This class of meteorites lack chondrules and are composed of mafic or ultramafic rocks such as basalt, dolerite, gabbro, and pyroxenite. They thus represent material from differentiated bodies, such as rocky planets, the larger rocky satellites, and larger asteroids. Martian and lunar meteorites are examples of achondritic meteorites. At present GA only has a cast of an achondrite from the asteroid belt, the Millbillillie meteorite from Western Australia, plans exist to replace with an actual specimen in the future.

Iron meteorites: Numerous small planets were formed in the early solar system. Their mantles and crusts were stripped by collision, exposing their iron-nickel alloy cores, these are preserved as the M group asteroids and the source of the iron (and perhaps some of the stony iron) meteorites. Psyche is one of the larger examples, and there are plans for it to be orbited by the Psyche mission in 2026. Iron meteorites are represented in the GA collection by Henbury, Coolac, Tawallah, and Mundrabilla, the last as a sawn slab. The Henbury meteorites are associated with a cluster of small impact craters south of Alice Springs.

Stony iron meteorites: This class of meteorites are among the rarest known and are among the most beautiful. They are well represented in the GA display by Imiliac (Chile), Brenham (US), and Huckitta (NT). They formed at the boundary between the metallic cores of small planetary bodies and the silicate mantles.

Tektites

Tektites are glassy bodies generally widely accepted to represent impact melt that was ejected during crater formation. Tektites are found in Europe, Africa and North American, and have been linked to specific craters. The mostly widely distributed tektite field is the Australasian, which covers south-east Asia, southern China, the Indian and Southern

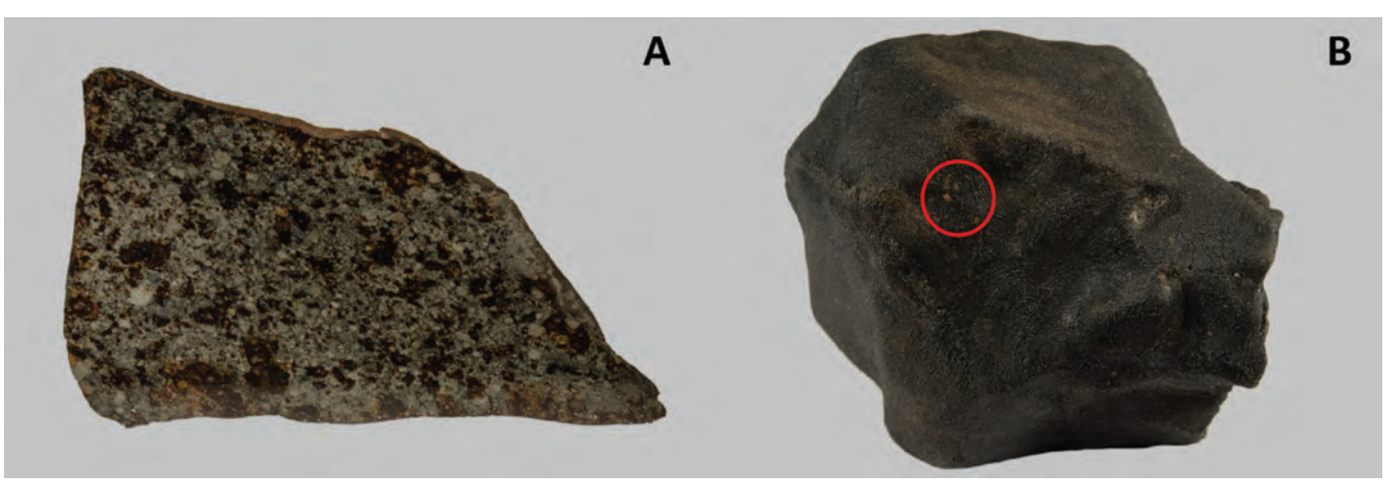

Figure 6. *A) Chondrules (small rounded grains 1-2 mm across) in L5 ordinary chondrite Kybunga). B) Murchison carbonaceous chondrite showing small calcium-aluminium inclusions (CAIs) that are ~5 billion years old and predate the formation of the solar system.*

Oceans, Australia, and parts of Antarctica. Tektites from this field, the Australites, occur in different forms; "splash form" tektites, which include the classic button and dumbbell-shaped tektites; "ablated form" tektites, which preserve evidence of the glass having partially re-melted during atmospheric re-entry, and "Muong-Nuong type" tektites, which preserve conspicuous layering and relicts of the unmelted parent rock. In size they range from micro-tektites, found in deep sea cores, to kilogram-size. Unlike other tektite fields, the source crater for the Australites has not been discovered, despite the fact at 790 000 years in age, it is the youngest of such fields known. It most like occurs in south-east Asia (Cavosie et al. 2018). The GA display features a large splash-form tektite from Thailand and several Australian ablated tektites.

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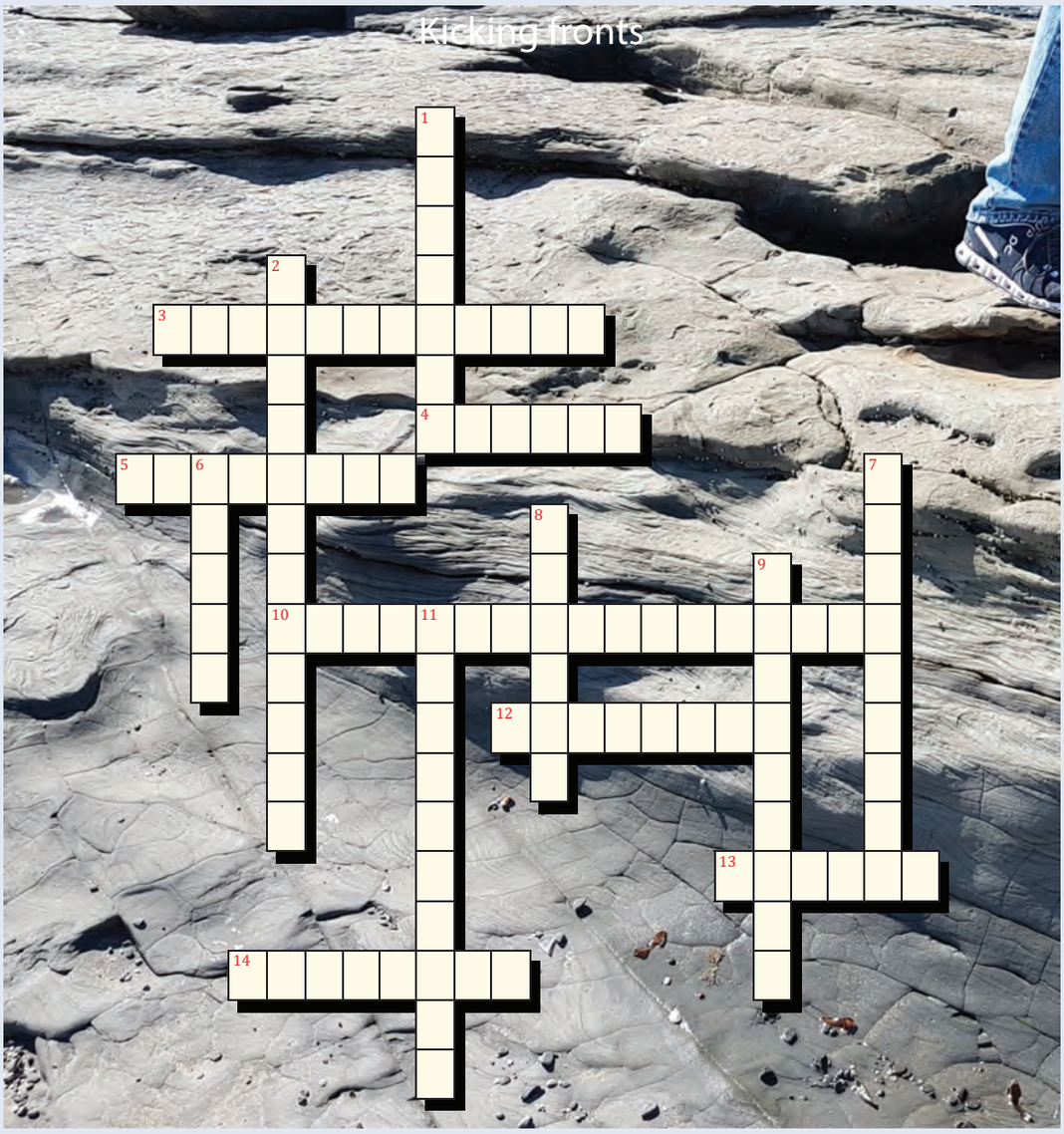
Preview crossword #4



Across	Down
3. The stress-strain ratio for simple shear in isotropic materials that obey Hooke's law	**1.** The sinuous trace of a stream channel often best developed over a floodplain
4. A seismic wavelet where the attenuation is proportional to the square of the frequency	**2.** A fold which maintains its geometric form, integral wavelength, and symmetry throughout a sequence of layers
5. In marine ecosystems, the shore area or intertidal zone where periodic exposure and submersion by tides is normal	**6.** Visually, the most prominent lunar crater
10. A very fine aggregate of crystals in an igneous rock, and to minerals in which the individual crystals are too fine to be distinguished, even under a petrological microscope	**7.** The total continuous and interconnecting void space in the bulk volume of soil or rock
12. In statistics, applied to the re-evaluation of probabilities based on empirical observations	**8.** The colour of a mineral when in the form of powder
13. A variety of chalcedonic silica, which is reddish-brown, opaque and cryptocrystalline	**9.** A wavefront which has no effective curvature because of its distance from the source
14. A measure of the tendency of a gas to escape or expand	**11.** The time taken for a wave to travel from a source generator, through some media, to a detector at a known offset

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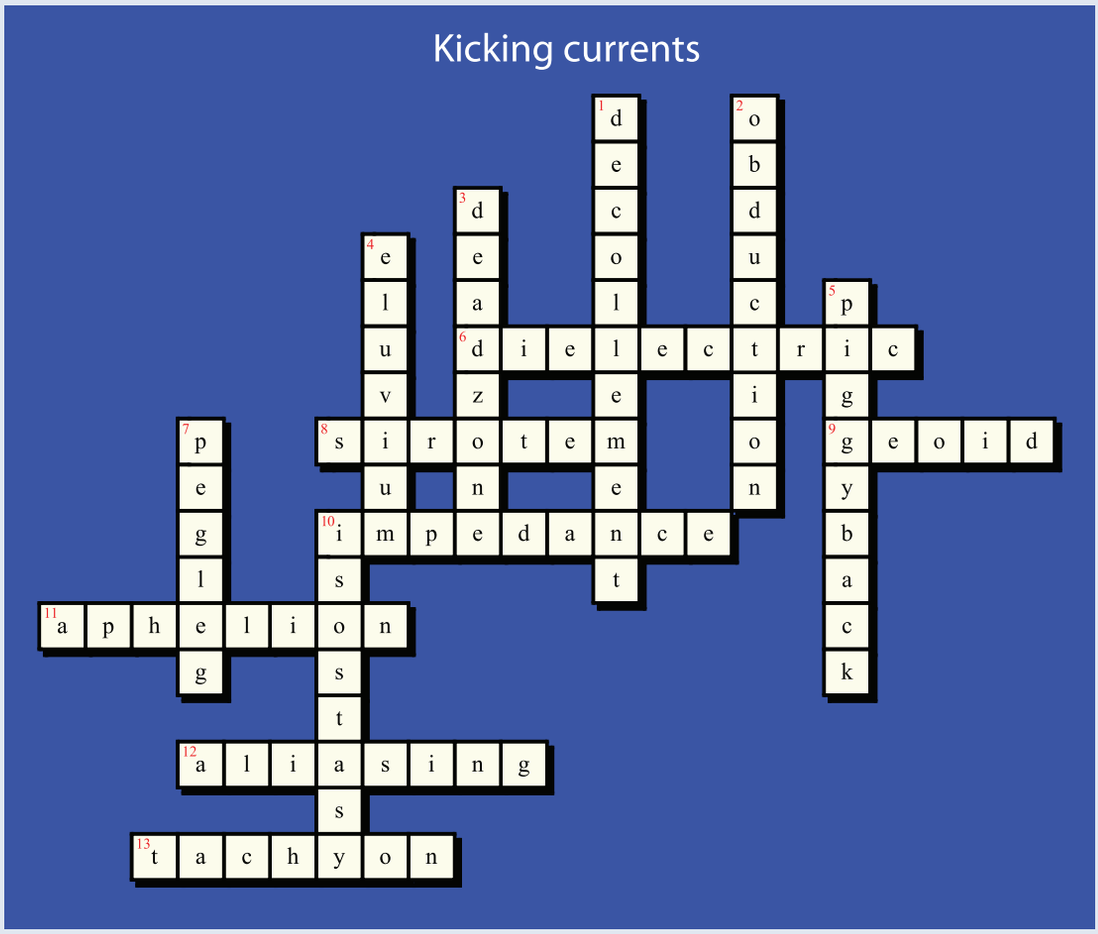
Good luck!

Preview crossword #3 solution



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Business directory

Noll Moriarty and Stephanie Dietrich of Archimedes Financial Planning enjoying AEGC 2019. Photo taken by David Broadway

October	**2019**		
6–9	SAGA 16th Biennial South African Geophysical Association Conference and Exhibition http://sagaconference.co.za/	Durban	South Africa
21–24	Fifth International Conference on Engineering Geophysics (ICEG) https://seg.org/Events/ICEG-2019	Al Ain	UAE
29–30	Asia Petroleum Geoscience Conference & Exhibition (APGCE 2019) www.apgce.com	Kuala Lumpur	Malaysia
29–31	OTC Brazil http://www.otcnet.org/Brasil	faRio de Janeiro	Brazil
30	2019 Oil and Gas Machine Learning Symposium https://www.upstreamml.com/	Houston	USA
November	**2019**		
5–7	SEG 3rd International Workshop on Mathematical Geophysics: Traditional vs. Learning https://seg.org/events/mathgeo	Beijing	China
13–14	EAGE Workshop on Faster Subsurface Characterisation for Reservoir Modelling – Integrated and Innovative Workflows from Geoscience to Dynamic Simulation https://events.eage.org/en/2019/EAGE%20Workshop%20on%20Reservoir%20Modelling%20Perth%202019	Perth	Australia
14–15	Dorothy Hill Women in Earth Sciences Symposium https://absoluteevents.eventsair.com/dorothy-hill-women-in-earth-sciences-symposium-2019/	Brisbane	Australia
18–22	GSA Specialist Group in Tectonics and Structural Geology and Specialist Group in Solid Earth: Convergence on the Coast https://www.sgtsg.org/	Port Lincoln	Australia
18–19	SPE/AAPG/SEG Asia Pacific Unconventional Resources Technology Conference https://www.spe.org/events/en/2019/conference/19apur/spe-aapg-seg-asia-pacific-unconventional-resources-technology-conference.html	Brisbane	Australia
December	**2019**		
9–13	American Geophysical Union Fall Meeting https://www2.agu.org/fall-meeting	San Francisco	USA
19–2	SEG | EAGE Workshop: Geophysical Aspects of Smart Cities https://seg.org/Events/SmartCitySingapore	Singapore	Singapore
March	**2020**		
3–8	36th International Geological Congress https://www.36igc.org/	New Delhi	India
11–16	SEG International Exposition and 90th Annual Meeting	Houston	USA
15–20	International Symposium on Deep Seismic Profiling of the Continents and their Margins (SEISMIX 2020) http://www.seismix2020.org.au	Fremantle	Australia
April	**2020**		
19–21	AI Earth Exploration Workshop: Teaching the Machine How to Characterize the Subsurface https://seg.org/Events/Artificially-Intelligent-Earth-Exploration	Muscat	Oman
24–27	Offshore Technology Conference Asia (OTC Asia) http://2020.otcasia.org/welcome	Kuala Lumpur	Malaysia
May	**2020**		
3–8	European Geosciences Union https://www.egu2020.eu/	Vienna	Austria
September	**2020**		
7–11	ISC (International Conference on Geotechnical and Geophysical Site Characterization) conference www.isc6.org	Budapest	Hungary
28–02 Oct	Australian and New Zealand Geomorphology Group Conference https://www.anzgg.org/conferences	Alice Springs	Australia

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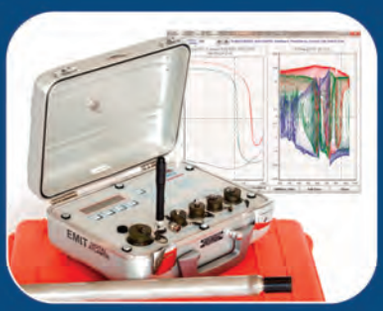

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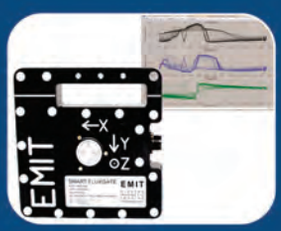

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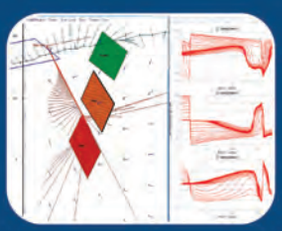

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