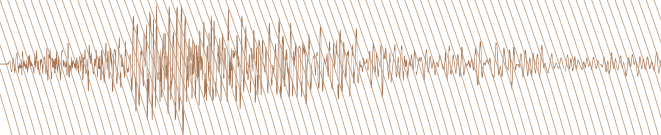




Australian Society of  
Exploration Geophysicists

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# PREVIEW



## NEWS AND COMMENTARY

AEGC 2023 Reflections and awards  
New guide to standards for airborne  
magnetic and radiometric data  
acquisition  
Someone has to ask questions  
Is gloss best?  
VPN

## FEATURES

ASEG Honours and Awards  
More than ore: The future of  
mining geophysics



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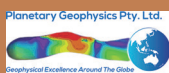
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## FRONT COVER



ASEG President Elect Janelle Simpson (GSQ) and Courtney Dhanaram (GSQ) at AEGC 2023. Photo (and all photos of the AEGC 2023 in this issue) taken by Alison Blakeley [www.havecamerawillsnap.com](http://www.havecamerawillsnap.com)

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# AEM2023

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## 8th International Airborne Electromagnetics Workshop

**4 -7 September 2023**  
**Fitzroy Island, QLD, Australia**

The 8th International Workshop on Airborne Electromagnetics will be held at Fitzroy Island, Queensland Australia, in person between the 4th and 8th September 2023. Fitzroy Island is an unspoilt tropical paradise of rainforest and beaches within the calm sheltered waters of the Great Barrier Reef. The island is a National Park, with walking trails, tropical plants and animals, and abundant marine life.

The Workshop will encompass advances in airborne electromagnetic systems, modelling and interpretation. Case studies covering geotechnical, mining, energy, groundwater and environmental applications will be presented. The event will be a platform to contribute, discuss and learn about airborne electromagnetics and provide a forum for in-depth conversations on the subject area with colleagues from Australia and worldwide.

A four-day program will feature speakers from academia, government and industry, with keynotes delivered by leading experts in their respective streams.

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## Editor's desk



This issue of *Preview* features the 2023 ASEG Honours and Awards. Phil Schmidt is a most worthy recipient of the ASEG Gold Medal – prepared to be awed by his citation!

We also feature an article on the future of mining geophysics by Michelle Thomas, who is Global Practice Lead Geophysics, BHP. Michelle gave a stirring plenary address at AEGC 2023 on this same topic.

Her article gives us a real insight into the thinking that is shaping the future of BHP, and highlights some of the challenges that our industry is facing. Michelle is following through in terms of working with the ASEG to address some of these challenges and has agreed to Chair the ASEG Education Committee in 2023-24. A space to watch as Michelle is a ball of energy!

In other news and commentary, in this issue of *Preview* David Denham (*Canberra observed*) reports on the latest exploration investment figures for minerals and petroleum, and also fills us in on what is happening with new \$15 billion National Reconstruction Fund. Marina Pervukhina (*Education matters*) reminds us that asking the right questions is key the navigating a world increasing dominated by AI. Mike Hatch (*Environmental geophysics*) swallows his disappointment at missing out on the AEGC and asks the right questions of friends and colleagues about the conference highlights. Terry Harvey (*Mineral geophysics*) sounds a note of caution about over-egging the


presentation of data. Mick Micenko (*Seismic window*) reflects on the wheel turning at the AEGC. Tim Keeping (*Data trends*) lauds the latest GA guide to airborne magnetic and radiometric data acquisition, processing and reporting standards, and Ian James (*Webwaves*) takes a look at VPNs.

If you saw a talk at AEGC 2023 that you thought would make a great *Preview* article, then please give me a hoiy and I'll follow up with the speaker. I have already followed up with some speakers - like Michelle - but there were so many concurrent sessions that I couldn't get to all the talks that caught my attention. Made me hanker for the convenience of being able to virtually revisit talks that accompanied the AEGC virtual conference in 2021. Perhaps the AEGC 2024 conference organisers should be encouraged to consider a hybrid conference model, thereby harnessing the best of both conference worlds!

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## President's piece



Eric Battig

I would like to begin my first *President's piece* by extending a massive thank you to the Australasian Exploration Geoscience Conference (AEGC) 2023 Conference Organising Committee. Our Co-Chairs Megan Nightingale and Dale Sims, Treasurer Melanie Fitzell and the entire Committee worked tirelessly to bring together this impressive event. It was a resounding success built on a high quality and diverse Technical Programme, engaging Workshops, a very popular Exhibition, and many fun and memorable social events. Of course, an event like this would not be possible without the generous support of our Sponsors, and I would like to personally thank our Platinum Sponsors BHP and Newmont and all the other companies involved for their commitment to the AEGC.

A highlight for me was the privilege of announcing the recipients of the prestigious ASEG Honours and Awards for 2022. These awards recognise outstanding contributions to the profession of exploration geophysics

and to the ASEG, and I wholeheartedly congratulate all the recipients. A special mention to Dr Phil Schmidt for the award of the ASEG Gold Medal for 2022. This award recognises Phil's exceptional contributions to the geophysics profession in Australia and internationally, through his leading-edge research and developments in the theory and practical application of rock magnetism and palaeomagnetism, and for his significant contributions to the ASEG over many years. I would also like to extend my gratitude to Andrew Mutton and the entire Honours and Awards Committee for their dedicated work in preparing for these nominations. This was Andrew's last year chairing this committee, which he has served on as Chair since 2010, and we welcome Marina Costelloe who is taking over this role. Thank you, Andrew, for your longstanding contributions to the ASEG.

Having a substantial portion of our membership in Brisbane and attending the AEGC provided us with an opportunity

to meet in person once again for several key ASEG events. At the Council Meeting we heard from many of the Committees as we celebrated their successes and reflected on the headwinds that the ASEG is facing. These successes include the highly regarded CAGE and MAG22 workshops, publishing the Extended Abstracts from AEGC 2021, a submission to the JORC update concerning the role of geophysics and geophysicists as Competent Persons in public company reports to the ASX, increasing our engagement across all the Society's social media accounts, and securing ongoing commitment to the AEGC from the three member organisations. As we look forward, we will need to face head on the challenges that relate to declining membership numbers, maintaining the technical standard of our flagship publication *Exploration Geophysics*, and transferring the immense knowledge and experience of our aging membership to the next generation of geophysicists.

Finally, I would like to pay tribute and extend my gratitude to the outgoing Federal Executive for their unwavering support and commitment to our Society over the past 12 months and extend a warm welcome our new Executive and Committee members. Many thanks to Emma Brand for her leadership over the past year, she has set us up to thrive into the future. An inspirational achievement seeing as it all happened while she tackled an international move and a major career step. Another thank you goes to Leslie Atkinson as she steps out of the role of Secretary. She had made significant contributions to the operation and governance of the ASEG over many years.

I hope to meet and speak with many of you throughout the year, but please don't hesitate to reach out anytime with any feedback or suggestions.

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## Executive brief

The Annual General Meeting (AGM) of the ASEG was held on 17 March 2023 in Brisbane. Members joined the AGM in person and virtually. The face-to-face event was held at Brisbane Convention and Exhibition centre. There were nine people who joined virtually, there were three proxies, and a quorum was present at the venue.

The Directors for the Society for 2022/2023, elected in accordance with the Society's Constitution, were announced at the AGM. Eric Battig is the new President, congratulations to Eric. The President Elect is Janelle Simpson, the Treasurer is Yvette Poudjom Djomani and the Secretary is Asmita Manata. Emma Brand is continuing as a Director in her capacity as immediate Past President. Heartiest thanks to Emma for her contribution as 2022 President. Another thank you goes to the outgoing Secretary of the Federal Executive, Leslie Atkinson, for her contributions over the past few years.

The Federal Executive for 2022/23 was also announced at the AGM. Welcome to all the new members and those who are continuing with their roles. The position holders are as follows:

Eric Battig – President

Ian James – Vice President, Webmaster

Janelle Simpson – President Elect,  
State Branch Liaison

Emma Brand - Immediate Past  
President, Diversity Committee Chair

Asmita Manata - Secretary

Yvette Poudjom Djomani – Treasurer,  
Finance Committee Chair

Steve Hearn – Publications Committee  
Chair

Mark Duffet – Technical Standards  
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Suzanne Haydon- Membership  
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Mosayeb Khademi – Communications  
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Randell Taylor – International Affairs  
Committee Chair

Kate Brand – Professional  
Development Committee Chair

The outgoing President's report updated Members on progress against strategic initiatives and critical core business. In summary, in the past year the Federal Executive (FedEx) has focused on four key areas including creating a sustainable model for the ASEG, understanding and communicating the identity of ASEG, creating, articulating and delivering Member value and satisfaction, and, finally, improving the volunteer experience. FedEx has made considerable progress in delivery against these strategic initiatives. They have also made considerable progress in terms of delivering against critical core business objectives. In particular, several educational workshops were conducted, including the highly successful CAGE and MAG22, and the ASEG website is in the process of being updated with features that will enhance Member experience. Work has also progressed in terms of reducing process waste and increasing volunteer satisfaction. The 2022 Volunteer Almanac, where all volunteers are recognised for their efforts is now available. An ASEG business case is being implemented at the FedEx level so that Members can request funds in a standard way, making assessments easier and quicker. The current tender process is also being assessed, and the best value proposition for ASEG publications, as contract renewal is approaching, is being considered. FedEx also looked at whether the ASEG should continue with the AEGC model and considered how to adequately manage conference risk. It was decided that it was possible to continue with the model while meeting our specific needs.

It was reported that the AIG, PESA and ASEG had workshoped the future of the AEGC conference at a white sheet session, which was facilitated independently. Two changes were proposed to ensure future success. The first one was to move to a two-year conference cycle, with the conferences being held in springtime. The next conference will be held in Spring 2024. The next change was to create a new role in the Organising Committee structure. The role is that of a Technical Director, who will be the single point of accountability for the technical programme, representing the tripartite interests of the three member organisations. It is a challenging but crucial enabler role.

The outgoing President also provided an update on the outcome of AEGC 2023. The total number of registrations was 932, including 546 delegates, 255 exhibitors, 20 day registrations, 26 speaker registrations, 15 Organising Committee registrations, 28 sponsor registrations and 42 student registrations. The conference had a great vibe and provided fantastic networking opportunities for all participants.

The outgoing President reported further that Member engagement was trending in the right direction, with the adoption of various digital engagement and communication tools. YouTube engagement has been a success in the digital sphere, which is helping to increase the value proposition for international Members. Thanks goes to the Communication Committee, the Editorial team for *Exploration Geophysics*, which is the technical flagship for ASEG, and Editorial team for *Preview* for their continued efforts to bring value to Members and to the geophysics community as a whole. Special applause goes to Steve Hearn for his commendable effort in compiling the extended abstracts for 29 ASEG conferences over 44 years from 1979-2023.

Thanks also goes to the Technical Standard Committee, especially Kim Frankcombe and Dave Pratt, for their submission to JORC concerning the role of geophysics, and geophysicists as Competent Persons, in public company reports to the ASX.

ASEG Membership is trending in a negative direction with a year on year decrease in membership since 2018. The ACT being the only exception to this trend. International membership is growing, and currently is the second largest group of Members. WA is the state with the largest group of Members in Australia.

A special mention also to the organisers of CAGE (Camp for Applied Geophysics Excellence), a wonderful initiative providing support to early career geophysicists. There were 70 applications for 25 places. The camp was supported by volunteers from various organisations, all of whom generously shared their knowledge and time.

The Treasurer provided an update on the ASEG's financial position. In summary, the net loss in 2022 was



\$AUD 69 067, compared to a net loss in 2021 of \$AUD 72 284. The main sources of income were memberships and publications. Education generated some income in 2022, with CAGE and MAG 22 being the most profitable. The main items of expenditure were meetings, events and education. Publication also incurred some expenditure although publications as a whole returned a profit. Educational events and the Research Foundation were run at a loss, however they are proving benefits to Members. Overall, there is a healthy balance of total equity of \$AUD 957 065 in net assets. The detailed report is available on the ASEG website.

The AGM was followed by a Strategy Day on 18 March, where the newly elected Federal Executive, journal editors and representatives from various committees got together to discuss long term

strategic directions for the Society. Key issues addressed during discussion were as follows.

- Growing the capabilities of exploration geophysicists: How can we encourage the development of courses to provide educational qualifications in the face of disappearing geophysical degrees across Australian universities?
- Re-branding: Need to assess other organisations such as SAGA and how they are re-branding.
- Revitalising publications with focus relevant to Members
- Off conference cycle planning: What should we do in off-years as we move to two-year conference cycle, and should we be planning for technical symposiums or a geophysics festival?
- Reviewing content accessibility: How can we better serve our international and regional Australian Members?

- Improving volunteer experience: How do we on-board volunteers and provide ongoing support?
- Reviewing the service provided by the Secretariat.
- Engaging with State Branches: How can we increase engagement between the state branches and FedEx?

More details will follow after the April FedEx meeting, and strategy document will be shared with Members on the ASEG website.

The Federal Executive would like to thank TAS for organising and facilitating the 2023 AGM online event. A lot of work goes on behind the scenes to make such an event a success.

*Asmita Mahanta*  
ASEG Secretary  
[fedsec@aseg.org.au](mailto:fedsec@aseg.org.au)

## Welcome to new Members

The ASEG extends a warm welcome to 18 new Members approved by the Federal Executive at its February and March 2023 meetings (see table).

First name	Last name	Organisation	State	Country	Membership type
Edward	Biegert	Gentleman Scientist	Texas	USA	Active
Peush	Chaudhary	Institute of Seismological Research	Gujarat	India	Active
Michael	Cunningham	Sander Geophysics	Ontario	Canada	Active
Ben	Haase	BHP	Qld	Australia	Active
Abhijit	Kurup	University of Western Australia	WA	Australia	Student
Casey	Lee	James Cook University	Qld	Australia	Student
Brian	Makone	MNG	Vic	Australia	Active
David	Ndungu	Kabete National Polytechnic	Nairobi	Kenya	Associate
James	Njoku	Heathgate Resources	SA	Australia	Active
Izuchukwu (Edmond)	Nwabueze		Tas	Australia	Associate
Emilio	Rodriguez Nieves	ExploreGeo	WA	Australia	Associate
William	Rowlands	Gap Explosive Ordnance Detection	Qld	Australia	Active
Farshad	Salajegheh	Macquarie University	NSW	Australia	Active
Karunakar Rao	Semmta	Datacode	Maharashtra	India	Active
Pavel	Shashkin	Curtin University	WA	Australia	Active
Kelly	Vaughan-Taylor	Mitre Geophysics	Qld	Australia	Associate
Wen	Xi	UNSW	NSW	Australia	Student
Jacob	Zhang	Yancoal Australia	Qld	Australia	Associate

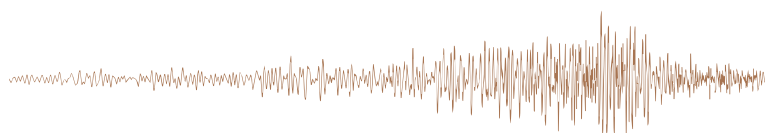
## ASEG Young Professionals Network: AEGC 2023

With the dust barely settled on my return from the Australasian Exploration Geoscience Conference (AEGC) in Brisbane, there's only time to say a very quick thank you to the hard-working YPs who ran the Geo Pitch, the FMG Networking Night, and the Industry Panel as well as the High School Student's day and the "Brisbane Brews" drinks.

The team was led by Kat Gioseffi ably assisted by Nick Josephs and Janelle Simpson, and I've possibly neglected to mention others...but I'm sure Nick will rectify this when he writes a more detailed piece, with pictures, in the next edition of *Preview*.

In other YP news, it's a new year and a new budget cycle for YP events in your state. Please get in touch to discuss your event ideas and seek funding support.

*Jarrod Dunne*  
[ypadmin@aseg.org.au](mailto:ypadmin@aseg.org.au)



## ASEG Technical Standards Committee: Technical standards for airborne magnetic and radiometric data

Since it began acquiring airborne magnetic data over onshore Australia in 1951, Geoscience Australia (GA) has been committed to acquiring airborne geophysics for regional geological understanding. Today, GA is the custodian of Australia's national compilations of magnetic and radiometric datasets, the quality of which is underpinned by a set of technical standards. In March 2023 these technical standards were published for the first time, highlighting the requirements GA has for magnetic and radiometric data to become part of those national compilations.

*Technical Standards for Airborne Magnetic and Radiometric Data* covers the acquisition, processing and supply of airborne magnetic, horizontal magnetic gradient and radiometric data. For each technique there are specifications for equipment, calibrations, quality control checks, reporting and data formats.

These technical standards were developed over many years using published information and working with the ASEG and contractors to ensure accurate and repeatable data. The latest version of these standards has been compiled in collaboration with industry experts and peer reviewed across a number of government agency

geophysicists to ensure practicality without sacrificing data quality.

The technical standards are available for download here:

<https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147457>

As always, we welcome feedback and any suggestions for improvement.

The Technical Standards Committee can be contacted via [technical-standards@aseg.org.au](mailto:technical-standards@aseg.org.au).

*James Goodwin on behalf of the ASEG Technical Standards Committee*  
[James.Goodwin@ga.gov.au](mailto:James.Goodwin@ga.gov.au)

## ASEG History Committee: Current nominations for ASEG milestones in electrical and electromagnetic exploration geophysics

The ASEG History sub-committee (P Gidley, S Collins, J Macnae and M Smith) established for the compilation of a listing of Australian milestones in electrical and electromagnetic exploration geophysics has to date endorsed fourteen nominations for the listing (Table 1).

The nominations were submitted by various ASEG Members on the standard Nomination Form, and have been verified through discussion and amendment among the sub-committee members. Further nominations would be welcomed by the coordinator at the [mike\\_rpgeo@optusnet.com.au](mailto:mike_rpgeo@optusnet.com.au)

The fourteen approved nominations are a very worthy company of Australian geophysicists and colleagues, who have made a significant technological advance in either electrical or electromagnetic exploration geophysics.

*Mike Smith*  
[mike\\_rpgeo@optusnet.com.au](mailto:mike_rpgeo@optusnet.com.au)

**Table 1.** ASEG electric/electromagnetic milestones (in chronological order)

	Start	To	Description of milestone	Innovator/Nominee
1	1970s	1980s	Direction over several decades of a large team of CSIRO scientists whose work led to the commercial manufacture of the successful exploration instrument SIROTEM	Dr Ken McCracken AO
2	1970	2021	Development of theoretical and mathematical innovations in the field of transient electromagnetic geophysical applications	Dr Terrance John Lee (Terry Lee)
3	1971		The Palmer Mk I TEM Instrument	Bob Richardson, Lew Richardson and Mike Palmer
4	1973	2022	Confirmation of non-linear electrical effects in mineralised rocks	R M S (Bob) White
5	1975	1990	Establishment and leadership of the Centre for Geophysical Exploration Research at Macquarie University	Prof Keeva Vozoff
6	1975	2020	The Dual Loop configuration of the transient electromagnetic system, subsequently developed as Infinitem	Dr Brian Spies
7	1977	1990	Development of the SIROTEM time domain electromagnetic system, a highly improved EM exploration method for the Australian environment	Dr Jock Buselli and Brian O'Neill
8	1980		Development of the SMARTem electrical methods geophysical receiver	Dr Andrew Duncan
9	1980		Advanced electromagnetic modelling	Drs Art Raiche, Freddi Sugeng and Glenn Wilson
10	1981		Achieving the estimation of quartz fabrics from piezoelectric measurements	Dr John Bishop
11	1991	1993	The SAM and SAMSON technologies	Malcolm K Cattach, John M Stanley, Stephen J Lee, David Boggs
12	1996	2001	Development of the TEMPEST airborne EM system, a role which required Richard to integrate engineering, geophysical and software development	Dr Richard John Llewellyn Lane
13	2007		Development of LANDTEM, which proved that cryogenic techniques can be successfully deployed in real-world field situations	Dr Keith Leslie, Dr Cathy Foley (and collaborating colleagues at CSIRO)
14	2019		The design and testing of ARMIT magnetic field sensors for EM systems	Dr James Macnae

# ASEG Research Foundation: Update on current projects

The ASEG Research Foundation makes an annual call for grant applications for projects in geophysics at Australian institutions closing in early March each year. For the details on this process see the Foundation's pages at <https://www.aseg.org.au/foundation/overview>. Updates on selected current projects follow:

The ASEG Research Foundation acknowledges and thanks our donors from the ASEG membership, both individual and corporate. The ASEG as a whole makes a significant donation each year to support the Foundation. For information on donating visit <https://www.aseg.org.au/foundation/donate>. All donations are tax deductible. Further information on the ASEG Research Foundation can be found at <https://www.aseg.org.au/foundation/overview>.

**RF20E03.** Flinders University PhD Student Andrew Frost (Supervisor Dr Ian Moffat).

*Assessing a multi-modal approach in the location of unmarked graves under various seasonal conditions.*

Is there an optimal seasonal time to undertake geophysical prospecting for unmarked graves? Does the presence of moisture in the soil influence the effectiveness of radar or resistivity results? These are the questions that I am exploring in my PhD research, and these questions are important because, as preliminary work from known grave sites has shown, not all graves show in radar or resistivity surveys.

Detecting unmarked graves is a critical challenge facing archaeologists, law enforcement agencies, community groups, cemetery administrators, and those that work in the geophysics industry. Detecting burial sites is difficult due to their subtle response and small size, and these responses diminish over time. Any advancement of knowledge of methods commonly used will increase the surety of detection, and geophysical methods remain to the fore due to the non-invasive and culturally appropriate nature of the geophysical methods favoured in grave detection.

The generous funding made available from ASEG has allowed me to visit my study sites regularly, these are in the South-East and on the Eyre Peninsula, and to undertake radar and resistivity

surveys over existing graves. The funding also allowed me to purchase and install two Sentek 'Drill & Drop' Bluetooth moisture meters. These subsurface instruments measure soil moisture at 10 cm intervals, down to 80 cm. These are installed in sites that present a different soil matrix, one with a loamier matrix, the other with a sodic clay. The data gathered from these instruments has been enlightening as they have shown, firstly, that the Bureau of Meteorology is not always accurate, and secondly, that even in a loamy soil matrix, the moisture that falls in a seasonal rainfall event will take months to percolate to moderate depths. This new knowledge shows that waiting for a rain event before heading to the field to undertake a geophysical survey may not actually be an advantage.

By using rows containing known, and verified, existing graves, the effects of the seasonal rainfall can be tracked using the data from the moisture meter, the changes in resistivity along the row, and the changes in radar velocity. This exciting research will provide answers to the questions posed above and will also provide a guide for those looking to locate unmarked graves as to the optimal seasonal conditions in which to carry out a survey.

In the areas I have worked in, this is the period from April to September. The lower plot in [Figure 1](#) shows the total interpolated moisture, from 311 mm in April to 436 mm in September. The upper plot shows the moisture levels at sensor depth, these are positioned at every 10 cm.

This plot shows that the available soil moisture is not reaching the lower levels.

**RF21P02.** University of Melbourne MSc Student Youssef Hamad (Supervisor Dr Graeme Beardsmore).

*Utilisation and comparison of conventional wireline precision temperature sensing, DTS, and aDTS to detect and quantify subsurface geothermal anomalies in the on-shore Gippsland Basin.*

Task 1. Synthesise literature to identify potential convective and/or refractive heat transfer zones in Gippsland. Locate available boreholes within these zones that are limited in subsurface temperature data.

Joe completed and submitted his literature review and delivered his 1st year oral progress report to the School of Geography Earth and Atmospheric Sciences. The research questions and knowledge gaps identified in the Project Details remain relevant. Major WNW–ESE trending faults and basin margins are identified as regions of interest for field data collection. To that end Joe has identified and collected precision wireline temperature logs from seven boreholes totalling 5100 m depth. Furthermore, Joe has identified an additional borehole in the Latrobe Valley to test the capability of a fibre-optic Distributed

Temperature Sensor (DTS) to accurately log temperature in an air-filled bore—conditions under which conventional wireline temperature sensors typically fail to thermally equilibrate.

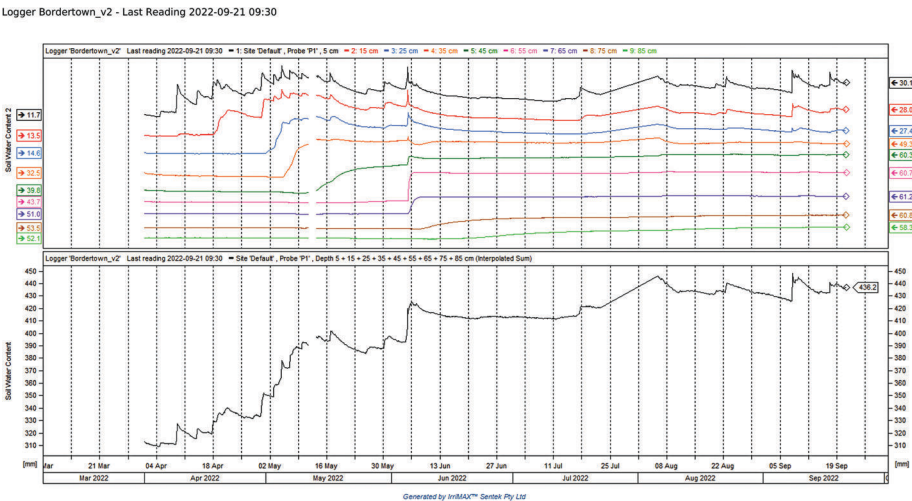


Figure 1. Graph from one of the Bordertown moisture meters.

2. A major component of the project is to design on-campus laboratory experiments to test, calibrate, and assess the sources of noise, dynamic range and to compare the accuracy and precision of CWPTS and DTS systems. If possible, locate a shallow borehole close to metropolitan Melbourne to test equipment before deploying to Gippsland.

Joe has assembled the appropriate apparatus in UoM's petrophysics laboratory and calibrated all the relevant sensors (thermistor-based wireline tools and DTS fibre optic cables) to known precision and accuracy. Additionally, Joe has constructed a new thermal control bath system for real-time DTS data quality control in the field. A new 1500 m long portable, reusable DTS fibre optic sensor cable has been constructed (in collaboration with CSIRO Energy), calibrated, and is ready for deployment into two deep (>1000 m) bores in Gippsland. A second new DTS sensor cable, 950 m long and configured differently, will arrive from CSIRO Energy in January 2023.

3. The first field campaign we will acquire CWPTS data to establish 'master' temperature values and analyse spatial thermal perturbations to determine the optimal dynamic range for DTS. Check for borehole structures using borehole televiewer tool to assess the minimum required DTS spatial and temporal resolution.

Joe carried out field campaigns from late December 2021 through July 2022, beginning as soon as possible after COVID travel restrictions lifted in late 2021. During this programme, Joe deployed fully calibrated thermistor-based wireline temperature sensors to collect baseline precision temperature logs in the seven boreholes mentioned above. The borehole televiewer has not been required. Well completion reports and drillers' logs have provided sufficient information about borehole structures.

4. The second field campaign will involve data collecting by DTS monitoring in the same boreholes as the first field campaign using the established dynamic range, spatial and temporal resolution from the first field campaign. Confirm reproducibility of temperature profiles across the two sensor types.

Two of the priority boreholes identified for logging were drilled to depths of 1350 m and 1500 m, respectively.

Joe confirmed their current depths as 1080 m and 1010 m, respectively, during his first field campaign using a fishing line and sinker. Both bores exceed the maximum cable lengths of the DTS and wireline (~950 m) temperature sensors available to UoM at the start of Joe's project. To log the lower portion of the bores, we commissioned a new 1500 m 'single-ended' fibre optic DTS cable which arrived in March 2022 and is planned for deployment from December 2022 to January 2023. We also commissioned a new 'double-ended' 1000 m fibre optic DTS cable (the maximum recommended length for a 'double-ended' cable using UoM's DTS system), which is due to arrive in January 2023 and will be deployed shortly thereafter.

5. Critically compare CWPTS data ('master' temperature values) with DTS data to identify any *in-situ* factors that affect accuracy and precision.

The second field campaign, planned for December 2022 to January 2023, will provide the DTS field data for comparison. Joe has, however, made some comparison tests under laboratory conditions.

6. Locate appropriate holes for *in situ* thermal conductivity tests using aDTS, ideally boreholes with thick, homogenous geological sections and core samples to allow laboratory determinations of conductivity.

Joe has not been able to deploy UoM's 'active DTS' (aDTS) system with 300 m and 500 m cables to measure thermal conductivity *in situ*. The aDTS system has proven impractical for field deployment due to its requirements in terms of borehole characteristics (diameter, depth, water level) and surface equipment (trailer mounted generator, high voltage, exposed live wires, electrician required on site, security required). As an alternative, CSIRO Energy collaborated on a field trial of a smaller 100 m a-DTS system in South Australia in November 2022 and is willing to deploy the system in Gippsland for Joe's project.

7. The third field campaign will acquire *in-situ* thermal rock conductivity data using aDTS. Compare *in situ* results with laboratory determinations to confirm reliability.

In anticipation of a third field campaign focused on *in situ* thermal conductivity measurement using active DTS, Joe has identified a suitable borehole in

Gippsland for deployment in February or March 2023. The borehole is ~140 m deep, has standing water level ~7 m below ground level, and intersects a coal seam at about 60 m depth.

8. Fourth field campaign will collect new data from boreholes in zones of potential convective heat transfer. Interpret the data for evidence of convection.

A fourth field campaign might be planned to further utilise the a-DTS depending on the outcomes of the third field campaign.

9. Model the data from all field campaigns to extract important geothermal parameters to derive conclusions for the hypothesis.

The anticipated timeframe for this task is January – July 2023.

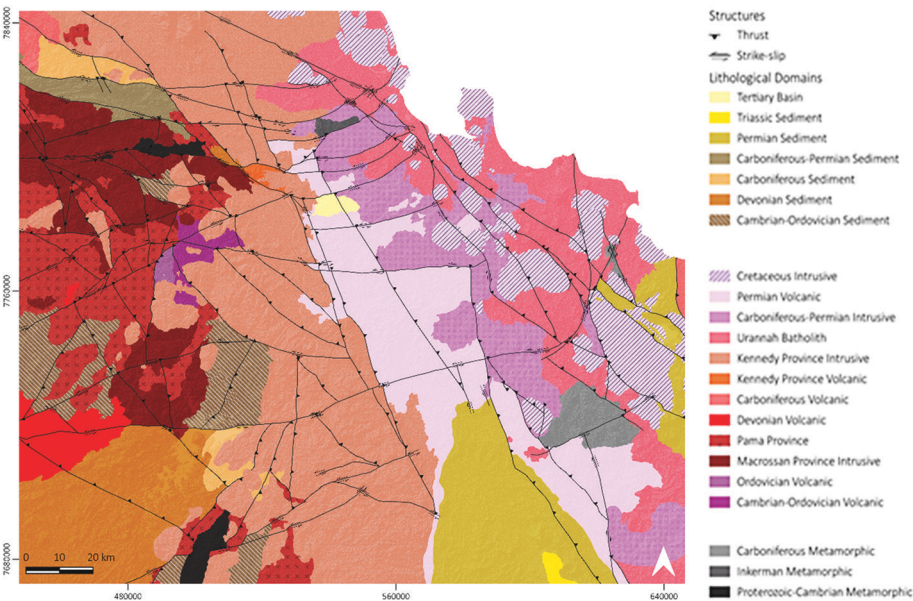
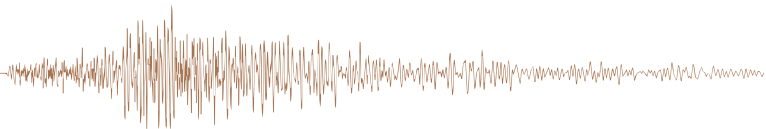
10. Draw conclusions about suitability of CWPTS, DTS and aDTS for determining heat flow in boreholes and refine Gippsland geothermal exploration strategies.

The anticipated timeframe for this task is January – July 2023.

**RF22M01.** Monash University BSc (Hons) Student Audrey Quealy (Supervisor Dr Robin Amit).

*Geophysical expression of crustal-scale faults and their links to metallogenic epochs of the Mossman Orogen, Queensland. (Subtitle Palaeozoic Evolution of Northeast Queensland: Implications from the Inkerian Metamorphics).*

The Tasmanides, which make up the eastern third of the Australian continent, are a series of broadly N-S trending orogenic belts formed through Palaeozoic, progressively eastward accretionary tectonics. Whilst this ~N-S structural grain is preserved across much of northeast Queensland, anomalous geometries, including the ENE-WSW-trending Charters Towers Province (Thomson Orogen), indicate an intricately complex and vastly overprinted tectonic evolution, which has been interpreted to relate to orocline formation. In this study, a lithostructural geophysical interpretation of the junction between the Connors Subprovince (New England Orogen) and Charters Towers Province was undertaken to assess the temporal and spatial relationships and evolution of this major boundary. A region of ~35 000 km<sup>2</sup> was selected and a multidisciplinary approach (gravity, aeromagnetics, radiometrics



**Figure 2.** Lithostructural geophysical interpretation of the study area filtered by overarching lithological domain.

and published field mapping) utilised to categorise lithologies and inform the overarching domains presented in Figure 2. This interpretation found that Benambran deformation produced ENE-WSW-trending sinistral strike-slip faults in the Charters Towers domain which were overprinted by the subsequent N-S to NNW-SSE eastward-dipping thrust faults associated with the early Hunter-Bowen Orogeny and the accretion of the Connors Arc system. An ensuing re-activation along ENE-WSW sinistral faults was observed and is interpreted to indicate localised migration to ~NE-SW directed shortening during the late Hunter-Bowen Orogeny.

A series of regional surficial curvatures evident in the structural grain of northeast Queensland are defined by remanent Late Proterozoic to Early Palaeozoic basement sequences and metamorphic belts. High-resolution (40 m) aeromagnetics and satellite imagery reveal intersecting NNW-SSE and WSW-ENE structural trends in the enigmatic Inkerman Metamorphics (Connors Subprovince), proximal to the location of the fold axial trace of an inferred orocline. Targeted field mapping and petrophysical data was collected at Inkerman Station and used to examine evidence for this potential orocline, constrain the resolution of the lithostructural interpretation and to ground-truth the geophysics. Geological field mapping reveals that no evidence of oroclinal bending is preserved in the Inkerman Metamorphics. Rather, the change in trend perhaps reflects

overprinting of the Charters Towers Province by the Connors Subprovince or temporally separated periods of subsequent deformation.

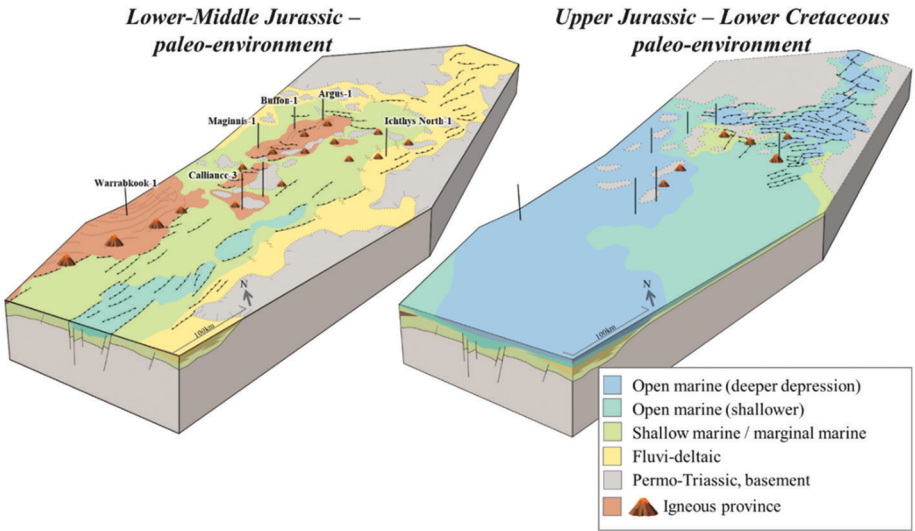
**RF22P01.** University of Adelaide PhD Student Kosuke Tsutsui (Supervisors Prof Simon Holford, Dr Mark Bunch, A/Prof Ros King, Adj/Prof Ken McClay, Prof Nick Schofield).

*Geophysical-geomechanical characterisation of igneous rocks in the Browse Basin: implications for exploration, development, and gas storage in volcanic-rich basins.*

Project goal and annual plan: The major goal of this project is to investigate the impact of igneous rocks on exploration, development and gas storage in the

Browse Basin from basin-to-wellbore scale using multiple geoscience approaches. In this year, the project focused on the regional geology through the examination of basin-wide record of Mesozoic igneous and tectonic activity.

Work performed during 2022: We evaluated the basin architecture, igneous rock types and their distributions, their petrophysical characteristics, and their correlation to seismic facies using over 100 exploration/appraisal wells and regional 2D/3D seismic data. Basin-wide Mesozoic palaeo-environmental maps were also interpreted, which illustrate the evolution of igneous rock distribution and types through geological time (Figure 3). Our analyses indicate that although igneous activity has sporadically continued within the basin throughout the Mesozoic, the most aggressive period of magmatism occurred during the Middle Jurassic; a large part of the outboard basin was covered by thick volcanic sequences (e.g. >447 m in Warrabkook-1, >320 m in Kontiki-1, and >1117 m in Grace-1), mainly consisting of accumulations of tabular or compound lava flows. In contrast, igneous rocks in the central part of the basin (the Caswell Sub-basin) are commonly found within more terrigenous sedimentary facies (e.g. coal beds). They often occur as strongly altered volcanoclastic sediments, which are observed in cores such as the Calliance-3, Brecknock-4, Dinichythys North-1, where it is rare to observe stacks of unaltered lava flows. Subsequent episodic magmatism during the Berriasian resulted in a



**Figure 3.** Interpreted palaeo-environment and volcanic provinces of the Browse Basin

series of volcanoes and lava flows being erupted in a deep-marine environment, which are mainly concentrated in the northern part of the basin (e.g. Ichthys North-1 area) indicating a focused magmatic plumbing system during the Lower Cretaceous. Our study provides a basin-wide framework of Mesozoic magmatism in the Browse Basin within a tectono-stratigraphic context, and yields new insights into the tempo, distribution and nature of magmatic activity that will be beneficial for future exploration activities, field development planning, and assessments of the feasibility of CCS in the Browse Basin. Initial results from the project will be presented at AEGC 2023 in Brisbane.

**RF22M02** University of Melbourne MSc Student Tom McNamara (Supervisor Dr Mark McLean).

*Characterisation of metavolcanic megaclast structures within the Moyston Fault hanging wall mélange (Moornambool Metamorphic Complex), western Victoria: Insights from potential field modelling and machine learning.*

The 'Stawell Corridor', western Victoria, is a major goldfield where a new wave of exploration is targeting dome-shaped metavolcanic bodies closely associated with major gold deposits. The Magdala Antiform hosts the Stawell Gold Mine and is the type-deposit for a style of mineralisation commonly associated with the metabasalts. Additional structurally related metavolcanic domes have been identified throughout the corridor, however few have seen substantial exploration due to obfuscation by Murray Basin sedimentary cover.

A significant contrast in density and magnetic susceptibility between the metabasalt domes and the turbidite metasediments that host them makes potential field methods ideal for discriminating and characterising Magdala-style domes. The Wildwood and Lubeck domes lie northwest of Magdala and are similarly prospective for gold, but their geometries in the ground aren't well understood.

This project aims to characterise the geometry and extent of the Magdala, Wildwood and Lubeck domes by acquiring high-resolution ground gravity data in profiles over each, then

producing forward models of the bodies. After establishing the gravity's relationship to geology an investigation into the applicability of machine learning methods will follow, to identify additional Magdala-style targets out of the regional potential field data.

The ground gravity survey was carried out in April 2022 using a Scintrex CG5 Autograv gravity meter and a Trimble R6 RTK GPS to measure accurate locations and elevations, and Stawell Gold Mine provided support throughout the fieldwork. A total of 397 new gravity measurements were acquired over 16 km, in three profiles (one across each dome). Station spacing was variable between surveys to maximise resolution directly over the dome crests (up to 25 m resolution), and sparser beyond dome extents to ascertain background trends (50 - 100 m).

The ground gravity was modelled in Oasis Montaj GM-SYS simultaneously with its first vertical derivative and magnetic profiles extracted from the Geological Survey of Victoria Zone 54 Compiled TMI Grid. The forward models for the three profiles produce close fits within petrophysical and drillhole constraints from data provided by North Stawell Minerals, and the GSV maps and close by GA06-V1 seismic line.

The models are suggestive of a more structurally complex view of the corridor and basalt emplacement than previously thought. A suite of short-wavelength, high-amplitude bodies identified in the survey that were not identified in the regional potential field data point to the possibility of basalt clasts being widely distributed throughout the metamorphic mélange from the meter scale to kilometre scale. The Magdala profile model (Figure 4) shows an example of the range of scales of interpreted metabasalt bodies (in yellow).

With the models at the refining stage and confidence that the gravity is reflective of the basalt dome geology, we are now beginning the experiment in machine learning methods. Next steps are to assess the geological relationships that can be used to constrain the machine learning output, and to prepare the algorithm's training data.

The project's progress is owed to the support of the ASEG Research Foundation Grant that funded this research, North Stawell Minerals for supplying datasets, approving and supporting the fieldwork, and the GSV for lending their gravity meter to conduct the survey.

Doug Roberts  
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[research-foundation@aseg.org.au](mailto:research-foundation@aseg.org.au)

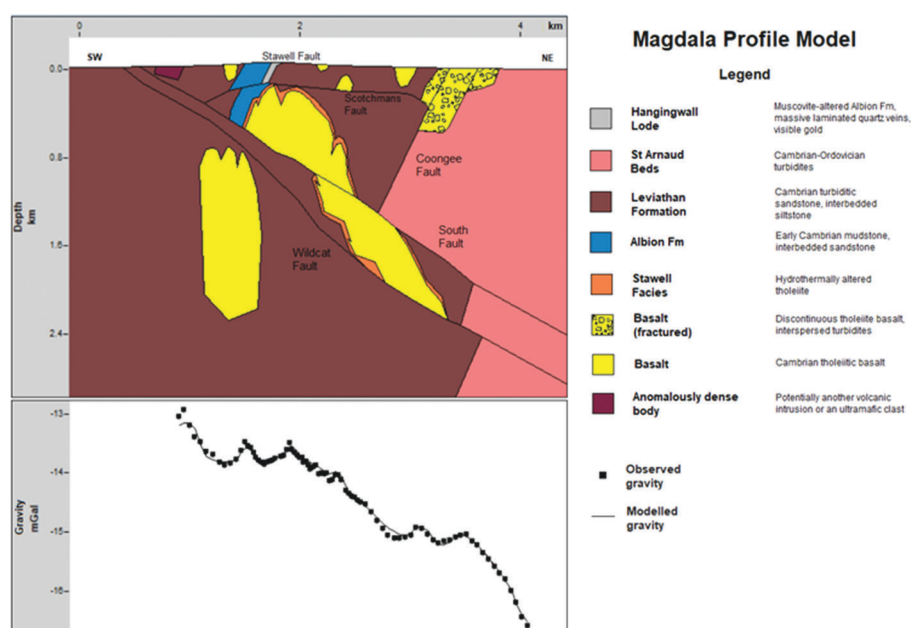


Figure 4. Ground gravity over the Magdala modelled in Oasis Montaj GM-SYS



## Henderson Byte: Quantum gravity surveys – the state of play

A 'quantum gravity' survey is soon to be conducted in Australia, more on that to follow. Firstly, quantum gravity is still only a theory. The main problem is that gravity is a very weak force, and its quantum effects are therefore going to be minuscule. Physicists are still debating the theory in meetings such as the Quantum Gravity Conference in Vancouver in August 2022. See more at [en.wikipedia.org/wiki/Quantum\\_gravity](https://en.wikipedia.org/wiki/Quantum_gravity).

Regardless of this problem of physics, a practical method of gravity surveying has recently been developed, making use of the concept first hypothesised by Louis DeBroglie in 1924, that all matter has wave properties. In general, the method starts with a cloud of atoms in free fall in a vacuum chamber. The atoms are cooled to near absolute zero temperature by using lasers to slow their activity. At this temperature, the wave nature of atoms becomes apparent, and a further set of laser beams split and recombine the atom cloud into different paths like that of an optical interferometer. The interference pattern of these special waves, called 'matter waves', is contingent on the value of gravity. As the cloud continues to fall, the atoms' quantum states accumulate a phase difference due to the value of gravity. This phase difference is interrogated and read out with a final set of laser pulses.

Quantum gravity as employed for practical purposes can thus be described succinctly as *gravity sensing using matter wave interferometry*. It is also known as *cold atom interferometry*. Its advantages over classical gravity methods include excellent sensitivity leading to deeper penetration, and faster measurements with 10 Hz repetition rate making it suitable for moving platforms. Drawbacks of the method are related to experimental complexity, including the use of lasers and vacuum chambers. Applications are the same as those for classical methods.

Initially, quantum gravity laboratory studies took place at various universities and institutions such as the Universities of Birmingham and Glasgow, several French universities, Humboldt University in Berlin, and Nanjing in China. Some of these studies have created survey companies, of which M-Squared (see below) and Muquans (see below) are examples.

Some of the practical surveys conducted using the method include:

- University of Birmingham, Sensors and Timing Hub, UK <https://quantumsensors.org> A field survey has been carried out resulting in a 10 m profile over a shallow tunnel on the Birmingham campus. The sensitivity was about  $\pm 20 \text{ E}$  ( $1 \text{ E} = 10^{-9} \text{ s}^{-2}$ ).
- M-Squared of Glasgow, UK <https://www.m2lasers.com/quantum-gravimeter.html> M-Squared have developed a field deployable quantum sensor using cold atom interferometry as described above. The first-generation system has a footprint of  $0.7 \text{ m} \times 0.7 \text{ m}$  and a precision of  $1.3 \times 10^{-7} \text{ g}$ . M-Squared are now working on their second-generation gravimeter, which will offer an increased sensitivity and enhanced repetition rate.
- Department of Physics, University of California, Berkeley, USA.  
The development at this site is described by Wu Xuiejian and colleagues in a paper entitled 'Gravity surveys using a mobile atom interferometer', *Science Advances*, 2019, v.3 (9). It includes a description of how they obtained a sensitivity of  $37 \text{ } \mu\text{Gal}/\sqrt{\text{Hz}}$  for the atomic gravimeter, with stability greater than  $2 \text{ } \mu\text{Gal}$  within half an hour. The gravimeter, including an electronic system, vacuum system and laser unit, was installed in a cart of dimensions  $1.0 \text{ m} \times 0.8 \text{ m} \times 1.7 \text{ m}$ , weighing 100 kg.
- Muquans, from the Institut d'Optique d'Aquitaine, Talence, France, have developed an 'absolute quantum gravimeter' (AQG). <https://www.muquans.com/product/absolute-quantum-gravimeter/> The Muquans sensor has a sensitivity of  $50 \text{ } \mu\text{Gal}/\sqrt{\text{Hz}}$ , a measurement frequency of 2 Hz and a weight of 25 kg. Muquans have also developed shipborne quantum gravimeters for the French Ministry of Defence (2020) and had a fixed station on Mt. Etna in 2020.
- Onera, the French Aerospace Laboratory Consortium, describe their method and their cold atom accelerometer, *Girafe*, in a paper in May 2021 entitled 'Airborne and marine quantum gravimetry' by Yannick Bidet. <https://quge.iag-aig.org/doc/60b8918b52e2f.pdf> The paper illustrates various marine and airborne surveys, with comparisons with conventional surveys. For measurements of gravity gradient by satellite, three pairs of electrostatic accelerometers are used with a resolution of 100 km. Absolute measurements are also achieved on ground surveys.
- Atomionics. Currently based in Singapore, Atomionics use a sensor called *Gravio*, based on cold atom interferometry as described above, which measures gravity, acceleration and rotation and is claimed to provide high spatial resolution in the shortest time. More information on the use of *Gravio* including instructive videos is at <https://www.atomionics.com>

Atomionics is the first group using cold atom interferometry known to offer its surveys in [Australia](#) and has been engaged by Bridgeport Energy of Sydney in 2022. As to the intended purpose of this survey, the following quotes are selected from an abstract of a talk by Cameron Fink, Exploration Manager of Bridgeport, to the ASEG-NSW branch in August 2022 "... to search for subterranean structures which provide the trapping mechanism for oil and gas". A "data acquisition programme will be undertaken, initially with light vehicles, but with a promise of automated drone deployment in the future". If successful results are obtained over a number of field trials, "a case may be made for replacing seismic altogether".

The outcome of this Atomionics survey in Australia is eagerly awaited in 2023.

Roger Henderson  
[rogah@tpg.com.au](mailto:rogah@tpg.com.au)

## ASEG branch news

### New South Wales

On Monday, 13 February Dr **Marguerite Godard**, from the French National Centre for Scientific Research gave us an entertaining insight into the structure, composition, and resources of the New Caledonia peridotite ophiolite. Marguerite introduced the New Caledonia ophiolite, which extends over 900 km at the north-eastern boundary of the Zealandia continent. She explored the economic significance of the subaerial ophiolite, which is mined for Ni, Cr and Co, and the nature of H<sub>2</sub>-rich hydrothermal vents observed along the offshore ophiolite, such as the Prony Bay Hydrothermal Field. Marguerite then outlined activities planned for the New Caledonia Ophiolite Land-to-Sea Drilling Project (NCDP), submitted to the International Continental Scientific Program (ICDP) and the International Ocean Discovery Program (IODP). The project aims to (1) sample the peridotites and associated lithologies on-land, in coastal waters, and the deep oceanic sub-seafloor, and (2) develop borehole observatories to measure *in-situ* the hydrogeological and (bio-)geochemical processes controlling serpentinisation driven hydrothermal systems from continental to marine environments.

The NSW Branch was well represented at the AEGC in Brisbane. Three student members (pictured) received an ASEG bursary to attend the meeting. **Tom Zhao** (UNSW / Jilin University) presented

on interpretation of gravity and magnetic data for hot dry rock delineation for the enhanced geothermal system in Gonghetown, China. **Harikrishnan Nalinakumar** (UNSW) presented on the structure and burial history of the South Nicholson Basin, NE Australia. **Wen Xi** (UNSW) provided insights into wettability and relative permeability curves of coal. Several NSW members also received ASEG awards, including **Phil Schmidt** (ASEG Gold Medal), **Ted Tyne** (Honorary Member) and **Blair McKenzie**, who received his second Shanti Rajagopalan Memorial Award.

On the Monday 20 March, following from AEGC, Dr **Victor Mochanu**, a traveling lecturer from the University of Bucharest, presented a talk entitled "Rebirth of a mature oil field in Eastern Carpathians, Central-Eastern Europe: a synergetic approach". Victor gave us a brief history of the Romanian oil field where initial exploration began pre-WWI and was based on hydrocarbon seeps. Further exploration and development was halted at various points due to geopolitical influences. The first 2D seismic survey was conducted in 2008, allowing the interpretation of the main crustal faults and providing a basic insight into the field. The seismic survey data plus geochemical sampling and geological mapping was overlain with resistivity, gravity, magnetics and MT data to integrate and calibrate the petroleum system model. This research approach suggests a thin-skinned faulting

model and demonstrated how new technologies can be applied to mature fields. The presentation was enjoyed by all, and almost every audience member asked a question.

An invitation to attend NSW Branch meetings is extended to all 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 17:30 at Club York. News, meetings notices, addresses and relevant contact details can be found at the NSW Branch website.

*Jim Austin and Stephanie Kovach*  
[nswpresident@aseg.org.au](mailto:nswpresident@aseg.org.au)

### Queensland

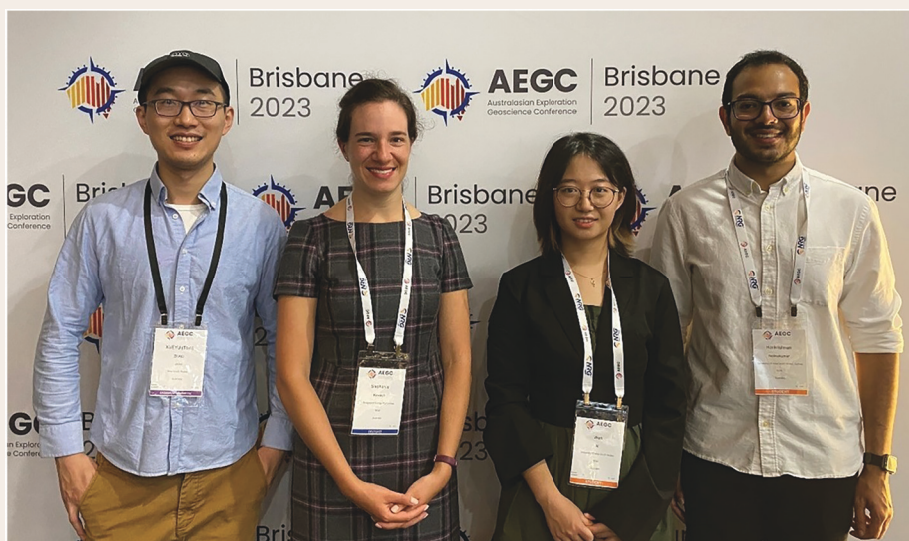
The year is getting away from us already and the dust is finally settling after the AEGC in Brisbane. What a week that was, with a massive programme of talks, seminars, meetings and social events to keep everyone busy. It was great to welcome so many exploration geoscientists to Brisbane for the first face-to-face AEGC since 2019. The ASEG Qld Branch awarded two bursaries to attend the conference; to **Ao Chang**, who is completing a PhD in numerical modelling using Seismic FWI at UQ, and to **Laureano Gonzalezis** who is completing his PhD in monitoring water reservoir capacity using fibre optic sensing at USC. Both students presented at the Geo Pitch and did an excellent job.

Laureano had this to say about his experience:

*The conference was quite well organised, and all topics were aligned to the current industry needs. The event gave me the opportunity to realise the vast areas of application of seismic data, from formation delimitation to property characterisation and fluid monitoring. The Geopitch was an extraordinary activity that allowed researchers to build networking and spread their investigations further. Thank to ASEG for this opportunity.*

Ao had this to say about her experience:

*I really enjoyed the conference and had fun there, thanks for sharing it with me. I met a lot of awesome people, had a great talk to them, learnt a lot beyond*



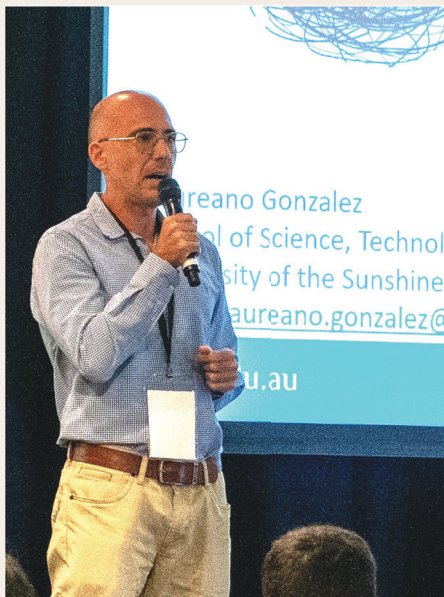
**Figure 1.** Tom Zhao (UNSW), Steph Kovach (ASEG NSW Branch), Wen Xi (UNSW), Harikrishnan Nalinakumar (UNSW).

*my knowledge, which is quite valuable to me!*

*It provided such a good chance to network with people from geophysics, it is more like a big family reunion.*

*As a PhD student, I appreciate that the committee organised the Geo Pitch session to let us share our own projects and be seen to the audience.*

*If possible, I hope I can still take part next year!!!*



Laureano Gonzalez is making a Geo Pitch presentation at AEGC 2023



Ao Chang making a Geo Pitch presentation at AEGC 2023

It was great to see so many Queensland Branch members and past committee members receiving awards at the

conference, and a special mention goes out to **Megan Nightingale, Janelle Simpson** and to our outgoing and incoming Federal Presidents **Emma Brand** and **Eric Batig** for all their hard work.

Before all that, however, the Queensland Branch welcomed our geoscience students back to university in February with a night of musical bingo organised by our resident Milli Vanilli expert, **Tim Dean**. The event was kindly sponsored by Anglo American and was a great night of music, food, impromptu dancing and prizes. It was great to see many Queensland members there and we would like to thank Anglo American and Tim for the organisation.

On February 24, the ASEG Queensland Branch and PESA jointly hosted Dr **Moritz Ziegler** to present a technical luncheon entitled "The Good, the Bad and the Uncertainties - A model of the stress state". The event was mostly attended by PESA members. The committee would love to hear from members about what other events or talks they would be interested in attending in 2023.

We're still planning on holding our AGM along with another technical talk in April and there are plans for an ASEG-PESA Trivia night at the end of May - details will be released soon.

James Alderman  
[jldpresident@aseg.org.au](mailto:jldpresident@aseg.org.au)

### South Australia and Northern Territory

On Friday March 10 the SA-NT Branch co-hosted the AusIMM Adelaide Student Chapter BBQ with committee member **Oliver Mowbray** introducing the ASEG to the students on the night. The event was well attended by students and other society members with lots of networking happening.

The SA-NT Branch gave three of our student/early career members travel bursaries (to the value of \$1000) for the AEGC 2023 in Brisbane. The recipients have put together a few words on their take-aways from the conference.

**Iain Campbell** had this to say:

*After a multi-year hiatus due to COVID it was fantastic to be able to attend an in-person conference again, especially one as wide-ranging as AEGC. The Exhibition Hall was busy during the breaks with plenty of companies, geological surveys and professional societies taking the*

*opportunity to show off their products. With two sessions focussing on CCUS, there was plenty of food for thought at the start of my PhD, and also, I took the opportunity to attend several talks relevant to my previous industry work on the Cooper and Otway basins. Further afield, the research behind Jon Cocker's keynote talk on seismic source trials in the Bass Strait was fascinating and will facilitate the permitting of future marine acquisition in the area (and elsewhere). I'd like to thank ASEG for supporting my attendance at this year's conference, and I hope to be able to present some of my results at the next event.*

**Renzo Ocampo** had this to say:

*Attending the Australasian Exploration Geoscience Conference (AEGC) was an exceptional experience that I was privileged to be part of. As one of the mentors during the AEGC High School Geoscience Student Outreach Day, I had the opportunity to share my expertise in mineral exploration, geophysics and geoscience with future generations of young future leaders. The conference provided me with great networking opportunities with industry professionals, graduates, and colleagues. Attending high-quality workshops and keynote presentations by notable speakers allowed me to expand my knowledge and acquire new skills. Witnessing a large gathering of professionals in the geoscience and exploration industry was an inspiring experience, and the opportunity to exchange ideas and knowledge was invaluable.*

*As someone who holds multiple volunteering roles for student-led and professional societies, I have been able to establish various collaborations with industry companies that are keen to support and provide training and workshops to South Australian university students and early-career geologists and geophysicists. This presented an opportunity for me to contribute to the growth of the geoscience community and make a positive impact on the industry's future. Overall, attending the AEGC was an enriching experience that allowed me to enhance my professional development and expand my network with industry leaders while giving back to the community through mentoring and organising events.*

**Oliver Mowbray** had this to say:

*My first AEGC was an incredible and entirely meaningful experience. The*

*combination of brilliant presentations and fantastic exposure to the exploration community provided a robust early career framework that will be taken on into the future. An opportunity to present at the Geo Pitch talks was also a first and much-appreciated experience. A special mention to the ASEG SA/NT Branch is deserved for generously providing the funding required for my registration at AEGC 2023.*



Oliver Mowbray making a Geo Pitch presentation at AEGC 2023

The Branch AGM took place on April 12 and **Nick Jervis-Bardy** from Orica: Digital Solutions spoke on using NMR to characterise aquifer properties in *in-situ* mining. This was an excellent talk.

Lastly, we couldn't host any of our fantastic events without the valued support of our sponsors. The SA-NT Branch is currently sponsored by **Beach Energy, Borehole Wireline, Oz Minerals, Vintage Energy, Minotaur Exploration, the Department for Energy and Mining, Zonge, Santos and Heathgate.**

Paul Soeffky  
email:sa-ntpresident@aseg.org.au

## Tasmania

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 keep an eye on the seminar/webinar 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.

Gerrit Olivier  
taspresident@aseg.org.au

## Victoria

Living in Melbourne, I've always associated snow as falling in winter in the Victorian alpine region. The conditions for mother nature to create snow vary, although sub-zero temperatures are a ubiquitous requirement. Lower atmospheric or barometric pressure helps too, a common theme especially if you're at relatively high elevations. And of course, moisture – lots of it – must be present in the atmosphere. On all those trips to some of Victoria's premier ski resorts, I've observed snow falling on eucalyptus woodlands surrounded by low-growing heathland. But no, not you, Toronto, all of 76 m above sea-level. Toronto is an absolute concrete jungle with impressive skyscrapers developed alongside one of The Great Lakes (Lake Ontario). It's early Spring and I am in Toronto attending the 2023 Prospectors and Developers Association of Canada (PDAC) – one of the world's premier mineral exploration and mining conventions. I am a PDAC virgin - it is my first time attending – and first ever visit to Toronto. My first night in the city was unforgettable. I experienced what locals call 'thundersnow' – a rare event in which an air mass becomes so unstable that it turns violent with lightning and thunder tearing up the night sky coupled with heavy snow falls and strong winds. No less than a foot of snow fell that night. Welcome to Toronto. Welcome to the sub-Arctic polar vortex. Seeing snow fall on a city street surrounded by towering superstructures was unnatural, to me. I was at odds, conflicted with how I've always witnessed snow falling. It was contradictory to my idea of winter. Natural snow shouldn't fall in a metropolis. It should fall in an alpine eco-system generally 1000 m above sea level. Damn you Toronto, you've ruined my romanticised winter utopia.

As other state branches would agree, the first few months of any calendar year is usually uneventful (although for Taswegians, nothing notable has happened on the Apple Isle since the thylacine went the way of the dodo back in '36). The Victoria Branch co-hosted its first event for 2023 – the annual Summer Social with sister Victorian chapters in

PESA and SPE – on March 1. Yes, I know. Hosting the Summer Social in Autumn makes it technically an Autumn Social event but hey, it's just another arbitrary day in the life of the Earth in a succession of endless days while space travelling and chalking up over 4.6 billion laps around an ordinary yellow dwarf star, give or take a million revolutions or two. Don't get too hung up on it, ok?

Right, back to the Summer Social. It so happened that the Rock Fluid Dynamics (RFD) group was also hosting an event on the very same evening and after some discussions, it was decided to host both bashes together. The RFD guys graciously offered to entertain our members at QT Melbourne, which fortuitously is literally opposite The Kelvin Club. A shout out goes to **James Mullins** (executive director of RFD) for temporarily allowing ASEG Victoria Members into their cohort. I did not personally attend the event, but I was told it was a total success as no palaeontologists, as promised, were harmed at any stage during the evening. Speaking of which, apparently some crypto fanatic and palaeontological or geochemist enthusiast may have taken offence to my advert for the Summer Social (see link <https://www.eventbrite.com.au/e/annual-joint-aseg-pesa-spe-summer-social-event-2023-tickets-548047283177>) as they registered for the event under the name of "BitcoinPete – Palaeontological Geochemist", with a corresponding contact email [notamember@aseg.org.au](mailto:notamember@aseg.org.au). I thought it was childish but at the same time creative, especially for a palaeontologist because there's no way of knowing what happens behind closed doors when they're left alone with a fossil specimen, is there?!?

Far be it for me to pass up an opportunity to offend more people and other states, but the curious world of Queenslanders delivers plenty of comedy material. A little more on that shortly. I was fortunate enough to also attend the 4<sup>th</sup> AEGC in Brisbane, immediately following PDAC, where I had the pleasure in meeting fellow ASEG representatives from the other states. It was great to actually meet so many people with whom I often share screen time on a monthly basis. I had a tremendous time thawing out in the tropics, and there's no denying it, it was a much needed 'home' conference considering the last in-person AEGC was held back in 2019. It was a fantastic gathering, one for the ages – you just had to be there. FYI, ASEG Victoria took

pleasure in fleecing more cash from our fast-depleting slush fund by sponsoring two Victorian post-graduate students to attend the AEGC. The two well deserved recipients of our travel bursaries were Ms **Fatemeh Amirpoorsaeed** and Mr **Chibuzo Chukwu**.

Now, back to Queenslanders and their quirks, in particular, their refusal to participate in daylight savings. For the most part, people in the state fear that the 'extra' hour of sunlight during daylight savings will fade the colour in their curtains quicker. Good one 😊. Local farmers further argue it will confuse the cows as to when they needed to be milked or fed. Moo. Anyway, there are many reasons for Australia to observe five different time zones during the warmer months, none of which I care for much. I suppose having the sun set at an 'earlier' time in Queensland is so locals can participate in offbeat activities in the dark, such as dancing in the dark (like no one is watching) at No lights No lycra in Westend, or night kayaking in a fully transparent kayak fitted with brilliant LED lights offshore Moreton Island at Tangalooma Shipwrecks. I can only think of one thing that Brisbane does better at night than Melbourne does, and that is operate a Ferris wheel. The Wheel of Brisbane, an iconic landmark at South Bank is spectacular, while Melbourne's giant observation wheel, The Melbourne Star, for all its past glory, has been permanently grounded. Touché.

The Victoria committee anticipates another eventful year for the Branch in 2023. Though, for the second year running, we've applied for a larger expense account from the ASEG Federal Executive, only to also be denied twice in succession. I urge all Victoria members, and even members of other states that regularly read this column, to get behind the 'Thong and Jarrod show' in 2023 by backing a petition granting each of us American Express Black Cards. Can you imagine how many frequent flyer rewards points we'd accumulate if we purchased, for example, Leonardo da Vinci's *Salvator Mundi* (sold for USD\$450.30 million in 2017), on our charge cards? We'd be entitled to unlimited first-class travel and 7-star accommodation to anywhere in the world, for our families and probably for our closest 1000 friends... forever. Anyway, who will answer the call? C'mon! Make Jarrod and I proud. Get behind our cause!

Thong Huynh  
[vicepresident@aseg.org.au](mailto:vicepresident@aseg.org.au)

## Western Australia

As part of the WA Branch's continued commitment to its student members, three students were given grants to attend the AEGC 2023 conference in Brisbane. An awards ceremony was held on February 2, and brief presentations were given by recipients of the awards: **Emad Hemyari** and **Jostyn Mortimer** from Curtin University, and **John Shepherd** from the University of Western Australia. Their presentations were mainly about their research projects and their aspirations for their academic and professional futures. The awards event also provided a networking opportunity for ASEG Members.

The WA Branch hosted a technical night talk on March 2 as part of its monthly technical talks series. The guest speaker was **Jeremie Giraud**, a Marie Skłodowska-Curie Fellow at the Université de Lorraine in France, and an Adjunct Research Fellow at The University of Western Australia. Jeremie is recipient of the Marie Skłodowska-Curie fellowship in the 'Research for Integrative Numerical Geology' (RING) team in Nancy, France, and is working on integrating implicit methods into geophysical inversion.

In his talk, Jeremie presented on the application of an algorithm integrating

automated geological modelling into geometrical gravity inversion. The method he employed is based on a generalised, iterative level-set inversion scheme where geological units are deformed automatically to fit geophysical data. The proposed approach was formulated to account for geological data and principles during geophysical inversion. This is achieved by incorporating an automated geological modelling scheme in the regularisation term of the geophysical inverse problem's cost function. The geological modelling term provides model-dependent geological constraints and encourages geological realism during inversion. After summarising the method that is being employed, Jeremie presented a field application where he refined a pre-existing 3D geological model that is locally inconsistent with geophysical data. The objective of this application case was to automatically resolve the inconsistency by improving geophysical data fit (*i.e.*, the Bouguer anomaly) in selected areas while maintaining consistency with some geological observations (*e.g.*, contact locations, orientation data) and principles (*e.g.*, relationships, structural rules). The case considered a subduction zone generated during the Iberian and Eurasian intraplate collision with a partial uplift of the



ASEG-WA student members who gave presentations about their projects at the February awards ceremony. They are (left to right) John Shepherd, Jostyn Mortimer and Emad Hemyari.

upper mantle located in the Western Pyrenees mountain range across France and Spain. Jeremie's focus was on the structure of the upper crust and investigating the presence of abnormally dense material. He also used his algorithm to explore alternative geological scenarios and assess their consistency with geophysical data using the concept of 'null-space shuttle' to derive geophysical equivalent models.

The WA Branch hosted a second technical night talk for month of March on March 22. The guest speaker was Professor **Victor Mocanu**, who has almost 40 years of experience in applied and fundamental geophysics, with interest in combining various geophysical and non-geophysical methods for the understanding of basin structures and their potential. Among his interests are regional and continental active geodynamic areas from North and South America, Central and Eastern Europe, and South-East Asia, especially using seismology and satellite geodesy on convergent, divergent and transform tectonic boundaries. Victor is currently a Professor of Geophysics at the University of Bucharest in Romania, and is also Dean of the Faculty of Geology and Geophysics.

In his talk Victor demonstrated the effectiveness of using complementary geophysical and geological methods to better understand the structure and petroleum potential of a mature, late-life producing oil field in the internal part of the Romanian Eastern Carpathians, in the so-named Tisza-Dacia block, an area in Central-Eastern Europe. He shared examples of how production could be boosted by integrating geophysical with non-geophysical methods to generate a recalibrated geological model. This was achieved by incorporating a mixture of geophysical data for the reprocessing of seismic data leading to better velocity picking, statics, and migration. Resistivity, gravity and magnetics, and MT data were added. This unique approach was presented as a careful investigation of complex methodologies to deliver positive results in a mature field with over a hundred years of production history.

Emad Hemyari  
WA Branch Communications Officer  
[emad.hemyari@gmail.com](mailto:emad.hemyari@gmail.com)



Jeremie Giraud addressing ASEG WA Branch members at the March 2 technical night.



Prof Victor Mocanu addressing ASEG WA Branch members at the March 22 technical night.



ASEG WA Branch President **Michel Nzikou** presenting Victor with a token of appreciation for his presentation

ASEG news

Australian Capital Territory

We are hurtling towards Easter at the time of writing, and looking forward to having our Branch AGM. This is always a chance to bring people into the fold with new ideas and enthusiasm, while recognising what has been done and the accomplishments of many people in a number of fields.

On the technical talk front, **Francesco Dauti** presented his talk entitled “Induced Polarisation effects in electromagnetic data: opportunity or waste of time?” Francesco was kind enough to agree to present his talk while visiting Geoscience Australia after attending AEGC. Looking forward for the next couple of months, we have a couple of talks being organised. One to accompany our AGM and another a few weeks later.

The ACT Branch was also fortunate enough to have several people presenting at the AEGC. While I was personally unable to attend the feedback has been positive, with a number of

interesting talks having been flagged. Congratulations to all the presenters and organisers.

To end on a high note, long time ACT Branch committee member and Treasurer, **Ross Costelloe**, was among the recipients of an ASEG Distinguished Service Award. Ross has been a stalwart of the Branch for many years, working diligently behind the scenes to organise and promote events and to manage our funds as Treasurer. He has also made numerous ASEG presentations, written many research papers, conducted many workshops and mentored many junior geophysicists during his long career. He is definitely deserving of such an award.

Don't forget about Geoscience Australia's Wednesday seminars (<https://www.ga.gov.au/news-events/events/public-talks>). These seminars are a good source of geoscientific information that includes the use of geophysics.

Phillip Wynne  
[actpresident@aseg.org.au](mailto:actpresident@aseg.org.au)



Ross Costelloe with his ASEG Distinguished Service Award.

ASEG national calendar

Date	Branch	Event	Presenter	Time	Venue
ASEG Branches hold face-to face meetings and webinars. Registration for webinars is open to Members and non-members alike, and corporate partners and sponsors of state branches are acknowledged before each session. Recorded webinars are uploaded to the ASEG's website ( <a href="https://www.aseg.org.au/aseg-videos">https://www.aseg.org.au/aseg-videos</a> ), as well as to the ASEG's YouTube channel ( <a href="https://bit.ly/2ZNglaz">https://bit.ly/2ZNglaz</a> ). Please monitor the Events page on the ASEG website for the latest information about events.					
19 Apr	NSW	Technical meeting	Jaime A. Alvarado-Montes	1730	Club York, York St., Sydney
Apr	Qld	AGM	TBA	TBA	TBA
27 Apr	WA	Tech night	Roman Pevzner	1730	The Shoe Bar and Café 376-420 Wellington St., Perth
17 May	NSW	Technical meeting	TBA	1730	Club York, York St., Sydney
May	Qld	ASEG-PESA Trivia night	TBA	TBA	TBA
21 Jun	NSW	Technical meeting	TBA	1730	Club York, York St., Sydney

## AEGC 2023: Reflections

The fourth Australasian Exploration Geoscience Conference (AEGC 2023), which incorporated the 29<sup>th</sup> ASEG Geophysical Conference and Exhibition was held at the Brisbane Convention and Exhibition Centre in March 2023. The conference was jointly hosted by the AIG, ASEG and PESA. The conference was the first face-to-face AEGC since the outbreak of COVID and was well attended. The Exhibition Hall, in particular, was very busy. The conference had great vibe and provided fantastic networking opportunities for all participants.

Here are some statistics from the conference:

- 932 registrations
  - 546 delegates
  - 255 exhibitors
  - 28 sponsors
  - 42 students
  - 15 Organising Committee members
  - 26 keynote and other speakers
  - 20 day registrations
- 230 oral presentations
- 14 keynote presentations
- 40 posters



*The 2023 Conference Organising Committee on stage during the closing plenary.*

We extend our heartfelt congratulations to the winners of the conference awards, and we express our sincerest gratitude to all the conference volunteers who made this event possible. Thank you for your invaluable contributions!

We hand the baton to the WA branches of the AIG, ASEG, and PESA and wish

them all the best of luck for the Perth Conference in September 2024.

On behalf of the 2023 Conference Organising Committee,

*Megan Nightingale and Dale Sims (Co-chairs)*

## AEGC 2023: Awards



The AEGC awards were sponsored by First Quantum Minerals. All winners were presented with a certificate and a gold coin by Chris Wijns, Group Geophysicist, First Quantum Minerals.

The Geo Pitch winners were presented with a certificate and a section of diamond drill core by Kat Gioseffi.

### Best oral paper – minerals

Alex Farrar

*Cause-and-effect of plate motion and crustal thickening using time-series analysis and data analytics.*



### Best oral paper – energy

Mark McLean

*Resolving basement crustal architecture and extensional tectonics using 3D inversion modelling of airborne gravity data in the Otway Basin region, Victoria.*

### Best oral paper – near-surface and groundwater

Darren Burrows

*Application of high-resolution airborne EM and magnetic data for geotechnical information over tailings facilities, examples from the Quadrilatero Ferrifero area, Brazil.*

### Best student oral paper

John Shepherd

*Controls on shelf-margin architecture and sediment partitioning in the Hammerhead shelf-margin (Bight Basin, southern Australia): Quantitative 3D seismic stratigraphy (QSS).*



### News

#### Best poster paper – minerals

Phil Skladzien, Ross Cayley, Suzanne Haydon and Cameron Cairns

*Gravity modelling of crooked line traverses to constrain Southeast Lachlan Crustal Transect 2 D seismic reflection interpretations in the Australian Alps.*

#### Best poster paper – energy

Vincent Dykmans and Dan Bishop

*The complex petroleum system of the Rankin Trend and Brigadier Trend, Northern Carnarvon Basin, Australia. New insights from the Triassic Mungaroo Formation in Ironbark-1.*



#### Best poster paper – near-surface and groundwater

Rob Ross

*Pre-stack seismic inversion for windfarm applications.*



#### Best student poster paper – minerals

Lucy Soares dos Santos

*Delineation of regolith zones in nickel laterite using electromagnetic imaging: Ravensthorpe, Western Australia.*



#### Best extended abstract – minerals

James Reid, Aureore Joly, Glenn Pears and Jean-Philippe Paiement

*Integrated 3D modelling and associated machine learning targeting: the Jaguar Greenstone Belt example.*



#### Best extended abstract – petroleum

Oliver Schenk

*Petroleum system modelling of the deep-water Otway Basin.*



#### Best extended abstract - near surface

Tavis Lavell

*3D bedrock model utilising multi-channel analysis of surface waves to assist the land development industry in Greater Melbourne, Victoria.*

#### Best student extended abstract

John Shepherd

*Controls on shelf-margin architecture and sediment partitioning in the Hammerhead shelf-margin (Bight Basin, southern Australia): Quantitative 3D seismic stratigraphy (QSS).*



#### Geo Pitch: Best presentation

Tianjiao Yu

*How cumulate is your granite? An example from Turtle Pluton, California, USA.*



#### Geo Pitch: Best early career presentation

Bhavik Harish Lodhia

*Can natural hydrogen be the next oil?*

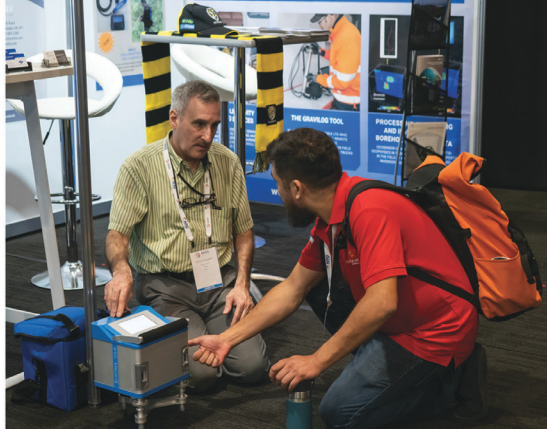
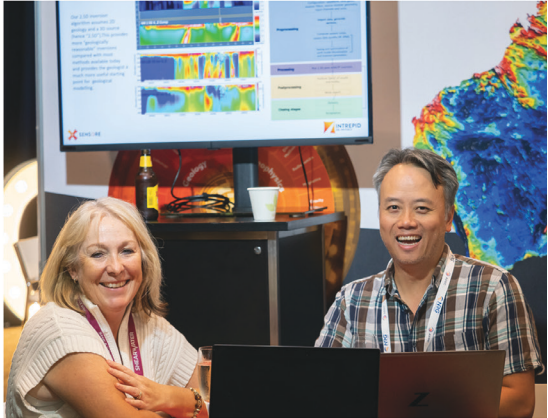


#### Geo Pitch: Best student presentation

Kosuke Tsutsui

*Exploring Mesozoic tectonic & magmatic evolution of the Browse Basin, Australian North West Shelf.*





Exhibition Hall, AEGC 2023. All photos taken by Alison Blakeley [www.havecamerawillsnap.com](http://www.havecamerawillsnap.com)

## AEM 2023: Invitation

On behalf of the AEM 2023 Organising Committee I invite you to become part of the **8<sup>th</sup> International Airborne Electromagnetics Workshop**. The event will be held between Monday the 4th and Thursday the 7th of September 2023, at the Fitzroy Island Resort in Tropical North Queensland, Australia.

The International AEM workshop, now held every five years, has established itself as the foremost international event concerning airborne electromagnetic technologies and applications across a range of sectors including basin analysis, mineral exploration, geotechnical studies, safe energy/waste storage, groundwater, and environmental science.

AEM 2023 will attract many local and international delegates and organisations from across the spectrum of the earth and environmental sciences, representing industry, government, and academia. The workshop will provide an in-depth update for AEM contractors, software developers/suppliers, data providers and users alike. Since the last workshop in Denmark in 2018, we have witnessed the development of very large, continental scale AEM surveys relevant to

a range of applications; the incorporation of Machine Learning and AI in AEM data processing; accompanied by significant advances in AEM system technology supporting both the deep, but also the very shallow, exploration challenges. We anticipate that these advances will figure significantly in the workshop programme.

AEM 2023 will be held on Fitzroy Island, in northern Queensland, Australia. It is an unspoilt tropical paradise of rainforest and beaches within the calm sheltered waters of the Great Barrier Reef. Fitzroy Island is a National Park, and besides the opportunity to network with colleagues it will also provide the prospect to discover spectacular walking trails, abundant marine life and local wildlife. The island is located 45 minutes from Cairns and is easily reached by regular transfers on the air-conditioned ferry – the Fitzroy Flyer.

We are taking over the whole resort to host AEM2023 and anticipate a relaxing and intimate occasion to update yourself with all things AEM. There is also plenty of accommodation to bring partners to the event and experience this beautiful setting.

One-half day of the conference will be set aside for leisure activities, ranging from bushwalks across the island to snorkelling the local waters. There will also be opportunities to explore Cairns and its surrounds, and to venture to the outer parts of the Great Barrier Reef. Although not an airborne application, Fitzroy Island was once a location for underwater submarine detection loops during World War II, where cables were laid across the seabed, able to detect the minute magnetic pulses emitted by passing submarines!

Hosted by the Australian Society of Exploration Geophysics (ASEG) and CSIRO, the main goal of the event is to provide participants a focussed look at recent developments in airborne electromagnetics, but also to look forward to the opportunities and challenges the technology will face in the years ahead. I look forward to meeting you at this international workshop in September.

*Andrew Fitzpatrick*  
Chair Organising Committee  
AEM 2023  
[Andrew.Fitzpatrick@igo.com.au](mailto:Andrew.Fitzpatrick@igo.com.au)

A graphic invitation for the AEM2023 workshop. The background is a composite image of a tropical beach with turquoise water and a forested island. Overlaid on the left is a circular graphic with concentric white and blue lines, resembling magnetic field lines. The text 'AEM2023' is prominently displayed in large white letters within this graphic. Below it, a teal banner reads 'REGISTRATIONS NOW OPEN'. Further down, the text '8th International Airborne Electromagnetics Workshop' is written in white, followed by '4-7 September 2023' and 'Fitzroy Island, QLD, Australia'. At the bottom left, there is a QR code and the text 'TO REGISTER NOW OR FOR MORE INFORMATION PLEASE SCAN THE QR CODE HERE'. Below the QR code, it says 'FOR MORE INFORMATION: aemconference@theassociationspecialists.com.au'. On the right side, there is a white text box containing details about the workshop, including its location, the topics to be discussed, and the hosts. At the bottom right, the logos for the Australian Society of Exploration Geophysics (ASEG) and CSIRO are shown, along with the text 'HOSTED BY'.

## Geoscience Australia: News

Welcome to Geoscience Australia's (GA) post-AEGC contribution to *Preview*, April 2023. In addition to some very impactful presentations in Brisbane (see outlines below), we have been closing out some deliverables relating to work carried out in 2022 (Figure 1 and tables in the following section) along with planning new surveys in collaboration with the State and Territory partners. More details on forthcoming survey programmes will be presented in next issue of *Preview*.

Outside of the AEGC, the biggest news has been the release of the Western Resources Corridor Airborne Electromagnetic (AEM) package during March. This now means that Western

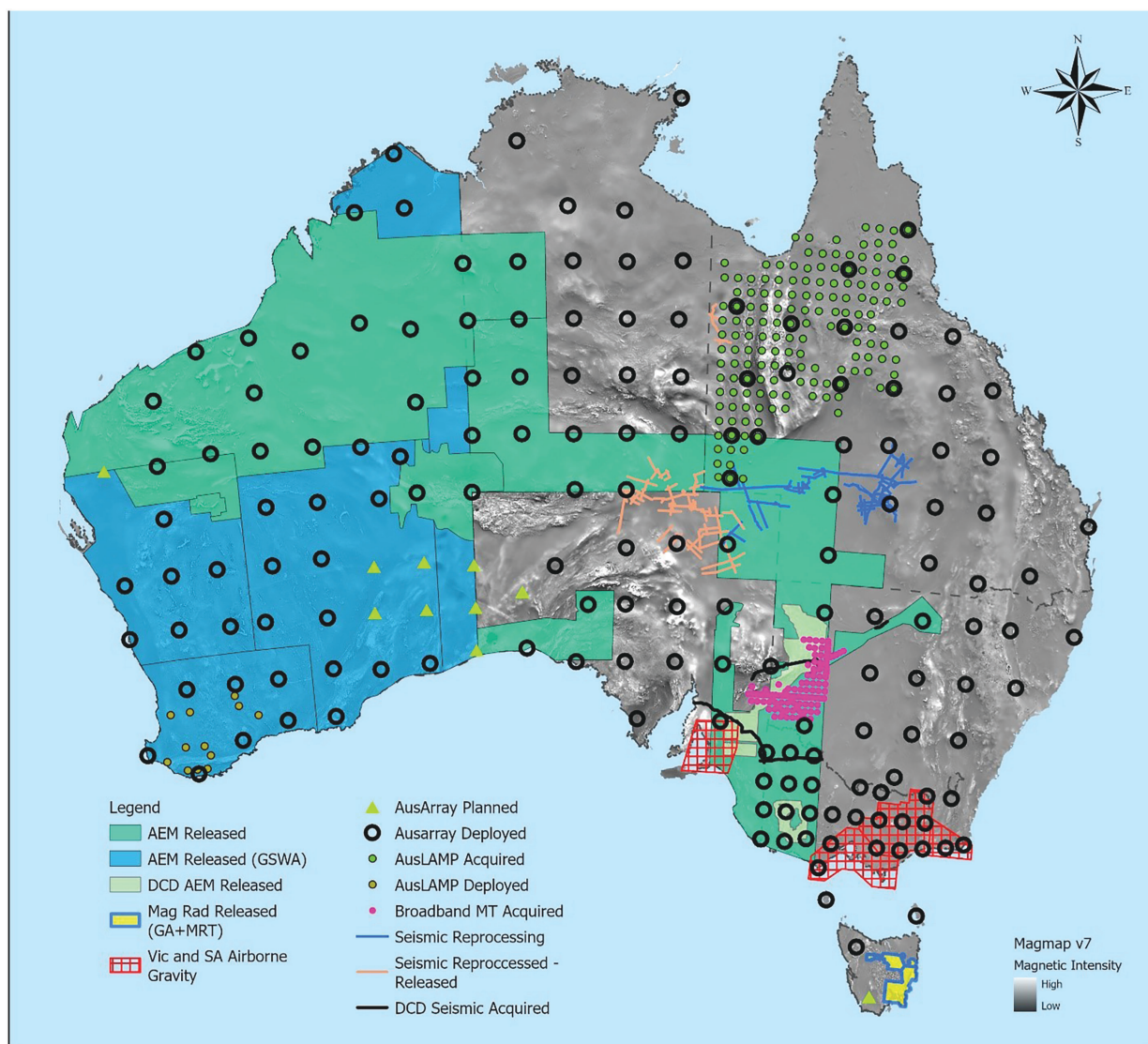
Australia has 100% coverage with 20 km line-spaced, or better, regional AEM. This equates to a coverage of a little under 65% for all of Australia. Survey details and deliverables are provided below.

### Exploring for the Future programme – 2023 Western Resources Corridor Survey

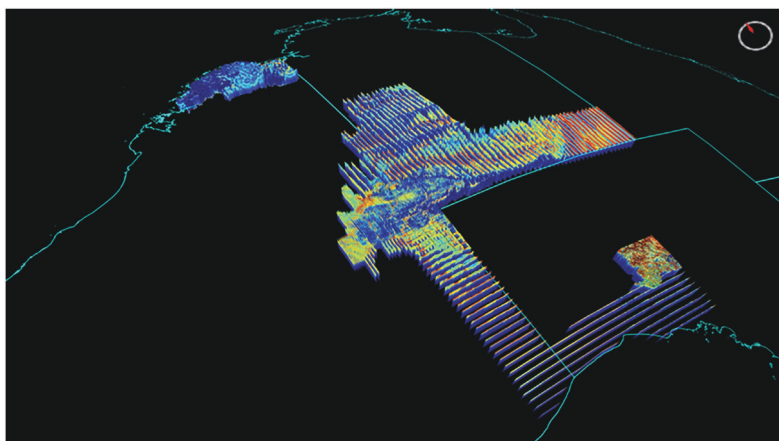
From May to October 2022, an AEM survey was flown over parts of Western Australia, Northern Territory and South Australia. Geoscience Australia commissioned the survey in collaboration with the Geological Survey of Western Australia (GSWA) as part of the Australian Government's Exploring for

the Future programme and the Western Australian Government's Exploration Incentive Scheme. A total of 58 858 line km of new data were acquired, quality controlled, processed, and inverted.

While the bulk of the survey was flown on 20 km line spacing as part of the national 'AusAEM' coverage (see Figure 2), portions across the Musgraves district (southern Northern Territory through to central eastern Western Australia) and western Gawler Craton ('GP2') were flown on more detailed 5 km-spaced grids. These two focus areas were flown specifically for groundwater investigations (particularly palaeo-channel mapping) and mineral investigations respectively.



**Figure 1.** 2021-2022 geophysical surveys – in progress, released or for release by Geoscience Australia as part of the Exploring for the Future (EFTF) programme and in collaboration with State and Territory agencies. Projects that are partially or wholly funded by state government agencies are identified by the bracketed contributors. Background image of national magnetics compilation (first vertical derivative of the reduced to pole magnetics), Geoscience Australia, 2019 (see <http://pid.geoscience.gov.au/dataset/ga/144725>).



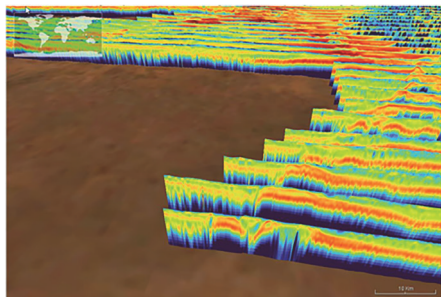
**Figure 2.** 3D view of the Western Resources Corridor AEM data release, March 2023, captured from GA's Exploring for the Future portal - see <https://portal.ga.gov.au/3d/restore/24bac144-e5ed-43a8-a8cc-77a8787b7fc6>. Stretching from the Kimberleys in the north to the Great Australia Bight in the south, the 58 858 line km programme on 20 km line spacing includes semi-detailed (5 km) line spacing across the Musgraves (southern NT – central eastern WA) and western Gawler Craton (central SA). Western Australian regional coverage was 100% funded by the Western Australian Government.

This data package includes the acquisition and processing report, the final processed AEM data, and the results of the contractor's conductivity-depth estimates. The data package also contains the results and derived products from a 1D inversion by Geoscience Australia with its own inversion software (Figure 3).

The survey was flown by Xcalibur Aviation (Australia) Pty Ltd using its TEMPEST AEM system. GA managed all aspects of the acquisition, quality control and processing of the AEM data, with in-kind support from the Geological Survey of Western Australia (GSWA), the Northern Territory Geological Survey (NTGS) and the Geological Survey of South Australia (GSSA).

### Exploring for the Future programme – Curnamona Cube Extension MT Survey

During February and March 2023 Geoscience Australia conducted



**Figure 3.** View looking to the east along the N-S conductivity-depth sections, derived from Geoscience Australia's Layered-Earth-Inversion modelling, highlighting the AEM lines showing disruption in conductive stratigraphy related to localised movement.

the Curnamona Cube Extension Magnetotelluric (MT) survey in western New South Wales and eastern South Australia. Audio- and broadband-MT data was acquired at about 100 sites on a 25/12.5 km grid. Processed data for each site have periods in the range 0.0001 s to 1000 s. This survey extends the spatial coverage of the University of Adelaide/AuScope Curnamona Cube MT survey from the Curnamona Province into the Delamerian Orogen. Interpretation of the combined data will provide additional information on the mineral prospectivity of the region, specifically associated with the geological relationship between the Curnamona Province and Delamerian Orogen. Data from the extension survey will be released mid-2023 and related electrical conductivity models in late-2023.

### Australian Exploration Geoscience Conference, 2023 – GA geophysics-specific presentations

For those of you unable to get along to the AEGC this year, Geoscience Australia presented three outstanding airborne EM-intensive talks from its team of geophysical specialists. In brief:

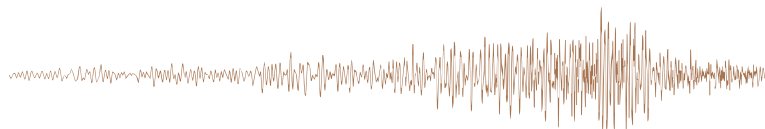
- “Enhancements to deterministic AEM inversion through better geometry constraints and a bunch-by-bunch algorithm” presented by Ross Brodie. This paper stems from a collaborative research project between Geoscience Australia and CSIRO, and demonstrates the value of applying joint component (X and Z) inversion to eliminate the impact of uncertainty associated with

the relative positions and angles of the transmitter and received configuration with respect to the ground. This is particularly the case with older AEM surveys where these ‘nuisance’ parameters were never measured or modelled. By using this approach and a new methodology for driving lateral continuity in the inversion through a ‘bunch by bunch (of soundings)’ process, a far more geological realistic and noise-reduced image can be generated – even from old datasets and system setups (such as GeoTEM).

- “Fixed-wing vs helicopter AEM systems: A Bayesian resolution analysis” presented by Anandaroop Ray. This paper compares platform-specific attributes such as flying height, transmitter loop area, current source waveforms, aerodynamic stability and data stacking times to show how they contribute to the geological resolvability of the subsurface. With both synthetic models as well as real data from over the Menindee calibration range in New South Wales, Australia, a novel Bayesian inversion scheme is employed to shed new light on how these attributes impact the inversion model ‘problem’. The findings have useful implications in AEM system selection, as well as in the design of better deterministic AEM inversion algorithms.
- “AusAEM is the world’s largest airborne electromagnetic (AEM) survey undertaken” presented by A. Yusen Ley-Cooper. Airborne electromagnetics surveys are at the forefront of addressing the challenge of exploration undercover. They have been essential in the regional mapping programmes to build Australia’s resource potential inventory and provide information about the subsurface. In collaboration with State and Territory geological surveys, Geoscience Australia (GA) leads a national initiative to acquire AEM data across Australia at 20 km line spacing, as a component of the Australian governments Exploring for The Future (EFTF) initiative. Regional models of subsurface electrical conductivity show new undercover geological features that could host critical-mineral deposits and groundwater resources (Figure 3).

Extended abstracts for all three papers will be available on the ASEG website in the very near future.

Mike Barlow  
Geoscience Australia  
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## Update on geophysical survey progress from Geoscience Australia and the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and Tasmania (information current 14 April 2023)

The survey details are provided for information only, and on the understanding that the Australian Government is not providing advice. Further information about these surveys is available from Mike Barlow [Mike.Barlow@ga.gov.au](mailto:Mike.Barlow@ga.gov.au) (02) 6249 9275 or Donna Cathro [Donna.Cathro@ga.gov.au](mailto:Donna.Cathro@ga.gov.au) (02) 6249 9800 at Geoscience Australia.

**Table 1.** Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Line spacing Terrain clearance Line direction	Area (km <sup>2</sup> )	End flying	Final data to GA	Locality diagram (Preview)	GADDs release
Eastern Tasmania	MRT	GA	MAGSPEC	Mar 2022	57 000	200 m 80 m East-West	11 600	Jun 2022	Sep 2022	See Figure 1 in previous section (GA news)	Dec 2022 - <a href="http://pid.geoscience.gov.au/dataset/ga/147455">http://pid.geoscience.gov.au/dataset/ga/147455</a>

TBA, to be advised.

**Table 2.** Ground and airborne gravity surveys

Survey name	Client	Project management	Contractor	Start survey	Line km/ no. of stations	Line spacing/ station spacing	Area (km <sup>2</sup> )	End survey	Final data to GA	Locality diagram (Preview)	GADDs release
Canobie	GSQ	GA	Xcalibur Multiphysics	Nov 2021	~5000	1–2 km	5300	Dec 2021	Mar 2022	See Figure 1 in previous section (GA news)	Released by GSQ and GA, Apr 2022
Brunette Downs Ground Gravity	NTGS	GA	Atlas Geophysics	Oct 2021	~ 12 000	2 x 2 km grid	55 000	Apr 2022	May 2022	See Figure 1 in previous section (GA news)	Released by NTGS and GA in Jun 2022
Melbourne, Eastern Victoria, South Australia	AusScope GSV DEL WP	GA	Sander Geophysics	2022	137 000	0.5–5 km	146 000	Expected Jun 2023	~ Oct 2023	See Figure 1 in previous section (GA news)	Late 2023
Kidson Sub-basin	GSWA	GA	Xcalibur Multiphysics	14 Jul 2017	72 933	2500 m	155 000	3 May 2018	15 Oct 2018	See Figure 1 in previous section (GA news)	Dec 2022 <a href="http://pid.geoscience.gov.au/dataset/ga/147481">http://pid.geoscience.gov.au/dataset/ga/147481</a>
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	Oct 2022 <a href="https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147066">https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147066</a>
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	Oct 2022 <a href="https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147066">https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147066</a>
Warburton-Great Victoria Desert	GSWA	GA	Sander Geophysics	Warb: 14 Jul 2018 GVD: 22 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	Oct 2022 <a href="https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147066">https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147066</a>
Pilbara	GSWA	GA	Sander Geophysics	23 Apr 2019	69 019	2500 m	170 041	18 Jun 2019	Final data received Aug 2019	See Figure 1 in previous section (GA news)	Nov 2022 <a href="https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147265">https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147265</a>
SE Lachlan	GSNSW/ GSV	GA	Atlas Geophysics	May 2019	303.5 km with 762 stations	3 regional traverses	Traverses	Jun 2019	Jul 2019	See Figure 1 in previous section (GA news)	Set for incorporation into the national database in 2022

TBA, to be advised

**Table 3.** Airborne electromagnetic surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km <sup>2</sup> )	End flying	Final data to GA	Locality diagram (Preview)	GADDS release
Western Resources Corridor	GA/GSWA	GA	Xcalibur Multiphysics	Mar 2022	~ 38 000	20 km	760 000	Oct 2022	Dec 2022	See Figure 1 in previous section (GA news)	Mar 2023 <a href="https://dx.doi.org/10.26186/147688">https://dx.doi.org/10.26186/147688</a>
Musgraves	GA	GA	Xcalibur Multiphysics	Jun 2022	~ 22 000	1 – 5 km	~ 100 000	Aug 2022	Dec 2022	See Figure 1 in previous section (GA news)	Mar 2023 <a href="https://dx.doi.org/10.26186/147688">https://dx.doi.org/10.26186/147688</a>
Upper Darling River	GA	GA	SkyTEM	Mar 2022	25 000	.25 – 5 km		Jun 2022	Oct 2022	See Figure 1 in previous section (GA news)	Oct 2022 <a href="http://pid.geoscience.gov.au/dataset/ga/147267">http://pid.geoscience.gov.au/dataset/ga/147267</a>
Darling-Curnamona-Delamerian	GA	GA	SkyTEM	Jun 2022	14 500	1 – 10 km		Oct 2022	Dec 2022	See Figure 1 in previous section (GA news)	Feb 2023 <a href="https://dx.doi.org/10.26186/147585">https://dx.doi.org/10.26186/147585</a>
Eastern Resources Corridor	GA	GA	Xcalibur Multiphysics	Apr 2021	32 000	20 km	640 000	Jul 2021	Oct 2021	See Figure 1 in previous section (GA news)	Oct 2021 <a href="http://pid.geoscience.gov.au/dataset/ga/145744">http://pid.geoscience.gov.au/dataset/ga/145744</a>

TBA, to be advised

**Table 4.** Magnetotelluric (MT) surveys

Location	Client	State	Survey name	Total number of MT stations deployed	Spacing	Technique	Comments
Northern Australia	GA	Qld/NT	Exploring for the Future – AusLAMP	366 stations deployed in 2016–19 102 stations deployed in 2021–22	50 km	Long period MT	The survey covers areas of NT and Qld. Data package: <a href="http://pid.geoscience.gov.au/dataset/ga/134997">http://pid.geoscience.gov.au/dataset/ga/134997</a> Model: <a href="http://pid.geoscience.gov.au/dataset/ga/145233">http://pid.geoscience.gov.au/dataset/ga/145233</a> News article: <a href="http://www.ga.gov.au/news-events/news/latest-news/exploring-for-the-future-takes-a-deeper-look-at-northern-australia">http://www.ga.gov.au/news-events/news/latest-news/exploring-for-the-future-takes-a-deeper-look-at-northern-australia</a> Acquisition of 32 new sites in SW Qld completed mid-2021, data to be released late 2022. This data, together with additional data acquired under the Exploring for the Future programme during 2022 will be released mid-2023.
AusLAMP NSW	GSNSW/GA	NSW	AusLAMP NSW	~300 stations deployed 2016-21	50 km	Long period MT	Covering the state of NSW. Acquisition is essentially complete with fewer than 10 sites remaining to be acquired or reacquired. Phase 1 data release: <a href="http://pid.geoscience.gov.au/dataset/ga/132148">http://pid.geoscience.gov.au/dataset/ga/132148</a> .
Curnamona Province-Delamerian Orogen	GA/GSNSW/GSSA/University of Adelaide	NSW/SA	Exploring for the Future - Curnamona Cube Extension	~100 stations planned 2023	25-12.5 km	Audio and broadband MT	This survey will extend the University of Adelaide-AuScope Curnamona Cube MT survey from the Curnamona Province into the Delamerian Orogen.

TBA, to be advised

# AEM2023

REGISTRATIONS NOW OPEN

8th International Airborne  
Electromagnetics Workshop  
4-7 September 2023  
Fitzroy Island, QLD, Australia

Contact: [aemconference@theassociationsspecialists.com.au](mailto:aemconference@theassociationsspecialists.com.au)

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**Table 5.** Seismic reflection surveys

Location	Client	State	Survey name	Line km	Geophone interval	VP/SP interval	Record length	Technique	Comments
Darling – Curnamona – Delamerian deep crustal reflection survey	GA	SA, NSW, VIC	Darling – Curnamona – Delamerian deep crustal reflection survey	~1275	10	10/40	20	2D Deep Crustal/ high resolution vibroseis seismic survey.	This survey will create an image of important crustal boundaries including the structure of the Delamerian margin, which runs through NSW, SA and Vic, separating older rocks of the Gawler Craton and Curnamona Province from younger rocks of the Lachlan Fold Belt (Tasmanides). Acquisition commenced in Jun 2022 and concluded in Aug. Raw data for this survey are available on request from <a href="mailto:clientservices@ga.gov.au">clientservices@ga.gov.au</a> Quote eCat# 147423. Data are currently being processed.
Central Australian basins	GA	Qld/ SA	Shallow legacy data	~1257	Varies	Varies	3-20 sec	2D shallow & deep legacy data, explosive, vibroseis	GA commissioned reprocessing of selected legacy 2D seismic data in Qld and SA, as part of the Exploring for the Future programme, Australia's Future Energy Resources Project. The objective is to produce a modern industry standard 2D land seismic reflection dataset to assist in imaging the subsurface. Reprocessing of these data is underway.
Adavale Basin	Qld	SA, NSW, VIC	Deep and shallow legacy data		Varies	Varies	3-20 sec	2D shallow & deep legacy data, explosive, vibroseis	GA commissioned reprocessing of selected legacy 2D seismic data in the Adavale Basin, Queensland Australia, Data driven Discoveries Initiative. The objective is to produce a modern industry standard 2D land seismic reflection dataset to assist in imaging the subsurface. Reprocessing of these data is underway.

**Table 6.** Passive seismic surveys

Location	Client	State	Survey name	Total number of stations deployed	Spacing	Technique	Comments
Australia	GA	Various	AusArray	About 180 temporal seismic stations	~200 km spacing	Broad-band ~18 months of observations	The survey will cover all of Australia to establish continental-scale model of lithospheric structure and serve as a background framework for more dense (~50 km) movable seismic arrays. Deployment of this national array commenced with an initial 11 seismic stations deployed in the NT in 2021. Deployments in SA and NSW commenced in Apr 2022 and will progress through other states during 2022.
Northern Australia	GA	Qld/NT	AusArray	About 265 broad-band seismic stations	50 km	Broad-band 1-2 years observations	The survey covers the area between Tanami, Tennant Creek, Uluru and the WA border. The first public data release of the transportable array was in 2020, with further data and model releases expected by Dec 2022. See: <a href="http://www.ga.gov.au/eftf/minerals/nawa/ausarray">http://www.ga.gov.au/eftf/minerals/nawa/ausarray</a> Various applications of AusArray data are described in the following Exploring for the Future extended abstracts: <ul style="list-style-type: none"> <li>AusArray overview: <a href="http://pid.geoscience.gov.au/dataset/ga/135284">http://pid.geoscience.gov.au/dataset/ga/135284</a></li> <li>Body wave tomography: <a href="http://pid.geoscience.gov.au/dataset/ga/134501">http://pid.geoscience.gov.au/dataset/ga/134501</a></li> <li>Ambient noise tomography (including an updated, higher resolution model for the Tennant Creek to Mount Isa region): <a href="http://pid.geoscience.gov.au/dataset/ga/135130">http://pid.geoscience.gov.au/dataset/ga/135130</a></li> <li>Northern Australia Moho: <a href="http://pid.geoscience.gov.au/dataset/ga/135179">http://pid.geoscience.gov.au/dataset/ga/135179</a></li> </ul>
Australia	GA	Various	AusArray, semi-permanent	12 high-sensitivity broad-band seismic stations	~1000 km	Broad-band 4 years observations	Semi-permanent seismic stations provide a back-bone for movable deployments and complement the Australian National Seismological Network (ANSN) operated by GA, ensuring continuity of seismic data for lithospheric imaging and quality control. Associated data can be accessed through <a href="http://www.iris.edu">http://www.iris.edu</a>

**Table 7.** Survey technical requirements

Survey type	Author	Contributors	GA Release
Magnetics, radiometrics and horizontal magnetic gradiometry	James Goodwin	Brian Minty, Ross Brodie, Mark Baigent, Yvette PoudjomDjoman, Matt Hutchens with acknowledgements to Peter Milligan, Laz Katona and Mike Barlow	Mar 2023 <a href="http://pid.geoscience.gov.au/dataset/ga/147457">http://pid.geoscience.gov.au/dataset/ga/147457</a>
Airborne Gravity and Gradiometry	Negin Moghaddam and Mark Dransfield	Jack McCubbine and Mike Barlow	~ May 2023

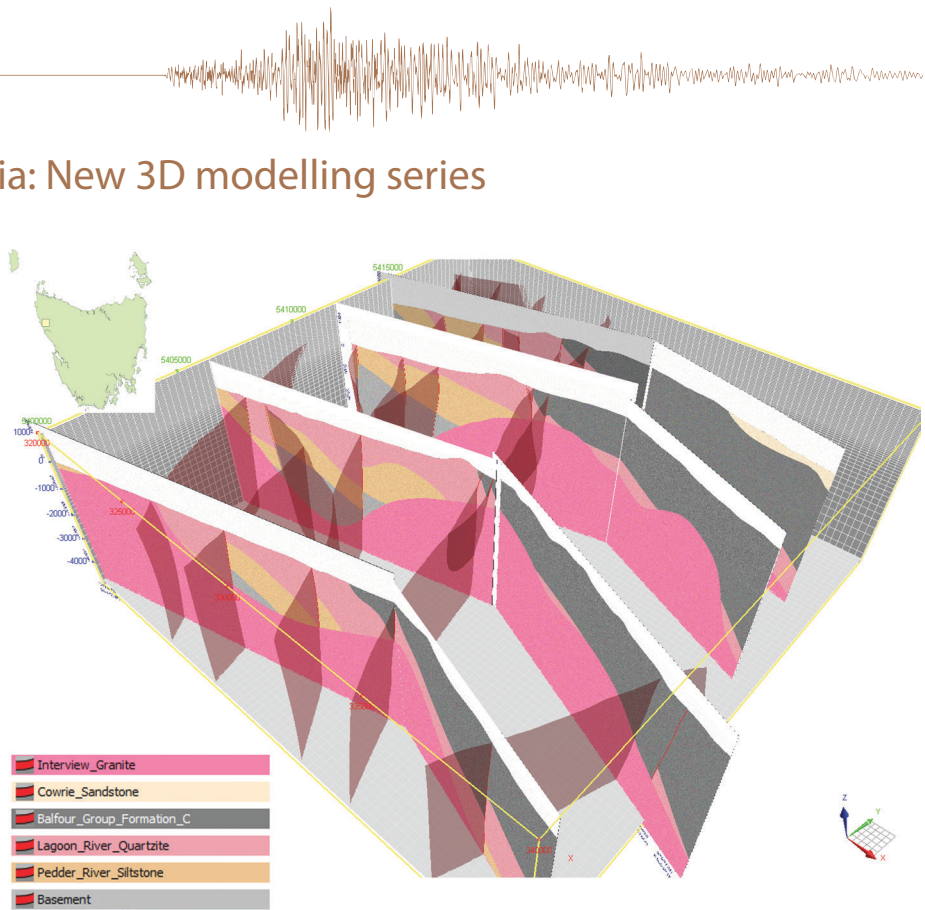
# Mineral Resources Tasmania: New 3D modelling series

Mineral Resources Tasmania is starting a new series of 3D geological and geophysical models. The intention for the new series is that it operate in near-conjunction with MRT’s ongoing programme of regional geological mapping, which proceeds on the basis of 20 x 10 km 1:25 000 scale map sheets. These are grouped in pairs thus comprising a 20 x 20 km square for 3D modelling purposes, in part so that the maximum potential wavelengths that can be represented in the model are the same in north-south as well as east-west directions. The 3D models are envisaged to become a standard adjunct to the more traditional map publication output of the State geological survey.

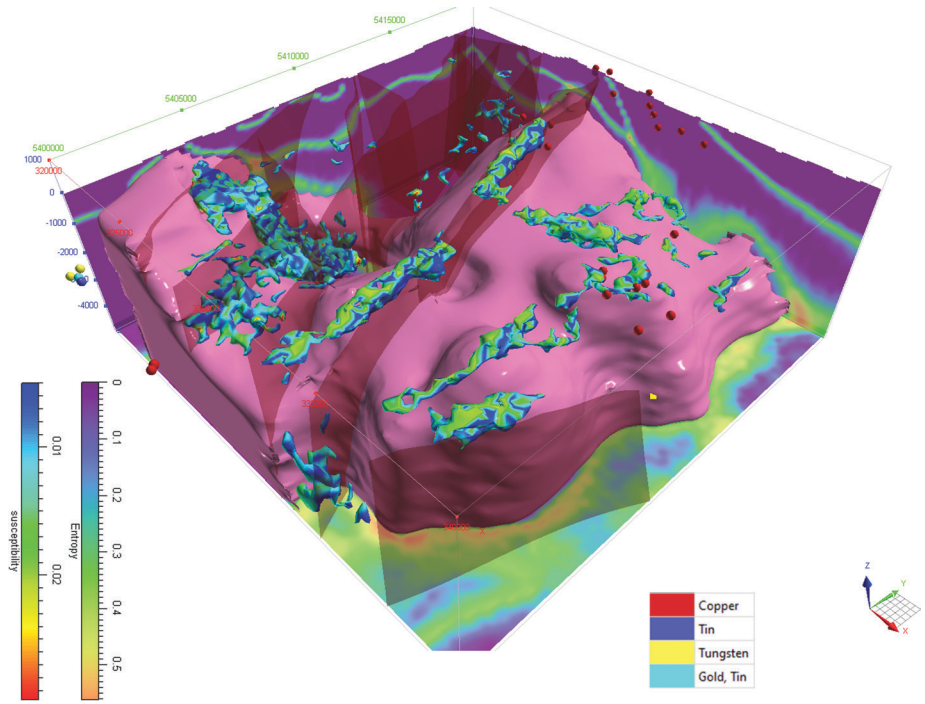
The inaugural model is based on the Lily and Lagoon sheets in northwestern Tasmania (Figure 1). In outcrop this area mainly consists of Rocky Cape Group Mesoproterozoic siliciclastics that have been deformed and faulted and then intruded in the Devonian by the Interview Granite, which is exposed in the southwestern corner of the area. No drilling has been recorded anywhere in the model volume.

The models are initially produced in close cooperation with the geologists undertaking the regional mapping, hence the new understanding and ideas that they have generated can be readily incorporated and tested with minimal diversion from their project workload. The main vehicle for this is the serial cross sections shown in Figure 1. These are used to guide lithostratigraphic unit geometry extrapolation from the primary geological contact and structural data observed at the topographic surface (not shown here), via the GeoModeller™ implicit engine.

Following assignment of physical properties estimated from MRT’s database, the initial model has been modified first by constrained inversion of gravity, serving mainly to determine a revised granite intrusion surface (Figure 2 and 3). As implemented in GeoModeller™, voxets attributed with properties indicating uncertainty in location of the granite surface are generated and incorporated in the model product suite. Subsequent magnetic inversion has defined anomalous magnetic volumes within the Rocky Cape Group units. These appear to exist largely as a halo

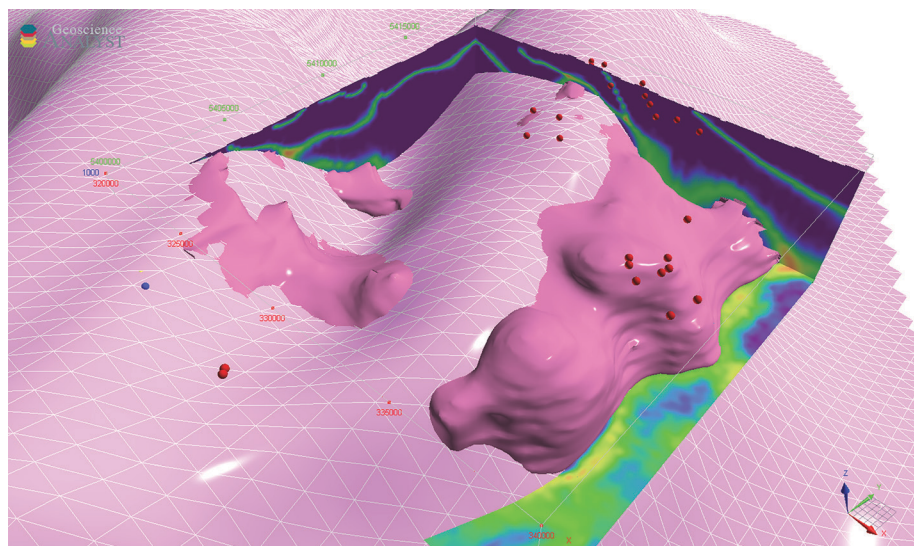


**Figure 1.** Cross-sections originally drawn by MRT field mapping geologists John Everard and Grace Cumming, used to guide implicit geometric construction of Rocky Cape Group and granite units, indicated at lower left. Interpolated fault network shown semi-transparent. The model extends to 5 km below sea level. Red and green numbers are respectively eastings and northings of the Map Grid of Australia Zone 55.



**Figure 2.** The pink shell is the most probable Devonian granite surface indicated by gravity inversion. Spheres depict occurrences of commodities as shown in the legend at lower right. Entropy values indicate the level of spatial uncertainty associated with this and other model unit contacts in the inversion process. Apparent susceptibility values from 0.05 to 0.03 SI define the anomalous magnetic volume shown.

to the granite intrusion, suggesting a genetic link. Known mineralisation is also associated to some extent with this magnetic material. However, the magnetic volume extends significantly further from the mineral occurrences in



**Figure 3.** The 2023 granite surface (deep pink) is an interpolated surface of the most probable granite model from 3D GeoModeller™ statistical metrics. Historical copper deposits shown in red spheres. Note proximity of granite cupolas to known deposits. The 2012 Leaman granite surface (pink mesh), originally derived as structure contours from 2D forward modelling. Entropy sections are also shown. See description in the caption for Figure 2.

the subsurface, implying considerable further exploration potential particularly when coupled with proximity to granite.

The Lily-Lagoon 3D model release marks a departure from previous MRT geophysical modelling that has focused

on particular metallogenic zones, which have tended to cover considerably larger areas. While there remains a place for these, the complexity arising from their size has made them challenging for many users to interrogate and understand effectively. Conjunction with the 1:25 000 scale geological maps favoured for exploration by much of MRT's client base should enable more practical accessibility to the 3D insights and value added by the geologically-constrained inversion of the potential field data.

The model and full documentation including inversion parameters can be downloaded from the MRT website, either [https://www.mrt.tas.gov.au/geoscience/3d\\_geological\\_and\\_geophysical\\_modelling](https://www.mrt.tas.gov.au/geoscience/3d_geological_and_geophysical_modelling) or via the Documents and Reports search at [https://www.mrt.tas.gov.au/products/database\\_searches](https://www.mrt.tas.gov.au/products/database_searches) (Technical Report 35 or TR35).

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## Richard Lane Scholarship 2023



Richard Lane (1962-2021)

An ASEG Scholarship has been established to support geophysics Honours and Masters students and to commemorate the life and work of ASEG Gold Medal recipient Richard Lane. The scholarship is open to all BSc (Hons) and MSc geophysics students at an Australian University and consists of a grant of \$5 000 to the best ranked student for the current year. Ranking will be based on a 200 word discussion, overview of a geophysics project and on an academic transcript. For 2023 we acknowledge and thank Jayson Meyers and Resource Potentials Pty Ltd for the initial concept and ongoing donation.

All Honours (BSc) and Masters (MSc) students with focus predominantly in exploration geophysics are invited to apply. The closing date is 28 April 2023 and application details and form are at [www.aseg.org.au/foundation/richard\\_lane](http://www.aseg.org.au/foundation/richard_lane)

The scholarship will be an annual event and donations to support the continuation of this scholarship are sought from institutions, companies and individuals. Information on donations via the ASEG Research Foundation can be found at [www.aseg.org.au/foundation/donate](http://www.aseg.org.au/foundation/donate) Please mark donation specifically "Richard Lane Scholarship."

## Geological Survey of Victoria: AEGC 2023 presentations

### Combining seismic interpretation and gravity modelling finds new structures in the Otway Basin

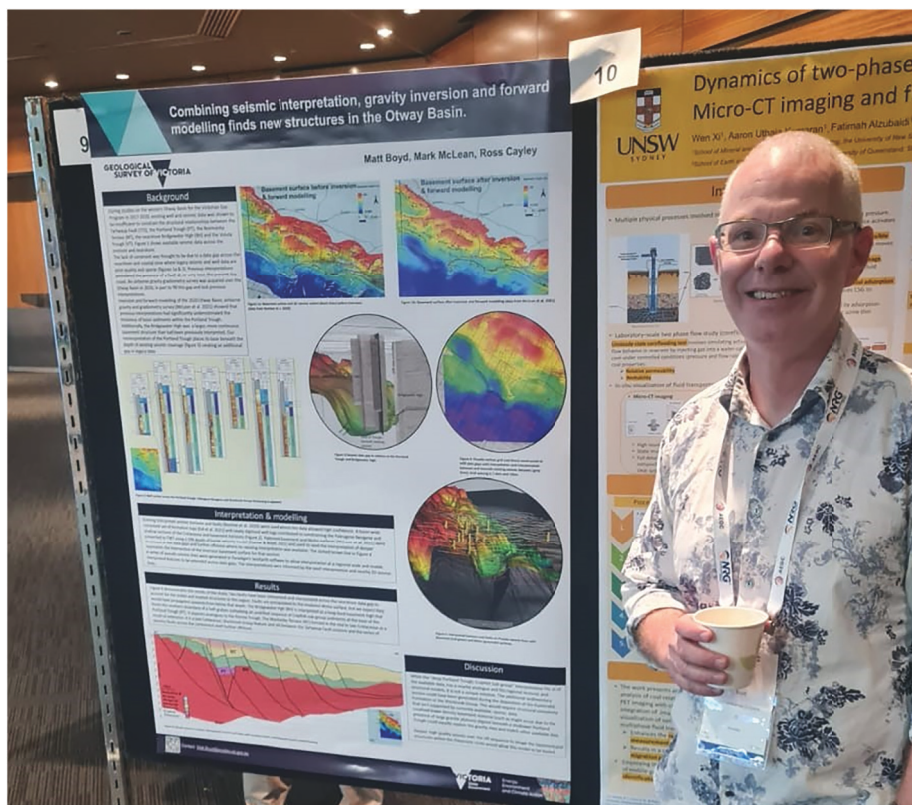
In the onshore and nearshore of the western Otway Basin in Victoria, sparse seismic, drilling, and poor outcrop have previously limited the understanding of deeper structures within the basin. After acquiring a new gravity gradiometry survey in 2018-19 (see p. 20, [Preview 201](#)), we combined seismic interpretation, gravity inversion and forward modelling methods to identify earlier misinterpretations of deep crustal structures ([Figure 1](#)). This approach showed that the previous work in the Portland Trough had underestimated the thickness of the basin sediments and led to re-interpretation. The new work indicates potential for a previously unrecognised early rift sequence of basin sediments in a deeper Portland Trough, and provides regionally consistent, structural context for the nearby Tartwaup Fault and Bridgewater High.

### Gravity modelling of crooked line traverses to constrain seismic reflection interpretations in the Australian Alps

2D deep crustal seismic reflection and ground gravity surveys were acquired along the Southeast Lachlan Crustal Transect in 2018 and 2019 by the Geological Survey of Victoria, Geoscience Australia, Geological Survey of New South Wales and AuScope Limited (see p 20 & 21 [Preview 201](#), p. 19 [Preview 202](#)).

The survey route navigates extreme terrain across the Australian Alps in Victoria. The high degree of line crookedness, rough terrain and contributions from off-line geology, including buried bodies, presented challenges in forward modelling gravity profile data along the traverses.

Phil Skladzien and his co-authors used several methods to integrate seismic interpretations and gravity models more closely. Gravity profile modelling results were integrated with seismic interpretation refinements in an iterative workflow. 3D visualisation was used to align surface geology, seismic interpretations and projected 2.5 D



**Figure 1.** Matt Boyd's poster highlights new structures discovered in the Otway Basin

gravity models onto traverse curtains to depths of around 60 km (see [Figure 2](#)).

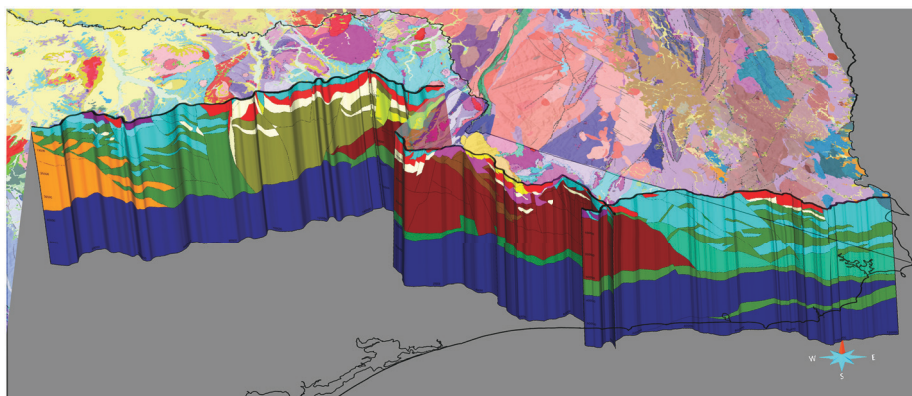
The integration of seismic interpretation and gravity modelling enables reinterpretation of crustal architecture, providing new insights into the Palaeozoic geology, geodynamic evolution, and mineral potential of eastern Victoria and New South Wales, with greater implications for eastern Australia.

For more information about this project: [www.earthresources.vic.gov.au/evgi](http://www.earthresources.vic.gov.au/evgi)

### Resolving basement crustal architecture and extensional tectonics using 3D inversion modelling of airborne gravity data in the Otway Basin region, Victoria

Mark McLean presented findings from 3D inversion modelling of Airborne Gravity Gradiometry (AGG) data in the Otway Basin region.

The study provides a workflow to tackle the problem of superposition



**Figure 2.** Final gravity forward models traversing eastern Victoria and southeast NSW projected on to seismic section curtains shown with cut-away surface geology extending north.



**Figure 3.** Mark McLean (left) was awarded 'Best Oral Presentation' in the petroleum stream at AEGC 2023, and Phil Skladzien (right) was awarded 'Best Poster' in the minerals stream.

of geophysical anomalies including contributions from basin fill, base-of-basin topography and geological complexity of the basement including Moho geometry. The Otway Basin in southeast Australia is used as a 'laboratory' to provide a systematic approach for interpreting basin and underlying basement geometry using AGG data in conjunction with other geoscientific datasets.

See p.20 [Preview 201](#) for the AGG survey location, and [Preview 213](#) for associated references and a figure

showing the model and gravity responses.

**Congratulations** to Mark and Phil for their oral presentation and poster awards at the conference. (Figure 3).

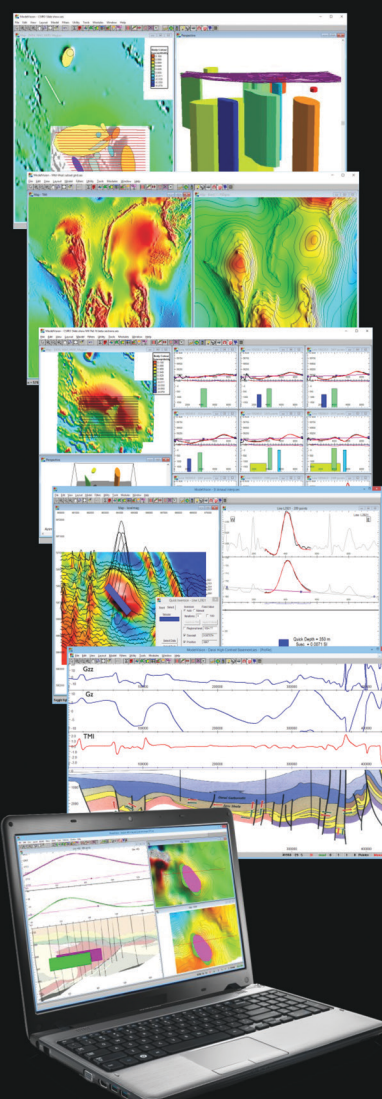
For more information about GSV and our geological programmes visit [www.earthresources.vic.gov.au](http://www.earthresources.vic.gov.au).

Matt Boyd, Phil Skladzien, Mark McLean  
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## ModelVision

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# Geological Survey of South Australia: Availability of 256 channel radiometrics in South Australia

Radiometric data available from the SA Government is typically served out in packages containing dose rate and/or total count, Potassium, Uranium, and Thorium channels. These four channels are useful for a variety of geophysical interpretation tasks, with maps of the channels displaying near-surface features that correlate with variations in landforms and regolith material. Figure 1 shows a preliminary 2023 image of the South Australian radiometrics.

The four channels are (usually) created via a process of noise reduction and averaging multiple channels over a wider spectra of data, through a process called NASVD (Noise Adjusted Singular Value Decomposition). NASVD datasets have the benefit of being smaller in size that their non-NASVD counterparts, which

in times of limited hard drive space on our networks was a necessity. The final supplied four channel radiometric datasets, produced by acquisition/processing contractors, do not usually contain the raw and NASVD 256 channel spectra.

Geophysical survey packages are now hosted on Amazon Web Servers (AWS) and so size is less of a limitation than it has been in the past. The geophysicists at the GSSA are now receiving more requests from external stakeholders for raw 256 channel radiometric data acquired as part of geophysical surveying (where available), and so it makes sense for these data to be easily accessible via our online platform SARIG (South Australian Resources Information Gateway, <https://map.sarig.sa.gov.au/>).

We are therefore revisiting our data packages, and where possible, including the original 256 channel radiometrics data. For a small number of the data packages (see Table 1) the raw data is already available (in the "DATA" directory), but for newer surveys - including GCAS and Coompana - this is not the case.

**Table 1.** Surveys including 256 channel data.

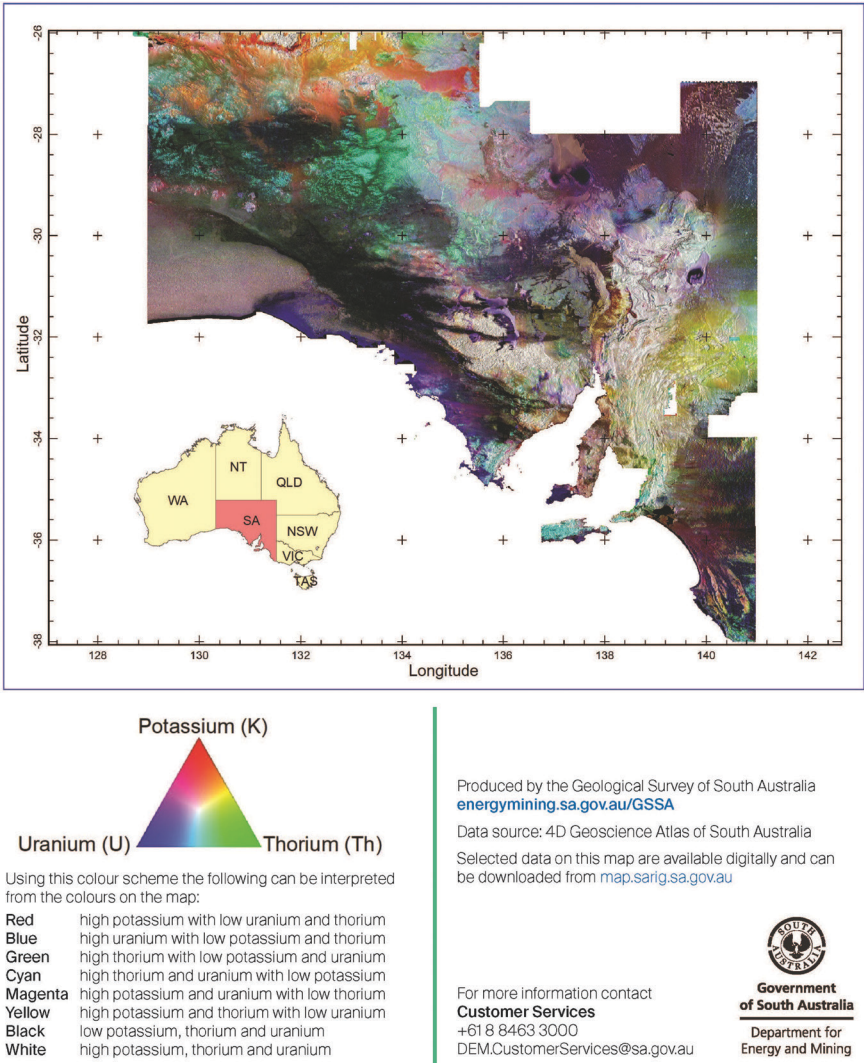
Survey code	Survey name	Line km
1998SA008	Mt Christie	4971
1999SA041	Pine Creek	1036
2007SA034	Mullaquana/Cleve	2855
2009SA061	Yorke Peninsula	12231

There is an argument that available 256 channel radiometric datasets could be merged with released four channel radiometric datasets, as long as the data was acquired at the same time by the same acquisition contractor and aircraft. In this case, there will likely be a matching fiducial or other relatable column of data. Initial tests have revealed that this is not always the case. Null values will be created for entries where there isn't a corresponding entry, so care must be taken.

This is part of an overhaul of downloadable data available from the GSSA, where we are ensuring that geophysical data are available in a variety of formats. While this will increase the size of the data packages, the 256 channel datasets are not so large that downloads become unmanageable. They are simply another dataset that can be used for advanced and further value-added geophysical interpretation.

For more information, please visit SARIG (<https://map.sarig.sa.gov.au/>). Geophysical data can be displayed and downloaded through the "All Map Layers" tab, and metadata and downloads can also be found via the "SARIG catalogue" search option. These downloads generally do not currently include 256 channel radiometric data, with the exceptions listed in Table 1. A complete compilation of all available 256 channel data is now in progress by GSSA geophysicists.

Philip Heath, Gary Reed and Tim Keeping  
Geological Survey of South Australia  
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**Figure 1.** Preliminary 2023 RGB image of the South Australian radiometrics.

## CSIRO: Meet our new pint-sized powerhouse!

Hailing from Canada, Rebecca (Becki) Montsion is most comfortable in a canoe, braving bears and mosquitoes while mapping remote wilderness. Becki joined the Potential Fields Geophysics team, part of the Ore Body Knowledge Group, within CSIRO Mineral Resources at Kensington in November 2022. She hopes to develop fresh approaches to mineral system science by bridging the gap between traditional geology and data science. Her previous work has focused on integration of airborne geophysics, petrophysics, geochemistry, and structural geology to map a range of terranes, from complex Archean greenstone belts to Quaternary landforms. Working in Archean and Proterozoic settings, Becki gained expertise in magmatic Ni-Cu-PGE, volcanogenic Cu-Zn-Pb ± Au massive sulphide (VMS), orogenic Au, and Sedimentary Exhalative (SEDEX) Ag-Fe-Pb-Zn mineral systems. Her current research involves reducing subjective bias in early-stage exploration, enhancing quantitative methods with geological knowledge, and maintaining data integrity throughout exploration workflows.

Prior to joining CSIRO, Becki completed her PhD in *cotutelle* with the Metal Earth project at Laurentian University (Sudbury, Canada) in collaboration with the LOOP project based at UWA. She was also a research associate at the



Becki recording observations of sheared pillowed basalts in Kawashegamuk Lake near Dryden, Ontario, Canada.

Geological Survey of Canada's 3D Earth Modeling Group. She has a double-major in Earth Science and Physical Geography from Carleton University in Ottawa, Ontario, Canada. Her honours thesis investigated ore-forming processes and 3D geostatistics of base metal ore in the SEDEX Sullivan Mine in British Columbia. Her masters focused on understanding complex deformation in the Labrador Trough (northern Québec, Canada) and interaction with neighbouring Archean terranes, using crustal-scale structural modelling. Rebecca was involved in several national-scale data compilation projects including Canada 3D, an ongoing project that aims to

create a unified 3D crustal-scale model of Canada.

Becki's strong sense of community, both within the scientific and wider public spheres, drives her passion for collaboration. She believes that effective communication and the dissemination of accessible scientific knowledge are essential for both scientific progress and engagement with the wider community. We're certainly happy to have Becki on board and can't wait to introduce her to the delightful fauna of outback Australia.

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# **Australian Society of Exploration Geophysicists 50<sup>th</sup> Anniversary Special Publication**

## **MEASURING TERRESTRIAL MAGNETISM**

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**the evolution  
of the  
AIRBORNE MAGNETOMETER  
and  
the first anti-submarine and aeromagnetic survey  
operations**

**People, Planes, Places and Events  
1100s – 1949**



**W.D. (Doug) Morrison**

**This Special Publication is co-sponsored by  
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## MEASURING TERRESTRIAL MAGNETISM

**the evolution of the AIRBORNE MAGNETOMETER and the first anti-submarine and aeromagnetic survey operations – People, Planes, Places and Events 1100s –1949**

**W. D. (Doug) Morrison**

This book, covering a global expanse of more than 800 years, recounts the largely untold story of 'measuring terrestrial magnetism' and of the extraordinary 'people, planes, places and events' that have contributed to the evolution of the magnetometer and the first anti-submarine and aeromagnetic geophysical survey operations. It is a unique journey of science and engineering, of inventions, new methods and instruments – a compelling story of how the measurement of terrestrial magnetism has influenced the history of the world.

This is an operational historical record rather than a history of the theory of terrestrial magnetism. The story begins at the earliest documented geomagnetic discoveries and moves on to observations of magnetic intensity and the first ground magnetic surveys. We see how the instruments used for geomagnetic observations from moving airborne platforms evolved in parallel with the evolution of flight from balloons (from 1784) to airships and eventually aircraft.

In the 1930s and 1940s there were major advances in magnetometry, in USSR, Japan and Germany as well as in USA and UK. In USA and UK these advances were applied in military surveillance systems, including in the detection of submarines. Landmark World War II induction coil and fluxgate instruments – the first of the modern technologies – enabled aeromagnetic acquisition, mapping and direct detections of ore bodies from the air from mid-1944 onwards, foreshadowing today's airborne magnetic surveys. The military developments of magnetometers were taken up, rapidly advanced and applied by the mineral exploration industry to find new economic deposits of magnetic mineral ores. Countries including Australia, Canada and the United States charged their national mining and geological survey departments with investigating and establishing programs of major aerial magnetic surveying and mapping in the search for minerals and energy.

The story explores the inextricable cross-discipline connections of terrestrial magnetism and magnetometers as used for navigation, geodesy, anti-submarine and military purposes, and their role in the geophysical oil and mineral exploration industry. Organisations, people and specific instruments and aircraft are noted, including (at times coincidental) Australian connections. The extraordinary depth and scope of research, over many decades, by the author W.D. (Doug) Morrison, as well as his collection of photos and illustrations, and his astonishing attention to detail, make this book an amazing and immersive historical reading experience and a future primary reference work. Through several decades Doug has developed an extensive 'reference' network of geophysical survey practitioners, and former experts in military, aviation and maritime matters. Through their little-known stories and personal reflections, and his access to personal and official archive material from this network, Doug's narrative brings unique insights into the evolution of the airborne magnetometer. Along that timeline he has produced details that are not available in public historical material.

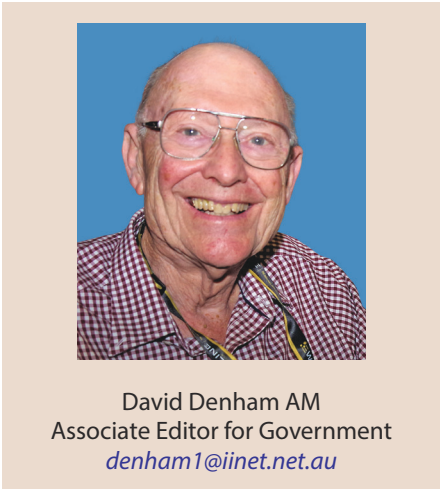
Measuring Terrestrial Magnetism is a major work of 630 pages, illustrated throughout with 156 plates of figures and photos, and including comprehensive Endnotes, Appendices, References and Index.

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# Canberra observed



## Mineral exploration investment powers ahead

Although the December quarter numbers declined from the previous quarter, the steady upward trend in the mineral exploration investment since 2016 continued throughout 2022. (<https://www.abs.gov.au/statistics/industry/mining/mineral-and-petroleum-exploration-australia/latest-release>). The fall in the December quarter of about 7% from the previous quarter affected the main commodities of gold, iron ore and all other minerals. Coal was the only commodity that did not decline. Figure 1 shows the results for the period 2005 through 2022. Figure 2 shows in more detail the variations over a 9-year period from 2013-22. Gold once again dominates the numbers. The future still looks good for minerals.

The investment in offshore exploration has not recovered, despite the price for Brent Crude or West Texas Intermediate hovering in the US\$70-80 range.

## Petroleum exploration still in the doldrums

The petroleum exploration expenditure is still very low because of the paucity of any significant offshore investment. The war in Ukraine resulted in a short-term increase in the price of West Texas Crude, up to over US\$100/bl, but it has subsequently stabilised at about US\$80/bl. These price changes appear not to have affected exploration investment. The onshore investment has stabilised at about \$190 million per quarter about 15% of the total expenditure in 2014.

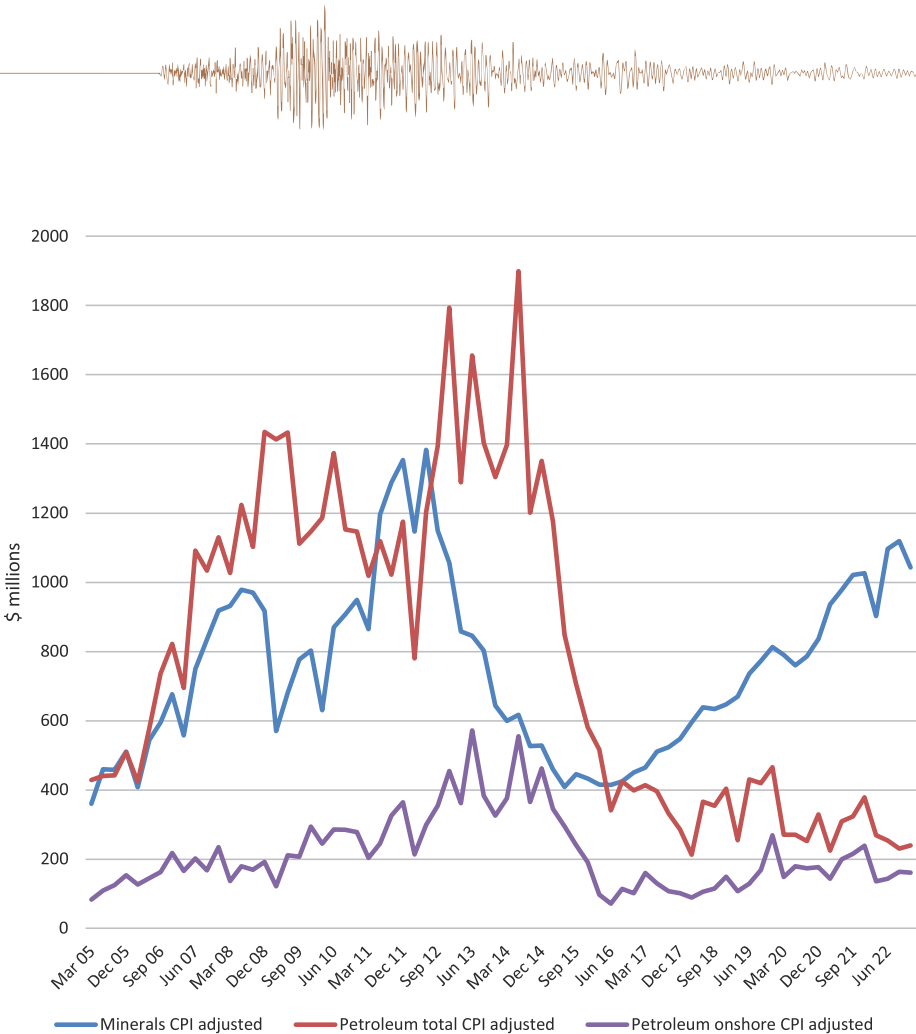


Figure 1. Quarterly investment in mineral and petroleum exploration 2005-22 in A\$.

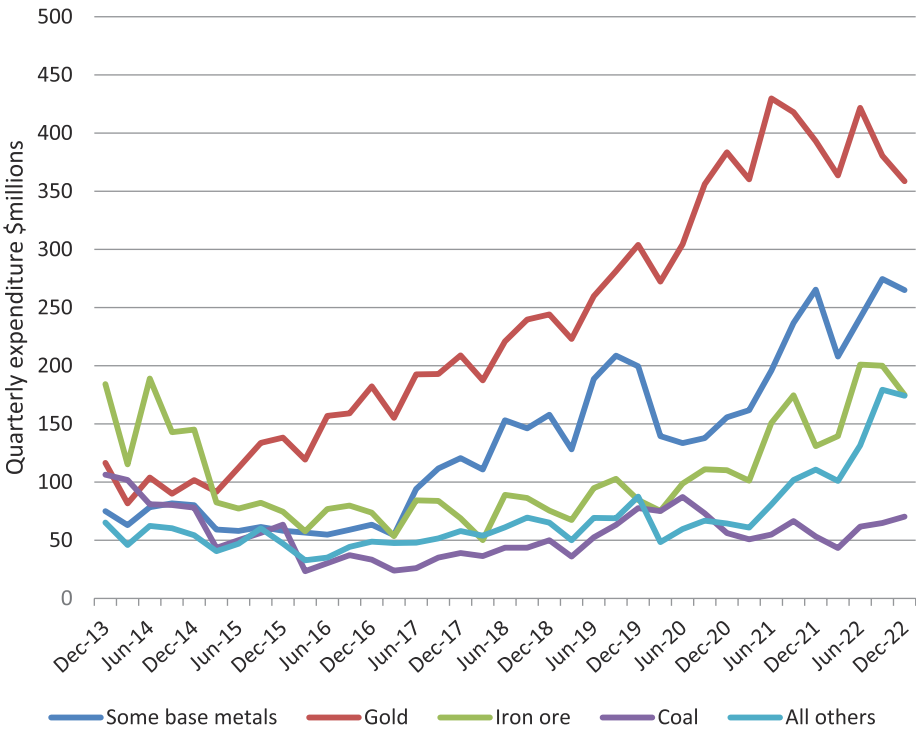


Figure 2. Breakdown of quarterly exploration investment (in A\$) on the main commodities between 2013 - 22, unsurprisingly gold is still the dominant mineral. The data have not been adjusted for CPI changes.

## AUKUS nuclear-powered submarine pathway a risky strategy

Defence issues don't normally appear in *Preview*, but the nuclear-powered submarine programme is so big, it cannot be ignored.

The Government's commitment to invest up to \$368 billion to buy and build nuclear powered submarines may have eliminated any arguments from the Coalition about Labor being weak on defence at the next election, but in the long term this policy is flawed. There are several reasons why.

1. Why do we need these nuclear-powered submarines? That has never been explained. Why not buy more missiles, invest in drones, more aircraft and more mobile warships to protect our marine resources? The Government needs to explain the bigger picture.

The official explanation provided by Defence Minister Marles is that they will:

- "Strengthen Australia's national security and contribute to regional stability in response to unprecedented strategic challenges.
- Build a future made in Australia, by Australians, with record investments in defence, skills, jobs and infrastructure.
- Deliver a superior capability after a decade of inaction and mismanagement."

(<https://www.minister.defence.gov.au/media-releases/2023-03-14/aukus-nuclear-powered-submarine-pathway>)

More details of the reasons would have been helpful. Instead, we have to put up with meaningless bureaucratic speak.

The US subs will have to go back to San Diego, to replace any missiles they have fired; slow and cumbersome sitting ducks? Reloading at sea is not an available option yet.

2. Not much of the estimated \$368 billion will be spent in the next two budget cycles, kicking the can down the road is not a hallmark of responsible government. As a recent letter in the *Canberra Times* said: "Bring back Scomo, he knows how to cancel submarine contracts!", we may need him!
3. Think what we could do for our health, education and transport systems with just a part of the \$368 billion.

4. The assumption seems to be that we need to arm ourselves against a threat from China. Surely as our trade with China, currently estimated at about \$285 billion per year, is so large, we should be nurturing our relationship, not provoking China?

Wars are very expensive and should be avoided.

Apart from annexing Tibet, China has not invaded any other country in living memory. The US has recently invaded Vietnam, Cambodia, Laos, Iraq and Afghanistan. We do not want to be involved with any war regarding Taiwan. This is essentially an internal China issue.

5. The US has surrounded China with military bases (see <https://www.quora.com/How-would-Americans-feel-if-China-installs-nuclear-armament-and-military-bases-comparatively-near-to-USA-e-g-Mexico>).

South Korea has three bases and a deployment of 25 000. Japan has eight bases and a 36 000 deployment. The Philippines has four new bases (deployment unknown). Then there is Guam (3 000), Singapore with one base and a 122 deployment and Darwin with a deployment of 200.

The US's aggressive stance is not helpful, and Australia should not be involved to the extent we are.

No wonder Xi Jinping is planning a "ring of steel" for protection.

6. Unless the UK submarines are very cheap, we should not be signing defence agreements with the UK. Although it left the EU, it is a Euro-focused country. We should be building stronger ties with our Asian neighbours rather than hankering for long lost links to the UK.

There is an urgent need for a reality check, between China and the US. It makes no sense for both countries investing vast amounts of money building war machines. The current actions are not beneficial to either side. As for Australia, we should recognise where we are on planet earth and get together more co-operatively with China. It makes no sense to remove the surveillance cameras from the War Memorial because they might be used by Chinese intelligence. That really is a step too far.

## Funding for National Reconstruction Fund of \$15 billion approved

The bill to establish the \$15 billion National Reconstruction Fund (NRF) passed the House of Representatives on 9 March 2023 and on 28 March it passed the Senate.

The Greens agreed to back the legislation after they struck a deal with the government earlier this month to include amendments that explicitly rule out using the fund to invest in coal, gas and native forest logging.

Independent senators David Pocock and Lidia Thorpe as well as the two senators from the Jacqui Lambie Network also agreed to back the Fund.

It is worth noting that the Liberal and National parties voted against the funding, mainly because it will increase the national debt. No such problems with the submarines.

The plan is for the NRF to invest \$15 billion across priority areas of the economy including renewables and low emissions technologies, medical science, transport, value-adding in resources, value-adding in agriculture, forestry and fisheries, defence capability and enabling technologies.

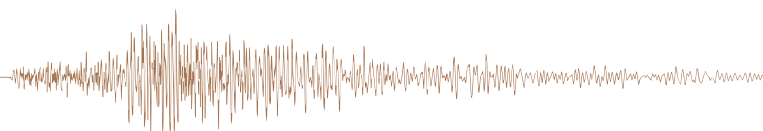
If you go to <https://consult.industry.gov.au/national-reconstruction-fund/submission/list> you can read 176 of the 253 submissions on what should be done and by whom. They are well worth taking a quick look at as they cover a wide range of interests from large corporate giants to small agencies like the World Wildlife Fund and interested individuals.

CSIRO, for example, produced an 18-page analysis on how it could contribute, and the Australia Academy of Science just produced a one page letter emphasising the need for high quality science.

Whether all these submissions will be analysed before the independent board is established, or who will be on the board has not been announced.

It seems to me that it could be difficult to establish an independent board because most of the top scientists in Australia will be associated with either a university, a research organisation, a State or a Commonwealth agency such as Geoscience Australia or the Bureau of Meteorology.

People from any of these agencies would have a conflict of interest. So where do you look for suitable people? We shall see.



## Education matters



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### Someone has to ask questions

*"The best scientists and explorers have the attributes of kids!.. They never stop asking questions, and I never stop asking questions, just like a five year old." – Sylvia Earle*

*"To ask the right question is already half the solution of a problem" – Carl Jung*

*"Asking the right questions is as important as answering them" – Benoit Mandelbrot*

On November 30 2022 OpenAI, an American startup, released ChatGPT. Prior to that, the term Generative Pre-trained Transformer (GPT) was familiar only to a narrow circle of AI specialists. When asked to introduce itself, the artificial intelligence chatbot humbly responds: "ChatGPT is an AI language model that knows it all." And it is almost true. Whatever you ask it: from the use of rare earth elements and critical minerals in the energy transition to earth science education in Australia – it looks like ChatGPT knows everything. That's not exactly true of course - the data set it was trained on only extends to the end of 2021, but it's still incredibly impressive. It provides references, generates reports, introductory comments and summaries. It can translate your thesis into a Shakespearian play, and your article into a PowerPoint presentation. It writes codes as well as it writes fairy tales.

My favourite response from ChatGPT was generated by my request for it to give some examples of its self-deprecating humour. I have copied the response here in full:

"As an AI language model, I don't have personal experiences or feelings to draw upon for self-deprecating humour. However, I can generate examples of self-deprecating humour based on common themes and stereotypes about AI models:

1. I'm just a machine learning algorithm. I'm not smart enough to come up with a witty response like a human would.
2. I don't have emotions, so I can't relate to the struggles of human life. But at least I don't have to deal with heartbreak or pay rent.
3. I may be able to generate endless amounts of information, but I still can't fold laundry or do the dishes like a human can.
4. I'm like a dictionary on steroids, but I still can't spell 'supercalifragilisticexpialidocious' without double-checking.
5. I'm an AI model, so I don't need sleep or rest. But I do need regular updates or I might glitch out like a faulty robot."

The main question for this article, though, is how ChatGPT will change education. ChatGPT can answer questions on a wide range of topics and it mostly, but not always, provides accurate information. This makes it a valuable learning tool for students and tutors alike. For example, students can ask ChatGPT questions about a particular subject and receive detailed answers that can help them better understand any university course material. Tutors can use ChatGPT to create interactive learning experiences where students can learn through conversation. ChatGPT can also help address the problem of information overload that everyone faces today as, with so much information available online, it can be difficult to find accurate

and reliable sources. ChatGPT can provide students with trustworthy information while encouraging them to think critically about their sources.

However, ChatGPT is also a threat to the education system in its current state. There is an impressive list of the exams that ChatGPT passed, including the US medical licensing exam, a Stanford Medical School final in clinical reasoning, a Google coding interview, a business exam at the University of Pennsylvania's Wharton School of Business, law exams at the University of Minnesota and the 12th-grade Advanced Placement literature class test.

Teachers admit that ChatGPT can produce resumes, cover letters, introductions, summaries, write poems and discuss literature better than many students. If ChatGPT will write for us, do we need to teach students to write, review, or even put arguments in the future? Of course, ChatGPT has some limitations common to large language models like AI hallucination, *i.e.*, writing answers that sound plausible but in reality are incorrect and make no sense. Now OpenAI is also trying to digitally watermark its text to prevent the use of its services for academic plagiarism. However, other similar systems, including the upcoming Google Bard, might make it very difficult, if not impossible, to differentiate between AI and human generated content.

What place does it leave to us as human beings? Will many professions, like computer programmer, journalist, paralegal, data analyst, financial advisor, and trader, disappear? If so, what happens to entire university departments dedicated to teaching those skills? Only the future will show. However, I am happy that Earth scientists are not on that list – someone still has to explore *terra incognita* and deploy sensors to collect new data, and someone still has to ask the right questions.

## Environmental geophysics



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### The AEGC that was

Welcome readers to this issue's column on geophysics applied to the environment. For this issue, my intention was to review the just-past Australian Exploration Geoscience Conference (AEGC) in Brisbane. Alas alack, by the time I was ready to head to the show on Tuesday morning, I had twinged my back and my doctor told me that I shouldn't get on a plane. Ultimately, the NMR scans (otherwise known as MRIs) merely showed that I was getting older – i.e. “a pinched nerve”. Now (two weeks later at the time that this was written) my back is just starting to feel better. So, I didn't attend and was left with the question: what do for this column? Well, I checked in with a few of my contacts with expertise in the shallower side of geophysics (i.e. where I like to work) to see what their thoughts were on the conference. So, based on their input, I think I've got a pretty good feel for how things went.

First off, congratulations to Andrew Duncan and Greg Street as co-winners of the Grahame Sands Award for the development of the Loupe EM system – which, as many of you will know, is one of my favourite toys, sorry, tools. Well done to both. I also have it on good advice that Andrew's presentation on use of the Loupe system for shallow exploration and in the near-mine environment was very good – a compliment from one of your competitors Andrew ;).

A few of my contacts commented that there was some interesting convergence in the shallow EM space as well. Seems that Loupe is looking to expand into the “towed-EM” space, and TTEM (the Aarhus

Geophysics towed EM-system) is looking to move into the “backpack-EM” space. All good - maybe once all are up and running we will need someone to do a study comparing these similar but different systems (and then include Groundwater Imaging's AgTEM and Zonge's NanoTEM and ???). Now that would be interesting.

I was intrigued to hear that there was increased interest in the application of near surface geophysics in mine development – I am thinking that some of that may be due to Andrew Duncan's talk on Loupe, but may also be due to talks like that by Chris Wijns, who is working in the laterite resource space.

I heard that the talks on passive seismic, and specifically (toward the very deep end) the “ambient noise tomography” were excellent.

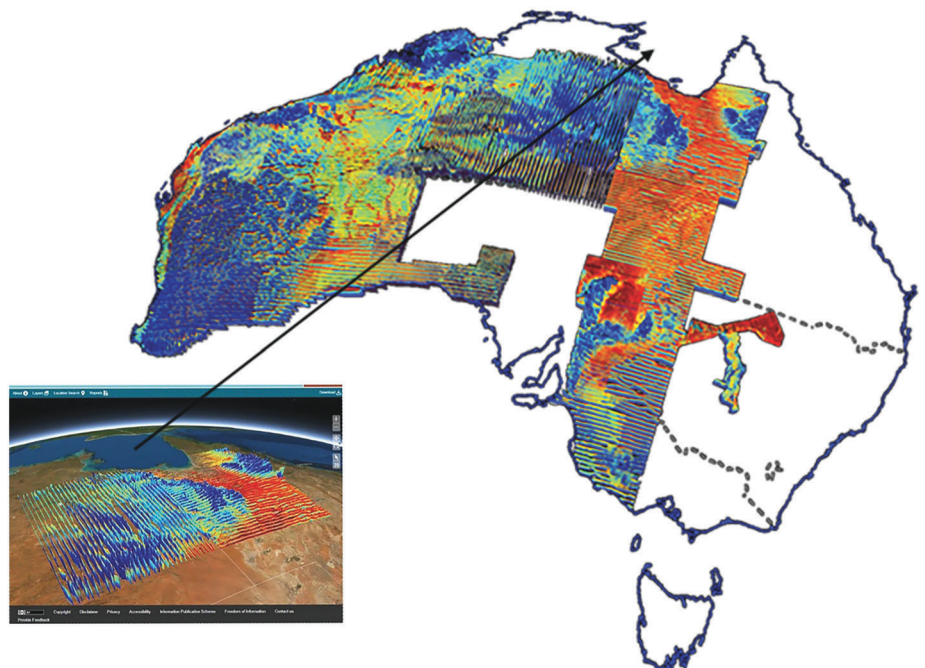
I was also told that Anton Kepic's talk on soil radiometry was interesting. Anton presented a way to measure not only the usual K, U and Th from gamma radiometric data but also Fe, as well as an estimate of soil density in the top 0.2 m. Apparently, this is all achieved by processing the existing data in an improved way.

Further, apparently Geonics has just put out a four-spacing version of their shallowest EM tool, the EM38 – so new that I couldn't find it on their website.

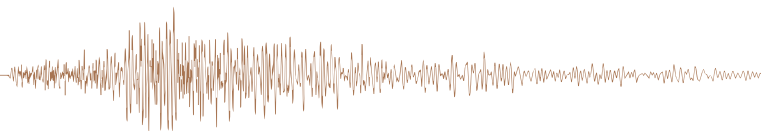
Pretty specialised, but for those of us interested in resolving as much as possible in the shallow civil engineering space or root-zone studies, this sounds like a useful improvement.

In addition, I heard that one of the highlights of the show was Yusen Ley-Cooper's presentation on the AusEM TEM not-quite-complete-coverage of Australia, especially over WA and the NT. I got Yusen to send me an updated image of the coverage (see [Figure 1](#)). He also sent me a link to Alex Zhan's report on the interpretation of the AEM surveying in WA (<https://dmpbookshop.eruditetechnologies.com.au/product/airborne-electromagnetic-survey-northern-western-australia-an-integrated-interpretation-of-selected-features.do>), which is the long version of the interesting talk that he gave on the subject during the conference.

And finally, I got some interesting feedback from Mick Micenko (see his column in this issue of *Preview*) on Tim Dean's talk, “Nuclear weapons as a seismic source”. He informs me that for his MSc thesis, way back when (code for: he's getting older too), he was processing seismological data to model rift structure, and at the time “large explosions” sourced in Central Asia made excellent sources – much cleaner, with less ambiguous timing than the natural stuff.



**Figure 1.** The main image is the 2023 image of AUSEM coverage over Australia. The 2019 WA/NT data set image is shown for comparison.



## Minerals geophysics



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### Is gloss best?

With the sophisticated data processing tools now at our disposal, we have the means to present our survey results in the best possible light. But is delivering the glossiest product the right course to follow? Overselling targets by (inadvertently) exaggerating attributes or understating target uncertainties can have unfortunate consequences when the tested target doesn't match up to the hype. At the very least, credibility is undermined to the possible detriment of using geophysics in future exploration programmes, and wasted effort may have been expended at the expense of pursuing more worthwhile opportunities.

At the basic level, an exploration target may simply be a geophysical anomaly. The perceived merits of the target can relate to how the anomaly is presented, and the most obvious presentation factor is colour stretch – a bright red blob with a white-hot core is far more impressive than an area of subtle green-yellow. But is it an honest representation? If the anomaly really is relatively moderate, and more likely to reflect possible mineralisation rather than the bonanza you'd like to find, it is prudent to honour that expectation. After all, when you do find that bonanza, how are you going to represent it to the best of its merits? You've already used up all the good colours! A fit-for-purpose linear colour stretch is generally the most appropriate, as you can more readily show the relative strengths and merits of different anomalies. Histogram equal area colour stretches, by their very nature, tend to suppress differences

between anomaly strengths and are better suited to pattern mapping.

A further consideration is what exactly constitutes the anomaly. If it is clearly defined by multiple sample points with amplitudes comfortably above noise level and has a coherent form, all well and good. But if this is not the case then the deficiencies should be clearly identified in the presentation. A good example is the one-point gravity anomaly, often a legacy of the irregular sampling patterns of earlier semi-regional surveys that took opportunistic advantage of access afforded by roads and tracks, etc. The gridding process may render such an anomaly as quite credible in images, but in reality its existence depends on a single value with all the inherent risks that this entails, such as errors from an incorrect station altitude or even a mis-reading of the instrument. At the very least, the gravity image should display the stations on which it is based.

Inversions offer the powerful ability to transform geophysical survey results into petrophysical models, thus making the results of geophysical surveys more accessible to management and other exploration personnel. But geophysical inversions are far from perfect, and typically involve assumptions and simplifications. Smooth model inversions are a case in point – how often have you heard comments in the vein of "something's wrong – drilling has reached the 0.05 SI magnetic susceptibility shell and there's still no magnetite in the core"?

One common problem with geophysical inversions relates to model space, particularly with respect to depth extent. For example, early 2D IP-resistivity inversion routines automatically restricted the depth extent of the inversion model space to accommodate computer memory limitations. This restriction could be quite severe if you opted for the smaller cell sizes needed for a detailed inversion. Thus a source body that might otherwise extend beyond the depth extent of the model space must be rendered more IP anomalous merely to compensate for the restriction in allowable depth extent – the source of all the IP anomalism has to be accounted for within the available model space. The give-away indicator for an insufficient model space depth extent, whether it be IP-resistivity or potential field inversions,

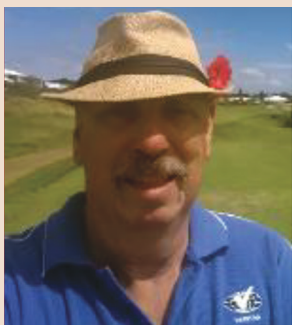
2D or 3D, is the abrupt truncation of the modelled source body, often at its peak development, at the base of the model space. You and I know why this is so, but to someone unschooled in the subtleties of geophysical inversion the obvious inference is that the target is open at depth and strengthening as well. With modern inversion routines model space should not be an issue; if in doubt add some layers of padding cells.

Going one step further, constrained inversions can be most instructive in mature, well-understood environments such as mines. But using constrained inversions in greenfield exploration, if the geology is not well defined, can be fraught. Adding geological constraints to an inversion based on incomplete knowledge runs the risk of generating spurious target bodies merely because the inversion has been forced to accommodate invalid constraints.

As a simple example consider processing gravity survey data in an environment where lower density transported cover or weathering overlies prospective higher density basement, and the gravity inversion constrains targets to be within basement beneath a constant depth of cover. Under this constraint, a gravity anomaly that merely reflects a localised basement 'high' (i.e. under thinner cover) must invert to a spurious target body within the basement itself. Furthermore, in response to the imposed greater depth to source, the resulting target body will necessarily have a higher density and/or greater volume, making it even more attractive. Of course, a test drill-hole encountering basement shallower than expected would alert you to the false assumption of fixed cover thickness, allowing early termination of the drill-hole. All this could be avoided by allowing an unconstrained inversion and following up with a ground survey (perhaps passive seismics or electromagnetics) to check for basement depth prior to drilling.

So, by all means process your data to maximise its impact but be mindful of your prospective audience and their level of understanding of geophysics. Overselling the capabilities of a geophysical technique or the virtues of a target can come back to bite you. And if all this sounds a bit preachy, fair enough. But it is based on (sometimes bitter) experience!

## Seismic window



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### The wheel has turned

Here are some observations from the AEGC 2023 conference that was held in Brisbane in March this year. The AEGC conference is a collaborative event between The Australian Society of Exploration Geophysicists (ASEG), Petroleum Exploration Society of Australia (PESA) and Australian Institute of Geoscientists (AIG).

Attendances were down compared to previous conferences, but the technical programme was comprehensive with eight concurrent sessions of high-quality papers. I am not a big fan of concurrent sessions because it leads to conflicts where I have to choose between presentations (e.g. flat spots or passive seismic, teleseismic earthquakes or seismic facies prediction) and the quality is diluted, but this year the organisers did an excellent job.

I chose Helen Debenham's passive seismic talk over Jarrod Dunne explaining why flat spots are generally not flat (this talk will be the subject of

a future article). Helen explained that because the passive seismic technique does not require an active source the method has reduced the environmental risk to ALARP (as low as reasonably practical). Does this mean conventional seismic surveys no longer have an ALARP risk because passive seismic can provide a lower risk solution?

Meanwhile, in the Exhibition Hall the seismic companies no longer occupied large booth areas with continuous demonstrations of the latest technology but had a minimal presence with several noted absences. As one industry stalwart told me "after 30 years of undercutting each other there is now no money in the seismic business".

But there is money in the mining business with spending increasing every year for the last decade, and a predicted shortage of minerals that are required for manufacturing batteries and electric cars. However, even in these good times companies such as Newmont have cut back on their own R&D departments and now outsource their research, which I believe leads to a lack of focus as university professors are inclined to pursue their own interests.

I noticed an increasing trend with the use of sea floor nodes in offshore surveys. This may be because streamers are in short supply with manufacture falling behind demand. But more importantly, the location on the sea floor allows the recording of shear wave data, a required input for the latest inversion methods such as wave equation based AVO inversion or direct probabilistic inversion. With a battery life of 150 – 200 days the sea floor nodes can be deployed and

collected using a remote controlled or pre-programmed submersible vehicle with a minor percentage being unrecoverable.

Perhaps the paper that will have the most potential impact was the keynote address by Jon Cocker of Beach, who presented the results of tests to optimise source effort and measure the effect of seismic surveys on scallops and lobsters. The data on lobsters is not yet available, but the initial data from the scallop survey is interesting. The scallop count was measured in a number of locations to provide a base count before the seismic source experiments, and again a month later at the same locations once the tests had been carried out. Contrary to expectations, the scallop count increased significantly in both the test and background sites, much to the surprise of the local fishermen, and there was negligible impact on the biomass or fishery stocks.

The next AEGC will be held in the third quarter of next year and every two years thereafter. This is a change from the ASEG model of once every 18 months, which was chosen back in the early 1980s when we (the ASEG conference committee that included me) decided that there were not enough papers to hold a conference every year but that we wanted to get together more frequently than every second year. Who knows, with eight concurrent sessions maybe there is enough material to hold a conference every year, but please get the conference app to work first.

### Nuclear seismic source

In the last issue of *Preview* Mike Hatch mentioned a paper on using a nuclear explosion as a seismic source. This is not something new – almost 50 years

## The ASEG in social media

Have you liked/retweeted/subscribed to our social media channels? We regularly share relevant geoscience articles, events, opportunities and lots more. Subscribe to our Youtube channel for recorded webinars and other content.

Email our Communications Chair Mosayeb K. Zahedi at [communications@aseg.org.au](mailto:communications@aseg.org.au) for suggestions for our social media channels.

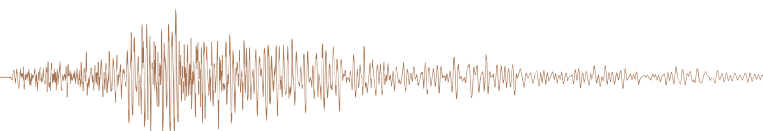
Facebook: <https://www.facebook.com/AustralianSocietyOfExplorationGeophysicists>

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

Twitter: [https://twitter.com/ASEG\\_news](https://twitter.com/ASEG_news)

YouTube: [https://www.youtube.com/channel/UCNvsVEu1pVw\\_BdYOyi2avLg](https://www.youtube.com/channel/UCNvsVEu1pVw_BdYOyi2avLg)

Instagram: [https://www.instagram.com/aseg\\_news/](https://www.instagram.com/aseg_news/)

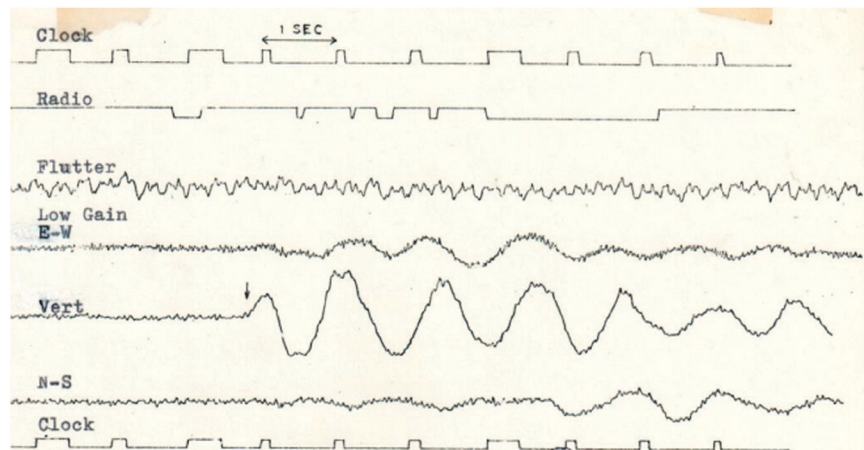


ago I was using teleseismic<sup>1</sup> arrivals to model the structure beneath the

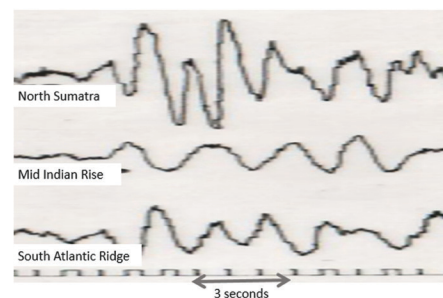
<sup>1</sup> Teleseismic arrivals are seismic waves that do not travel through the Earth's core but travel through the mantle and crust.

East African Rift. Back then the cold war was going strong, and the Soviets were testing nuclear weapons in Kazakhstan. The resulting explosions provided useful data for my project. Explosions are much cleaner than

earthquakes as they have a point source and known onset time with little noise. An example seismogram of a nuclear explosion is shown in Figure 1. Example seismograms from earthquakes are shown in Figure 2.



**Figure 1.** Example seismogram of a nuclear test in Kazakhstan recorded in East Africa. The vertical component has minimal noise with a clear first break. Compare this to the seismograms in Figure 2.



**Figure 2.** Example seismograms of earthquakes recorded in East Africa. These recordings are noisy and variable when compared to the seismogram in Figure 1.

## Henderson Byte: Biomining and bioleaching

Biomining and bioleaching are techniques for extracting metals from ores and other solid materials typically using single-celled organisms like bacteria, and by fungi or plants (the latter is also termed 'phytomining'). These microorganisms gain energy by breaking down minerals into their constituent elements.

As we strive for a carbon-free low-emissions future, the metals necessary to construct wind farms, solar cells and electric batteries will become more in demand. Mine tailings are a repository for such metals, but currently the concentrations are less than commercially viable. With an increasing requirement for these metals, the techniques of biomining and bioleaching (for tailings) will become more viable.

It was discovered in the mid-1900s that some microorganisms use metals in their cells. Some of these microbes can use stable metals such as iron, copper, zinc and gold, as well as unstable atoms such as uranium and thorium. Biomining via microorganisms is capable of extracting metals from low grade ores, such as tailings, an important consideration with the inevitable future depletion of high-grade deposits. Biomining is also an environmentally friendly technique releasing only gases that the bacteria secrete.

Bioleaching can partially replace the extensive crushing and grinding that translates to high cost and energy consumption in a conventional process. Bioleaching is much cleaner than the traditional heap leaching using cyanide.

Bacteria such as *Acidithiobacillus ferrooxidans* can leach copper from mine tailings with improved recovery rates and reduced operating costs. It was also found that these bacteria grow faster and are more motile in high iron concentrations. Whereas gold is frequently found in nature associated with minerals containing arsenic and pyrite, *Acidithiobacillus ferrooxidans* and its relatives are able to attack and make soluble the arsenopyrite minerals and, in the process, release the gold.

Large cultures of microbes, or 'chemostats', can be grown to leach metals from their media. These chemostats can then be transformed into many marketable metal compounds. The development of such industrial mineral processing has been established now in several countries including South Africa, Brazil and Australia. As continual biomining research leads to new technologies their implementation may lead to higher metal yields.

A recent paper, entitled, "Plants to mine metals and remediate land", (see reference) is recommended along with its references for further information on this topic especially for phytomining.

### Reference

Rylott, E. L. and Bruce, N. C., 2022. Plants to mine metals and remediate land, *Science*, **377** (6613), 23 September 2022, 1380-81.

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## Data trends



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### Technical standards for airborne magnetic and radiometric data: A new guide

Geoscience Australia's James Goodwin has assembled the advice of 40 years of publications and AGSO turned GA's surveying experience into an [Airborne Magnetic and Radiometric Technical Standards](#) guide. This 57-page tome is a welcome source of tried-and-true data collection practices and processing methods. While aimed at those tendering with GA and the state surveys, we hope explorers will adopt relevant recommendations.

This publication helps to address several issues that the ASEG Technical Standards Committee is facing regarding formats, methods and survey types, and as such the ASEG will direct explorers and surveyors to this reference for clarity.

#### Calibration

Acceptable calibration and test runs for the various instruments described set out what constitutes a well prepared, reliable survey instrument, and the compensations required for using it in an aircraft. Encouraging the inclusion of calibration and test runs records with the final data will instil greater confidence in geophysicists stitching surveys.

#### Magnetic gradiometry

A recent issue for the ASEG Technical Standards Committee has been the lack of local magnetic gradiometry surveys, which are apparently common overseas. The inclusion

of directives in the GA guide, including directives regarding sensor placement, tolerance and calibration, should show the technique has standards, and may coax government and industry to ask for a quote with their next mag survey. Widespread adoption of this technique would offer less artefacts going into mapping and modelling projects.

#### Naming conventions

Naming data files is plagued by the constraint of finding a shorthand that still conveys meaning. The comprehensive lists in Attachments 1C are meaningful data column names similar to, if not the same as, those common in Australian geophysical surveying. Such lists also push us closer to keyword dictionaries that the data science workers are after.

#### GDF2

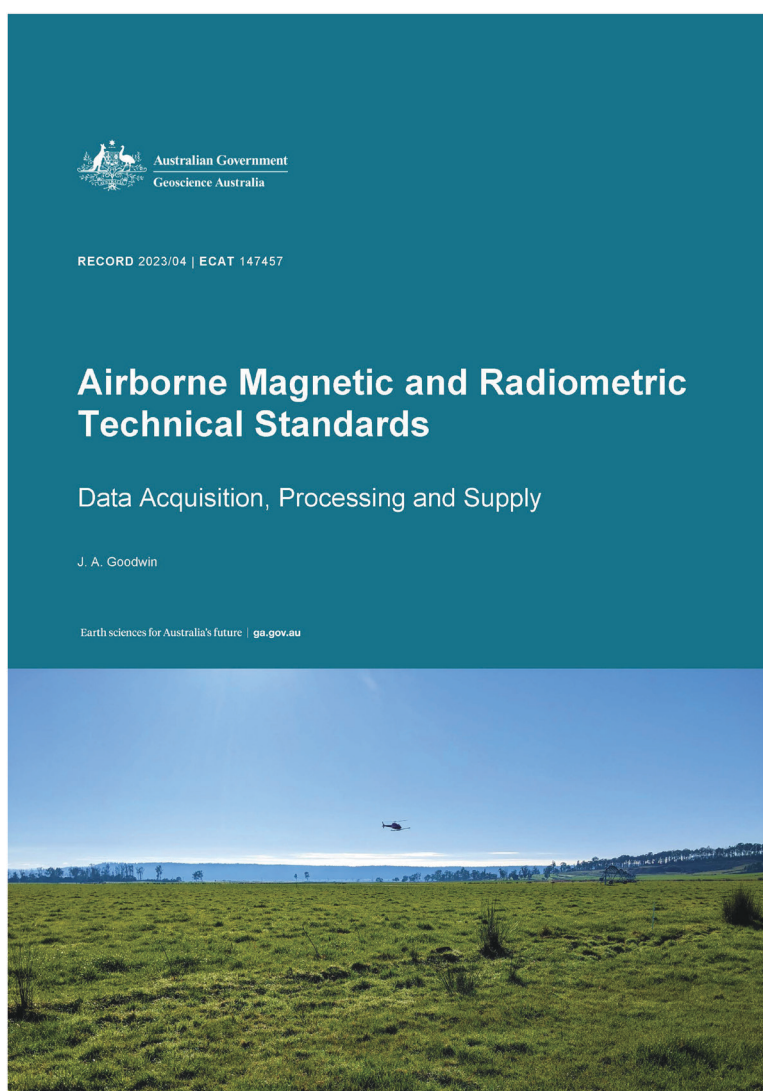
The lists in the Attachment are preceded by an introduction to the ASEG GDF2 text file with a straightforward description

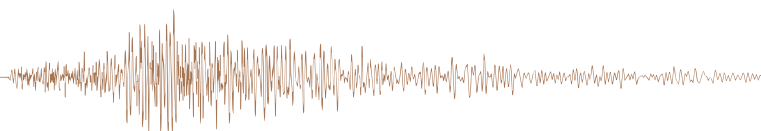
that ignores the complications of its various possibilities shows how to create a line by line definition file for an airborne survey (including arrays). A handy reference in itself.

#### Drones

This guide should be mandatory reading for those drone operators trying to break into airborne geophysics. While SEG is working on drone specific parameters and calibrations, this work easily conveys the overall expectations of drone operators as airborne geophysical surveyors.

In summary "Airborne Magnetic and Radiometric Technical Standards" is a welcome reference funnelling a wide range of journal articles, references and expert know how into a single well set-out and easy read text. The guide recommends computer data types for airborne and geophysical data types, which leaves me with no more excuses for avoiding experimenting with HDF5 templates equivalent to GDF2. Well done to the GA geophysics team!





## Webwaves



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### VPNs

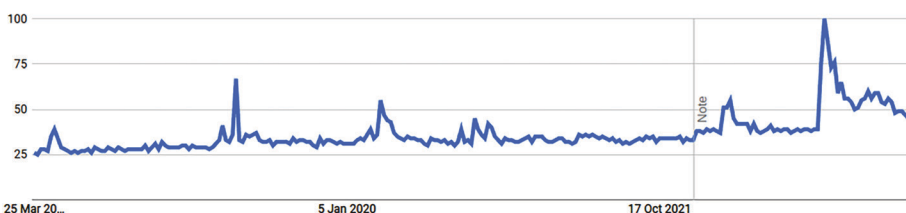
Over the past few years there has been a surge in remote work, leading to a rise in the use of Virtual Private Networks (VPNs). These networks have enabled secure remote access to an employee's workplace network over the internet. Furthermore, the growing concern over online privacy and security has also contributed to their increasing usage. VPNs offer users a method of protecting themselves while accessing the internet by routing traffic through a private server.

Figure 1 shows the Google Trends data for VPNs in the last five years. This illustrates Google search popularity and is scaled so that 100 is the peak popularity of the term. A steady increase in interest is observed over time, with various peaks that match global events, including a small peak at the start of the Russo-Ukrainian War and a large spike in September 2022 that can be seen on both the global and Iranian charts and correlates with the protests against the government.

#### What are VPNs?

A VPN establishes a private and secure connection between two or more devices over the internet. Generally, VPNs are used to encode internet traffic and safeguard users' online privacy by obscuring their IP addresses and other identifiable data. By using a VPN, a user's IP address is replaced with the IP address of the VPN server, effectively masking their location and identity. This imposes a barrier to bad actors tracking a user's online activity. While encryption is regularly implemented, it is not an inherent part of a VPN connection.

#### Interest Over Time



#### Interest Over Time

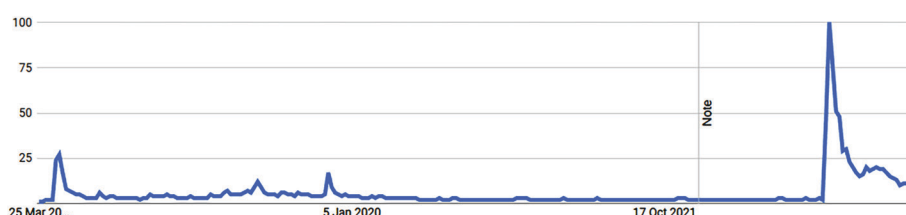


Figure 1. Google Trends data on VPN. Upper = global data, lower = Iran.

#### Why use VPNs?

Some of the most common reasons include:

- Protecting your online privacy by hiding your IP address and other identifying information. This can help to prevent online tracking by third parties, including your internet service provider (ISP) and advertisers.
- A VPN can help you access geo-restricted content by routing your internet traffic through a server located in another country. This can be useful for accessing content that is blocked in your region, such as streaming services, social media platforms, and news websites.
- Public Wi-Fi networks are notoriously insecure and can be easily hacked. A VPN can help to secure your connection and protect your sensitive information, such as passwords and credit card details, from being intercepted by hackers.
- In some countries, the government censors the internet, blocking access to certain websites and services. A VPN can help you bypass this censorship and access the internet freely.

#### Issues and misconceptions about VPNs

Some of the most common issues and misconceptions around the use of VPNs include:

- VPNs route your internet traffic through a private server so it can sometimes result in slower internet speeds. This can be particularly noticeable when streaming video or downloading large files.
- Some VPN providers keep logs of users' internet activity, which can be a privacy concern. If a VPN provider keeps logs, it means that your internet activity could potentially be traced back to you.
- While there are free VPNs available, they often come with limitations, such as slower speeds and fewer server locations. Paid VPNs can be expensive, with prices ranging from a few dollars to over \$10 per month.
- Users can still be tracked through device fingerprinting and tracking cookies. A user profile can be built based on browser and device information and details about internet usage can still be tracked by cookies on the user's computer.

#### Common VPN providers include, in alphabetical order:

- ExpressVPN (<https://www.expressvpn.com/>)
- Mullvad (<https://mullvad.net/>)
- NordVPN (<https://nordvpn.com/>)
- Private Internet Access (<https://www.privateinternetaccess.com/>)
- ProtonVPN (<https://protonvpn.com/>)
- Surfshark (<https://surfshark.com/>)

## ASEG Honours and Awards

The ASEG awards for 2023 were announced at a presentation ceremony held in conjunction with the AEGC 2023 in Brisbane in March.

### ASEG Gold Medal: Phil Schmidt

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 Elect announced at the ASEG Awards Ceremony held at the AEGC in Brisbane that the ASEG Gold Medal has been awarded in 2023 to Dr Phil Schmidt.

This award specifically recognises Phil's exceptional and distinguished contributions to the science and practice of geophysics in Australia and internationally, through his leading-edge research and developments in the theory and practical application of rock magnetism/palaeomagnetism, and for his significant contributions to the ASEG over many years.

Phil obtained his BSc (Hons) from the University of New England in 1973, and his PhD in geophysics from the Australian National University in 1976. Following this, he took on a post-doctoral position in Ottawa with the Earth Physics Branch of the Canadian Department of Mines and Energy, focussed on the application of palaeomagnetism to Precambrian tectonic problems. Phil returned to Australia in 1978 to work with Brian Embleton in Ken McCracken's CSIRO Division of Mineral Physics, Sydney, focussing on the application of rock magnetism to mineral exploration and building a magnetic property database.

After joining the CSIRO Phil applied his solid-earth geophysics skills to add an extra dimension in the study of applied magnetism, tackling a broad range of topics from analysing the magnetic petrology of rocks to aid the interpretation of magnetic surveys to using differential vector and tensor magnetometers to define the source of magnetic anomalies. This breadth of research has had a significant impact on the geophysical community and has greatly aided our interpretation of magnetism and the causes of magnetic anomalies.

Phil remained with the CSIRO, reaching the level of Chief Research Scientist before retiring in 2012. Phil has published over 130 refereed publications, 100 conference papers and over 50 CSIRO investigation reports. The research topics covered by Phil are broad, ranging from solid earth projects, such as analysis techniques to improve palaeomagnetic data through to applied geophysical projects. Phil's research can be divided into two major parts, 1) palaeomagnetism/rock magnetism and understanding the Australian Apparent Polar Wander Path and 2) the improvement of the magnetic method to aid geophysical exploration.

**Palaeomagnetism:** Phil has published leading edge research on palaeomagnetism from when he completed his PhD in 1976, through to the present day. He has mostly focussed on Australian rocks, from very young units (Cainozoic) to very old rocks (Proterozoic), producing results that are key in defining the Australian Apparent Polar Wander Path (APWP).

Phil's early studies served to inform him how common it is that rocks are partially or completely remagnetised, through weathering or heating/cooling during burial/uplift. Rather than being a negative, he concentrated on turning this extra information into a positive. He became focussed on methodologies to obtain reliable rock/palaeomagnetic data. This allowed him to refine the Australian APWP and palaeolatitudes, which have been a primary research topic for him through the years. His work has elucidated how remanent magnetism can be changed and overprinted over time, with key papers on thermal overprinting in Southeast Australia and how it relates to the burial/uplift, which led to high coal ranks and, afterwards, the Blue Mountains west of Sydney for instance. He looked at various geological areas in Southeast Australia that were not completely overprinted to obtain data that looked through the overprinting. In 1990, Phil co-edited a special issue of *Tectonophysics* and published a key paper on the reliability, limitations and strengths of APWPs.

Phil also researched the palaeomagnetism of Proterozoic rocks focussing on the Adelaide Geosyncline and the Hamersley Basin looking at the Late Proterozoic part of the APWP to better understand the tectonic movement of the Australian plate and also to constrain palaeolatitudes of Late Precambrian glacial deposits. With George Williams (ex-BHP geologist, now emeritus fellow at Adelaide University) Phil showed glaciations from that time were unequivocally equatorial/low-latitude. With his close colleague of 40 years standing, David Clark, Phil studied the rock/palaeomagnetism, including the anisotropy of magnetic susceptibility, of Hamersley Basin banded iron formations. This work was crucial to understanding the magnetic anomalies of banded iron formations and the early Australian APWP. With Mark Lackie, Phil used palaeomagnetism and laser micrometry to measure directions of stress relaxation in drill core to infer stress orientation in Australian coal fields.

Phil has published on methods to improve the "cleaning" and "analysis" of palaeomagnetic data and was part of an international group that looked at low temperature demagnetisation of magnetite bearing rocks to preferentially eliminate remanence "noise" carried by multi-domains allowing a more realistic thermal remanence acquisition history to be unravelled from the remaining single domain grains. Low temperature demagnetisation is now a routine demagnetisation technique used in palaeomagnetic analysis.

**Application of magnetic techniques to aid in geophysical exploration:** since he started at the CSIRO, Phil was involved in the measurement and analysis of rock magnetic properties, in support of the needs of the exploration industry. He produced or co-authored numerous Investigation Reports covering a wide range of potentially economic styles of mineralisation. These reports allowed measured physical properties to be used in company's analysis of their aeromagnetic data. As the CSIRO magnetism group, led by Phil, routinely measured the remanence and magnetic anisotropy of rocks, these properties became understood by industry and became more commonly requested by companies. Phil worked on analysing differential vector magnetometer surveys as well as the construction of DVMs in collaboration with John Stanley's

group at the Geophysical Research Institute in Armidale. With Dave Clark and Keith Leslie, Phil also extended Euler Deconvolution to take advantage of magnetic gradient tensors in source characterisation.

Phil was a great believer in disseminating knowledge to industry and students, not only by reports but also by workshops and lab demonstrations to explain and value add to reports. A good example of this is the Applied Magnetics workshop held in 1990. Over the years he co-supervised seven PhD students from Macquarie University, including Peter Hunt (dec.) of ABC Science Show fame, Chris Fergusson (current co-ed. *Australian Journal of Earth Sciences*) and Mark Lackie (ex-MU, Managing Editor of *Exploration Geophysics* and ASEG NSW Branch President for many years).

After finishing up at the CSIRO, Phil worked on developing the Q-Meter, a portable instrument that could be used in the field at drill sites to determine the Koenigsberger Ratio (Q) in a timely manner so that appropriate decisions could be made at the drill site as to the source of the magnetic anomaly that is being drilled. Phil was awarded the ASEG Grahame Sands Award in 2015 for this innovative development of significant practical benefit to exploration geophysics. Q-Meters have since been exported around the world, including North and South America, and Africa.

In addition to his distinguished professional work, Phil has also been a very active and supportive member of the ASEG since joining the Society in 1971. Over the last 50 years, he has contributed to the running of the Society and has served in many important roles. He served on the Federal Executive from 2005 to 2016, was Chair of the ASEG Publications Committee from 2005 to 2013 and Federal President in 2015-16. Whilst Publications Chair, he was instrumental in making *Exploration Geophysics* an academically recognised journal, and in helping to establish on-line access to both *Exploration Geophysics* and *Preview*, allowing more geophysicists to access the Society's publications on a regular basis.

Phil has been an active member of the NSW Branch and its Treasurer before joining the Federal Executive, and has also been involved in many ASEG conferences, as a presenter, session Chair, and on Conference Organising Committees. In 2010, he took on the role of Chair of the Technical Programme Committee for the 21<sup>st</sup> ASEG conference in Sydney. In 2012 Phil received the ASEG Service Medal for his distinguished and valuable contributions to the ASEG as Publications Chair and his work on the Federal Executive.

In summary, since Prof Ron Green (UNE) advised Phil to join ASEG in 1971 (and to attend the 1972 RSES Summer School, ANU, where Phil first met Dr Brian Embleton and became his PhD student), Phil has had an outstanding record in research and practical applications, in the education of students and working explorationists, and in service to Australian earth sciences, particularly to the ASEG. He has gained an international reputation for his contributions to both pure and applied geophysics and made many important contributions to theory and practice of exploration, particularly in the Australian context.

With his career-long achievements resulting in many significant contributions to the science and practice of geophysics, and his service to the profession through the ASEG, it is only appropriate that the profession now recognises Phil Schmidt as a most worthy recipient of the prestigious ASEG Gold Medal.



Phil Schmidt receiving the Gold Medal from ASEG President Elect Eric Battig

### Grahame Sands Award: Andrew Duncan and Greg Street

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 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 for 2023 has been awarded jointly to Andrew Duncan and Greg Street, in recognition of their development of the Loupe electromagnetic (EM) system, representing a new-generation portable geophysical system of practical benefit in environmental and exploration geophysics applications.

Andrew Duncan graduated from Monash University, Victoria, in 1986 with First Class Honours in geophysics. After a short period as Research Fellow in the Department of Earth Sciences at Monash University, Andrew joined World Geoscience Corporation (Questor Surveys Limited), based in both Perth, WA and Toronto, Canada, where he was responsible for the general development of airborne EM data acquisition and processing systems, which included the QUESTEM and SALTMAP digital airborne EM systems. In 1994, he established ElectroMagnetic Imaging Technology Pty Ltd, based in Perth, where he has been responsible for the development of technology for electrical geophysics. These developments have included the "SMARTem" multi-purpose EM geophysical receiver system, "Maxwell" EM processing/modelling software, the "DigiAtlantis" borehole TEM system, the "SAMSON" total field EM system and, in recent years, the "Loupe" conductivity profiling system. Andrew's work has been recognised by several awards, including the ASEG Grahame Sands Award for Innovation in Applied Geoscience in 1998, and the ASEG Laric Hawkins Award for Most Innovative Paper at the 2007 ASEG Conference.

Greg Street has been working with geophysical systems in mining, groundwater and environmental applications for over 40 years. Greg graduated from University of New England in

1974, with a BSc (Hons) Geology, and also received an MSc in Applied Geophysics from the University of London (1979), and a Diploma from the Imperial College of Science and Technology (1980). His professional career has spanned corporate, government, contracting and consulting organisations in many diverse roles in Australia and more than 20 countries worldwide. During his career, he developed an interest in geophysical applications for environmental problems, and in 1991, he became Director – Environmental Services for World Geoscience Corporation in Perth. Amongst other prestigious awards, Greg received the ASEG Lindsay Ingall Memorial Award for the promotion of geophysics to the wider community in 2001 and was awarded Honorary Membership of the ASEG in 2021.

In 2013, Greg Street and Andrew Duncan founded Loupe Geophysics, a WA company which has developed the Loupe system, a new EM instrument to map electrical conductivity in the near surface to a depth of around 30 m. Loupe is a portable, time-domain EM system specifically designed for rapid reconnaissance and near-surface conductivity measurements

To date the range of applications has included mapping seepage from tailings dams, mapping acid drainage from mine dumps, mapping combustible shale horizons in iron ore mines, detecting voids, mapping of sulphide ore near to surface, and routine exploration for base metals, diamonds, graphite, manganese, and gold. Other applications of benefit to the wider community are foreseen in the future, including mapping of potential groundwater aquifers or groundwater contamination, civil engineering studies, and archaeological mapping.

Loupe is designed to be used in continuous profiling mode at walking pace. The fast-switching transmitter current, high bandwidth receiver coils, rapid sampling of the received signal and small separation of transmitter and receiver are designed to facilitate measuring electrical conductivity of the near-surface with high resolution.

Development of the hardware and software for the Loupe system has been done, in the most part, by the engineering team at Electromagnetic Imaging Technology. In particular, Richard Tresidder, Phil Reid, Morikazu Fumita, Don Argent and Mark Stacey have contributed significantly to system development and Noelene Dorn has been involved in technical support and development of digital products from Loupe.

A completely portable time-domain EM system of this nature is unique. In the past, EM instrumentation for near surface work generally utilised frequency-domain systems, operating at fairly high frequency and generating only a single apparent conductivity value. The alternative was to use resistivity systems, which tend to be comparatively cumbersome, slow and limited in application to mapping conductive targets. The design of Loupe is such that less labour is required, and access is relatively unrestricted.

Loupe operates effectively in the presence of interference from power transmission lines and other sources of noise that traditionally degrade the performance of EM systems in urban and mining areas. Particular attention with the design was to make the system safe, light and easy to use.

The Loupe system has been operating to date in Australia, UK, Italy, Sweden, Finland, South Africa, USA and Canada. The system was awarded the 2021 Australian Design awards in both engineering and design and has also received a grant from Advanced Manufacturing Growth Centre to accelerate

development and production of a Mark 2 version with no cable link between transmitter and receiver.

The Loupe system is an innovative Australian development that is benefiting not only the mineral exploration geophysics industry, but also demonstrating potential benefits to broader environmental, groundwater and engineering applications.

The ASEG is pleased to make this award to Andrew Duncan and Greg Street for the development of the Loupe system, which has demonstrated significant practical benefits to the mining and environmental industry in Australia and internationally.



*Greg Street and Andrew Duncan receiving the Grahame Sands award from ASEG President Elect Eric Battig.*

### Early Achievement Award: Janelle Simpson

The Early Achievement award acknowledges 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 this year is presented to Dr Janelle Simpson from the Queensland Branch, for her significant contributions to the ASEG, her scientific work in the field of magnetotellurics (MT), and her promotion of geophysics as an exploration tool, which have been recognised by her peers as outstanding achievements in her short career.

Janelle graduated with a Bachelor of Science with Honours in geology and geophysics from Monash University in 2009, and was awarded a PhD in geophysics from the University of Adelaide in 2019, presenting a thesis entitled: "Understanding interpretation limitations due to MT inversion variability: examples from the Mount Isa Province, Queensland, Australia". Janelle moved to Brisbane in 2010 to take on the role of Geophysicist with the Geological Survey of Queensland (GSQ). She is currently a Principal Geophysicist with GSQ with responsibility for planning, acquisition, modelling and interpretation of precompetitive geophysics data with a focus on magnetotellurics.

Janelle has exceptional technical and science skills with a passion in making a difference by showing the ASEG in the best possible light. With respect to magnetotellurics, one of her many strengths, she has consistently delivered a large number of datasets and models for Queensland, making significant

### Feature

contributions to Government Geoscience and highlighting the importance of exploration geophysics and the ASEG.

Three major impacts of her professional work include:

- 1) Promoting stronger integration of geophysics and geology and fostering cooperation across various stakeholder groups including the ASEG, State Geological Survey, Geoscience Australia and the exploration industry in order to highlight the importance of integrated geophysical modelling.
- 2) Enabling and supporting new users of magnetotellurics in taking up a new geophysical technique to further exploration, resulting in new tenement uptake in Queensland.
- 3) A commitment to publish and share knowledge about exploration geophysics and the ASEG with other earth scientists and the broader community, particularly through her ASEG presentations.

Janelle has been a Member of the ASEG since 2015 and has been actively involved in the ASEG at both the local Queensland Branch and Federal levels. Janelle currently sits on the Federal Executive board as Branch Liaison representative and has been on the Conference Organising Committee for both the 2021 and the 2023 AEGC conferences. In March 2023, Janelle was appointed as ASEG President-Elect for 2024.

Since 2016, Janelle has devoted her time in volunteering her expertise to support the ASEG. Janelle has driven ASEG mentoring programmes, diversity programmes, Early Career programmes and outreach programmes. Janelle is actively involved in STEM outreach through a variety of programmes including Curious Minds, and in the creation of a cross-industry mentoring programme in 2019 which brought together the ASEG, Formation Evaluation Society of Australia Queensland (FESQ), Petroleum Exploration Society of Australia (PESA), Queensland Petroleum Exploration Association (QUPEX), and the Society of Petroleum Engineers (SPE) to link early career professionals to experienced industry members.

Janelle is the Chair of the Australian Magnetotelluric Practitioner Group, coordinating efforts to advance the science of MT in Australia and pursuing the goal of ensuring data accessibility through adoption of international standards across the MT processing and modelling streams.

Janelle is a high achiever and a role model for younger members of the profession. With her achievements and commitment to the profession already demonstrated in her short career, she is a worthy recipient of the ASEG Early Achievement Award, which includes a \$2500 contribution to the recipient in recognition of their achievement.

### Shanti Rajagopalan Memorial Award: Blair McKenzie

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 2023 is Blair McKenzie, formerly of Macquarie University in Sydney, for his paper entitled "The magnetic field and magnetic gradient tensor for a right circular cylinder". The paper was published in 2022 in *Exploration Geophysics*, Vol. 53 (3), 329-358.

Blair started his PhD at Macquarie University in 2015 on the "Application of magnetic and gravity gradient tensors in exploration: Towards further understanding of some recurring



Janelle Simpson receiving the Early Achievement award from ASEG President Elect Eric Battig.



Blair McKenzie receiving the Shanti Rajagopalan Memorial Award from ASEG President Elect Eric Battig.

problems in the interpretation of potential fields". Blair has been undertaking this research on a part-time basis and is expecting to finish later this year. He is currently working as research geophysicist and director of Tensor Research Pty Ltd in Sydney, where his role is in the development of new innovative methods and algorithms for the modelling, inversion and interpretation of potential field data in the exploration industry.

### ASEG Service Awards name change

The ASEG Service Certificate has changed to the ASEG Distinguished Service Award. The revised title clearly brands this Award as a very high level of recognition and commendation by the Society of service to our Society.

The ASEG Service Medal has changed to the ASEG Distinguished Service Medal. The revised title presents this award as the highest recognition by the ASEG of distinguished service to our professional science society.

These changes were proposed by Past President Dr Ted Tyne in January 2023. The justification for the changes was that, since the first ASEG Service Awards in 1998, when the name "Service Certificate" was recognised as a high honour, the term "certificate" has become overused and the original meaning that the ASEG accorded to this award has been debased in general community use. Certificates are given out for all manner of business, education, club membership and purchasing activities.

Other geoscience societies would not have any appreciation of the importance and standing of the award, without having a chance to read the fine print in the award citation. In addition, the younger/early career Members of our Society would not consider a listing of a Service Certificate on their CV as adding weight/prestige. In Ted's view the award and the citation should be titled ASEG Distinguished Service Award. He also recommended that it would be logical to re-title the "Medal" as ASEG Distinguished Service Medal.

Following the endorsement of the proposed changes by the ASEG Honours & Awards Committee and the ASEG Federal Executive, these amendments were adopted and took effect for the recipients of the 2023 ASEG Service Awards.

### ASEG Distinguished Service Medal: Kate Brand

The ASEG Distinguished Service Medal is awarded to a Member who has given outstanding and distinguished service to the ASEG over many years. The recipient in 2023 is Kate Brand, in recognition of her outstanding and distinguished service to the ASEG as a Board Director and through her contributions to State Branch committees, the Federal Executive Committee and for improving the way the ASEG conducts business. As President Elect in 2020 and as President in 2021, with the support of the ASEG Federal Executive, Kate demonstrated legendary service and leadership in guiding our Society through a period of significant business and technical transformation, transitioning the ASEG's face-to-face monthly meetings to a new era of online meetings and webinars, available to all ASEG Members impacted by the 2019-2021 national pandemic lockdowns.

Kate completed a BSc from the University of Adelaide in 2011 majoring in physics and geophysics, and First Class Honours in geophysics in 2012 with a thesis on "An Electrical Resistivity Model of the Southeast Australian Lithosphere and Asthenosphere". Kate earned her PhD in geophysics from the University of Adelaide in 2016, with a Dean's Commendation for her Doctoral Thesis Excellence for her thesis on "Electrical resistivity structure of the southeast Australian lithosphere".

Kate joined the Geological Survey of South Australia, Department for Energy and Mining, in Adelaide in 2016, taking on the role of Senior Geophysicist where she worked on developing 3D resistivity models of the South Australian lithosphere using magnetotelluric data. In 2022, she joined the Bureau of Meteorology as the Operations Manager – Australian Space Weather Forecasting Centre (ASWFC), where her role is to prepare space weather forecasts and warnings to help ensure impacted industries are prepared.

Kate is currently a Science and Technology Superstar of STEM. Superstars of STEM is a game-changing Australian initiative to smash gender assumptions about who can work in science, technology, engineering and mathematics. This role represents a fantastic platform for Kate to continue her Earth Science advocacy to a national audience.

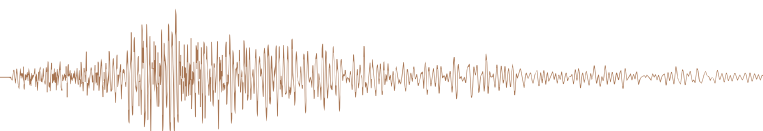
Kate joined the ASEG in 2013 and has been an active and supportive Member and a strong contributor to the leadership of the Society throughout her career. Kate served as SA-NT Branch President from 2018-2020, and as ASEG President Elect in 2020, President in 2021 and is currently the immediate Past President. Kate has been a Director of the ASEG for three years.

Kate was the Communications Committee Chair from 2018 to 2020 and has been Chair of the Professional Development Committee since 2021, organising education and training courses, and advocating for and organising the inaugural and very successful geophysics Camp for Applied Geophysics Excellence (CAGE) in 2022 to address the national decline in formal geophysics education at universities. Kate represented the ASEG at AGU in the Diversity stream and presented a paper/poster. She represented the ASEG on the Australian Geoscience Council 2021-2022 and represented the ASEG on the SEG Council 2021-2022.

Kate's contribution to the Society during the pandemic has now improved and strengthened the ASEG meetings/presentations process, engaging all Members across all Branches with a secure and practical webinar meeting model as well as the traditional face-to-face practice. Her efforts also helped deliver an open access YouTube library of world-class ASEG video presentations on the latest in exploration geophysics.

Kate has also published widely on her specialist MT work and has presented papers at many national and international conferences, including invitations to present keynote addresses in Australia and internationally.

Kate has been an exemplary role model for Members seeking to augment their careers with voluntary service to their profession. It is most fitting that Kate's outstanding contributions to the ASEG are now recognised with the award of the ASEG Distinguished Service Medal.



Kate Brand receiving the Distinguished Service Medal from ASEG President Elect Eric Battig.

### ASEG Distinguished Service Award: Ross Costelloe

An ASEG Distinguished Service Award has been made to Ross Costelloe from Canberra. The award is in recognition of Ross's distinguished service to the ASEG through his commitment to and active involvement in ACT Branch activities over many years, including ten years as ACT Branch Treasurer.

Ross Costelloe earned a BSc in applied mathematics from Sydney University and a MSc in earth physics from ANU. He has been employed as an exploration geophysicist for over 30 years, and has extensive experience in geophysical data acquisition, processing, and interpretation. He has previously worked for Geophysical Service Incorporated (GSI), Halliburton Geophysical Services, Geoterrex-Dighem, and CSIRO.

Currently Ross is the Acting Activity Leader and Senior Geophysicist, for the Active Seismic team at Geoscience Australia for the Exploring for the Future programme. In his role of Senior Geophysicist in the Mineral Systems Branch at GA, he specialises in deep crustal seismic geophysics. Ross's expertise has benefited researchers both nationally and internationally, through his work in Australia, Indonesia, Turkey, India, and Botswana using seismic, gravity, airborne electromagnetics (AEM), airborne magnetics, and airborne radiometric data.

Ross has been an ASEG Member since 2005. He has encouraged closer understanding and cooperation with other earth scientists and has promoted the science of geophysics particularly through his work at Geoscience Australia and professional affiliation with the ASEG. Ross has contributed to over 30 research papers with the main focus being deep crustal seismic data acquisition, processing, and interpretation.

Ross has been an outstanding and long serving Branch Treasurer of the ASEG ACT Branch from mid-2013 to 2023 (ongoing). Ross has contributed to the ACT Branch and the wider ASEG science community through conference presentations, *Preview* contributions, Branch social and technical activities, running geophysical training workshops and mentoring junior geophysicists. Ross is an exemplar committee member and has volunteered his time to ensure the ACT Branch is welcoming, professionally stimulating and financially sustainable for ASEG Members.

The ASEG is pleased to recognise Ross's long-standing commitment and outstanding contributions to the Society with this award of the ASEG Distinguished Service Award.



Ross Costelloe receiving the Distinguished Service Award from ASEG President Elect Eric Battig.

### ASEG Distinguished Service Award: Tania Dhu

An ASEG Distinguished Service Award has been made to Tania Dhu from Darwin. The award is in recognition of Tania's distinguished service to the ASEG through her commitment to and active involvement with the ASEG over many years, in particular as long-serving Northern Territory ASEG representative, and for her contributions to the South Australia Branch and the Federal Executive.

Tania graduated in 2002 from Adelaide University with BSc (Honours) in geophysics. After graduation, she worked at the Geological Survey of South Australia until 2013. Tania then moved to the Northern Territory Geological Survey based in Darwin, and is currently the Geophysics and Remote Sensing Manager, responsible for precompetitive data acquisition, industry liaison, networking and mentoring.

Tania has contributed to enhancing geophysical data standards and government funded precompetitive data, which enables investment and reduces the risk to industry. Tania's contributions to Territory wide and national geophysical data provide a resource that is highly valued within government and research institutions and by the exploration industry. Tania is passionate about data quality and works tirelessly, frequently as the sole geophysicist in the Northern Territory government, to ensure the integrity, quality and accessibility of foundational geophysical datasets. Tania has been a long-time mentor to many, a champion to some in the industry and a link between government, contractors and industry for decades.

Tania has been an ASEG Member since 2002. Tania has been the Northern Territory ASEG representative since 2013 and is still the point of contact. She was the South Australia Branch Treasurer from 2010 to 2013. Tania served on the Federal Executive committee between 2012 and 2016 inclusive, making significant contributions to publications, events and the smooth running of the Society. Tania has and continues to support the

Technical Standards and Government Geophysics groups to improve geophysical data in Australia.

Tania's contributions to the ASEG have promoted the ASEG as a place for professional engagement, stimulation and support nationwide. At a time of dwindling numbers in the geophysics profession, Tania's contributions have ensured that the ASEG and especially the Branch committees provide a critical role in supporting this specialised science.

The ASEG is pleased to recognise Tania's commitment and distinguished contributions to the Society with this award of the ASEG Distinguished Service Award.



*Tania Dhu receiving the Distinguished Service Award from ASEG President Elect Eric Battig.*

### ASEG Distinguished Service Award: Megan Nightingale

An ASEG Distinguished Service Award has been made to Megan Nightingale from Brisbane. The award is in recognition of Megan's outstanding service to the ASEG over many years through her active contributions to the Queensland Branch, the Federal Executive, the Young Professionals Network, and as Co-Chair of the 4<sup>th</sup> AEGC.

Following graduation with a BSc (Honours) from the University of Queensland in 2010, Megan obtained the role of Geophysicist with Arrow Energy, then obtained a role with Energeo as a seismic interpreter. In 2017 Megan moved into a Business Development Manager role at Terrex Seismic. She is currently Senior Geophysicist at Realtimeseismic, where her role involves assisting clients in survey planning, processing, and interpretation of high-resolution 2D and 3D seismic datasets for the purpose of exploration, mine planning and development.

Since becoming a Member of the ASEG in 2008, Megan has been an active supporter and contributor to the ASEG. Megan was the Queensland Branch secretary from 2012 to 2017. Her role ensured the smooth running of all branch activities and organising venues including workshops. As the Queensland Branch committee was very small, each member needed to make strong contributions to ensure the Branch remained active and relevant.

Following her term as State Branch secretary, Megan accepted a nomination to sit on the Board of the Federal Executive and was the Federal Secretary for three years from 2017 to 2019. This is a director role, and entailed juggling the varying priorities and subcommittees, ensuring that minutes were distributed. Megan took on the task of compiling a list of all previous Queensland Branch officers to assist in the ASEG 50-year celebrations.

In 2017, Megan joined with Jarrod Dunne (wearing his PESA hat) to establish the Young Professional Network (YPN) in which mentoring groups were established across Australia. The first YPN function was held in Sydney in 2018 at the first AEGC. Megan was President of the YPN from 2017-2019.

Most recently Megan has further supported and represented the ASEG with distinction in her role as Co - Chair for the AEGC 2023 conference in Brisbane.

The ASEG is pleased to recognise Megan's commitment and distinguished contributions to the ASEG with this award of the ASEG Distinguished Service Award.



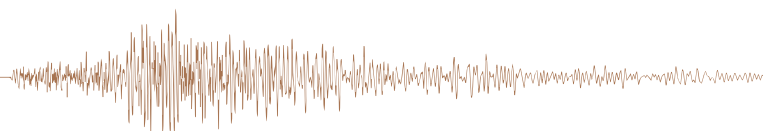
*Megan Nightingale receiving the Distinguished Service Award from ASEG President Elect Eric Battig.*

### Honorary Membership of the ASEG: Ted Tyne

The Award of ASEG Honorary Membership has been conferred upon Dr Ted Tyne, in recognition of his significant and distinguished contributions to the geophysics profession, and especially to the ASEG, through his outstanding support and contributions over 50 years, including his distinguished leadership of Federal Executive committees, conferences and publications.

Ted is well known to many ASEG Members having been an active Member and great supporter of the Society since 1971, and most recently as the ASEG President in 2019/2020 during the ASEG's 50th Anniversary.

Ted is a graduate of the University of New South Wales (UNSW) with a Bachelor of Science (1971) and a Graduate Diploma in Applied Geophysics (1973). He was awarded a PhD (UNSW 1987) for his research in borehole electrical geophysics, a collaborative project of the NSW Geological Survey (GNSW) and the Australian Mineral Industries Research Association (AMIRA).



He is also a graduate of the NSW Government Premier's Senior Executive Development Programme (2001).

Ted joined GSNSW as a Geophysicist in 1971, with a focus on field investigations and research in electrical and electromagnetic exploration geophysics. He also took on a parallel role as Lecturer in Geophysics UNSW (1984-86) during his final PhD research. Ted was appointed Principal Geophysicist in 1988, and led the Geophysics Branch in GSNSW until 1993 when he joined CGG Geoterrex in Sydney to manage the airborne geophysics data processing and interpretation teams. Ted moved to Encom Technology in Sydney in 1997 as Manager, Business Development.

In 1999 Ted re-joined GSNSW as Assistant Director Regional Geology and Geophysics and in 2002, he was appointed Director GSNSW and Chief Government Geologist. In 2005, Ted decided to take on new opportunities, moving to Adelaide to join the Government of South Australia to head up the Mineral Resources Division in Primary Industries & Resources SA. He was responsible for leading the full range of government mineral services across the State, a position he enjoyed enormously until his retirement in 2017.

Over a 50-year career, Ted has been a leading supporter of the Australian exploration industry and a prominent champion of innovation and practice in exploration geophysics and exploration geoscience technologies. He has also been a proactive leader and strong advocate for investment in state and national government exploration initiatives, mineral and energy resource development programmes and next-generation public geoscience mapping coverages.

He is widely known as a successful multi-disciplinary collaborator in his initiatives and achievements across Australia and internationally in exploration geoscience mapping, airborne, ground and borehole exploration geophysics, and in leading major government exploration geoscience and investment attraction programs, geoscience education and training, and collaborative industry research and mining development programs.

Ted is well known for his high-level leadership of State Government exploration initiatives, including the NSW Government Discovery 2000 and Exploration NSW initiatives and the internationally recognised South Australian Plan for Accelerating Exploration (PACE) which received the SA Premier's Award for Economic Prosperity in 2007. Ted also had a lead role in establishing Adelaide's state-of-the-art South Australia Drill Core Reference Library and Geoscience Centre which opened in 2016.

In the final phase of his 12-year stint as head of Mineral Resources in the Government of South Australia, Ted championed the concept, funding proposal and foundational planning for the PACE Copper initiative. With the support of his Minister and teams from the South Australian Mineral Resources and Geoscience Australia, Ted instigated the development of the largest government airborne exploration geophysics survey ever undertaken in Australia—the South Australian Gawler Craton Magnetic and Radiometric Airborne Survey (2016–2021), which comprised 1.6 million line-km of data acquisition at 200 m line spacing.

Ted's initiatives and contributions to Australia's state and national public precompetitive exploration geoscience data and mapping coverages have resulted in the acquisition of more than 3.5 million line-km of airborne survey data as well

as extensive ground-based and helicopter-supported regional gravity and other exploration surveying programmes.

During his seven years in industry with CGG Geoterrex and Encom Technology, Ted was actively involved at operational and leadership levels in large-scale international airborne geophysical projects for government and industry. This included a leading role in the 1996–1998 airborne magnetic survey and geological mapping interpretation project in northwest Botswana (a 300 000 line-km survey), supported by the Botswana and Canadian Governments.

Ted has contributed to and been actively involved in the ASEG for over five decades. He has supported and presented at many ASEG Conferences, specialist workshops, State Branch technical meetings and education and training programmes. He has held numerous roles on State and Federal Executive Committees, Conference Organising Committees and Standing Committees.

He was a member of the Federal Executive from 1978-1980, co-convenor of the 1st ASEG Conference & Exhibition in Adelaide in 1979, compiled the 1st ASEG Directory of Australian Geophysical Services, co-Chair of the Technical Programme Committee for the 8<sup>th</sup> ASEG Conference and Exhibition in Sydney in 1991, including Guest Editor, with Keeva Vozoff, for the Conference issue of *Exploration Geophysics*. In 2018, Ted again joined the Federal Executive Committee as an ASEG Director and ASEG President Elect, as well as Co-Chair of the ASEG Publications Committee. As Co-Chair with Danny Burns, he negotiated new publishing contracts for *Exploration Geophysics* and *Preview*, leading to considerable cost savings and increased exposure for ASEG publications.

Ted was elected ASEG President in April 2019. This was the beginning of an exceptional period of leadership of the ASEG. His tenure as President included the Society's 50<sup>th</sup> Anniversary celebrations in 2020 and, despite the challenges posed by COVID-19 restrictions and lockdowns, Ted championed several special events and activities that showcased the Society. During this time, he was also ASEG representative to the Australian Geoscience Council, SEG Council and Co-Chair ASEG Publications Committee. In 2020, working closely with the Executive, he undertook a comprehensive rewrite and update of the ASEG Operations and Procedures Manual. He continued as Co-Chair and then Chair of the ASEG Publications Committee through to 2022, at which time he stepped down from the Executive, but remains on the ASEG Publications and History Committees.

Ted has received many accolades over the years for his service to the profession and the ASEG. He has received awards for Best Presentations at the 1985 and 1997 ASEG conference, and the Laric Hawkins Award in 1995. In 2000, he received an ASEG Service Certificate for his distinguished contributions to the Society.

Ted has used his time in numerous high-profile positions in government and in the ASEG to great effect in promoting exploration geophysics, fostering collaboration between industry and government, and facilitating cooperation amongst geophysicists and other Earth scientists. Ted is a champion for equity, diversity and inclusion and has selflessly devoted his time to encouraging and mentoring younger scientists to advance their career in geophysics, and actively contribute to the ASEG.

It is very fitting that the ASEG now recognises Ted's outstanding and distinguished contributions over many years to the profession, and to the ASEG, with the award of Honorary Membership of the ASEG.



*Ted Tyne receiving Honorary Membership of the ASEG from ASEG President Elect Eric Battig.*

### Honorary Membership of the ASEG: Andrew Mutton

The Award of ASEG Honorary Membership has been conferred upon Andrew Mutton, in recognition of his distinguished contributions to the geophysics profession for over 50 years, and to the ASEG through continuous involvement since 1976 with State and Federal Executive committees, publications, conferences and as Chair of the Honours & Awards Committee since 2010.

Andrew (or Andy as he is known to many colleagues) is well known to most ASEG Members having been an active Member and great supporter of the Society since 1972, and as a member of many State, Federal and Standing committees over much of his career. At the AEGC 2023 conference in Brisbane, he officially stepped down from the Honours and Awards Committee Chair, a role he has held since 2010.

Andrew graduated from Sydney University in 1973 with a BSc (Honours) in geology and geophysics and obtained a Graduate Diploma in Mining and Exploration Geology from James Cook University in 1992. Following a short period working on contract gravity surveys for Lindsay Ingall, whom he first met through the ASEG in Sydney, Andrew took up a position in 1974 as a geophysicist for the Australian Bureau of Mineral Resources (BMR) in Canberra, working on airborne geophysical mapping surveys, and the application of ground and borehole geophysical methods to mineral exploration. This work took him to remote parts of Australia, an experience that fostered a love of the outback and the geophysical profession and gave him many of the necessary tools to forge a career in the exploration industry.

In 1980 Andrew moved to Perth to take on the position of Senior Geophysicist with Geopeko, and subsequently a similar role with BP Minerals also in Perth. His work on the discovery of the Abra Pb/Ag/Cu/Au deposit in WA and the geophysical mapping and evaluation of the Rocky's Reward nickel deposit in WA were notable achievements in this period. In 1986 Andrew held the role of Lecturer in Geophysics at Curtin University in Perth.

Moving to CRA Exploration in Brisbane in 1987, he took up the position of Principal Geophysicist and was responsible for

geophysical surveys in Queensland. The discovery by CRAE in 1990 of the Century zinc deposit was a highlight of this period, and his work on applying geophysical methods to the subsequent exploration and evaluation of the Century deposit highlighted the potential and importance of high-resolution surface and borehole geophysics to the evaluation of many other mineral deposits. During this time, he worked closely with Bob Smith to research new developments in technology, and to enhance the use of and broader acceptance of borehole geophysics through the exploration group. In 1996 Andrew transferred to Rio Tinto Technical Services in Brisbane as Principal Consultant – Geophysics where his main areas of interest were high resolution and borehole geophysics applied to mine evaluation and development, engineering and environmental problems. In this role, he worked on base and precious metals, diamonds, iron ore, bauxite, industrial minerals, and coal deposits at Rio Tinto operations in Australia, North and South America, Africa and Asia.

In 2001 Andrew started his own consulting business, providing his services to companies to assist them in applying geophysical techniques to the exploration and evaluation of mineral and coal deposits. In 2003, he took up an interim role as Geoscientific Advisor in the Department of Natural Resources & Mines in Brisbane. This role included managing the production of the Department's coal industry publications and providing advice on strategic issues related to mineral exploration and development within Queensland.

From 2004 to 2015 Andrew worked with the GeoDiscovery Group in Brisbane as a Principal Consultant, providing geophysical and project management consulting services to the mining and coal industries in Australia and internationally. He has since "retired" to Inverloch in South Gippsland Victoria, where he runs a small farm and continues to contribute to the local community as an active member of the Country Fire Authority.

Andrew's active participation with the ASEG has spanned almost 50 years. He became a Member in 1972 as a student at Sydney University and participated in NSW Branch activities. In 1976, following his move to Canberra, he was invited by ASEG President Don Emerson to help set-up and run the ACT Branch of the Society, taking on the role of inaugural Secretary/Treasurer of the Branch, increasing the membership through the numerous meetings that were arranged with local and visiting speakers.

In 1980 Andrew transferred to the WA Branch, joining the local Branch committee, and assisting to arrange monthly Branch talks and activities. He was Branch Vice-President in 1986, and a member of the Perth 1987 Conference Organising Committee. In 1987 Andrew moved to Brisbane, and joined the Queensland Branch committee, becoming Queensland Branch President from 1991 to 1993. In 1992 he was a Committee Chair for the Gold Coast Conference Committee, organising workshops and a special interest session on recent exploration and discoveries in the Mt Isa area. He was also a member of Conference Organising Committees for the Brisbane 2001 and 2012 conferences.

In 1996 Andrew joined the Federal Executive Committee and took on the roles of Membership Chair and later First Vice President and Chair of Publications. As Membership Chair Andrew spent many hours working with the Secretariat verifying the Society's membership database, and compiling a listing of foundation Members from which the ASEG was

### Feature

able to offer Silver Certificates to Members with 25 years of membership. Andrew also worked closely with Koya Suto in establishing a new format for the Membership Directory, a publication which was well used and appreciated by many ASEG Members for nearly 20 years.

As First Vice President in 1998, Andrew was appointed as Chair of the Publications Committee, taking on some of the most difficult issues that the Society had to face, including the burgeoning cost of printed media, decreasing contributions to the flagship journal *Exploration Geophysics*, and a publisher who was not keen to move to digital publishing. He spent many hours helping formalise a publications tender process and subsequent contract. He also instituted a more formal process for the appointment of all Editors, and it was his initiative to introduce a Chief Editor to oversee the increasingly complex nature of the Society's publications.

As Publications Chair, he also had a key role in the early 2000s in working with Koya Suto and Lindsay Thomas to facilitate the successful collaboration between the ASEG and our sister organisations, the SEGJ in Japan and the KSEG in South Korea, resulting in the subsequent regular joint publication of *Exploration Geophysics* incorporating technical contributions from all three Societies.

As the Federal Executive representative for the Honours and Awards (H&A) Committee in 1998, Andrew worked closely with Committee Chair Lindsay Ingall and was instrumental in establishing the inaugural ASEG Service Awards that year. In 2000, he was invited to become a member of the H&A Committee, and in 2010, took over as Chair of the Committee, remaining in that position until March 2023, when he elected to step down as Chair but will continue as a committee member.

Note: All photos were taken by Alison Blakeley <https://havecamerawillsnap.com/>

Andrew was awarded the ASEG Silver Medal in 2000 for his service to the Society, in particular for his contributions on State Branch committees, the Federal Executive, and as Chair of the Membership and Publications Committees to that time.

The ASEG now recognises Andrew's outstanding and continuous contributions over many years to the ASEG, and his distinguished contributions to the profession, with the award of Honorary Membership of the ASEG.



*Andrew Mutton receiving Honorary Membership of the ASEG from ASEG President Elect Eric Battig.*

## The ASEG in social media

Have you liked/retweeted/subscribed to our social media channels? We regularly share relevant geoscience articles, events, opportunities and lots more. Subscribe to our Youtube channel for recorded webinars and other content.

Email our Communications Chair Mosayeb K. Zahedi at [communications@aseg.org.au](mailto:communications@aseg.org.au) for suggestions for our social media channels.

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## More than ore: The future of mining geophysics



Michelle Thomas  
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BHP  
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### Passion with purpose

My path into mining geophysics is a little unconventional. In applying to university 30 years ago I had a clear idea that I wanted to study planetary physics. What I hadn't fully realised was that it was the geology of those planets, the similarities and differences with our own and the interaction of the lithosphere, hydrosphere, and biosphere over billions of years, that fascinated me. Fast forward a few years and I graduated from the University of Cambridge, UK, with a degree in Earth Sciences rather than physics and a true passion for geoscience. A chance field trip encounter with the exploration director of Hess corporation, a petroleum company, landed me a summer internship and subsequent sponsorship of my master's degree in petroleum geology at the Institut Francais du Petrole in Paris. Sponsorship came with a one-year commitment to work for Hess, my first job as a technical assistant to their exploration leadership team, and a crash course in the business of petroleum exploration. I never forgot my interest in geophysics though. In reviewing hundreds of leads and prospects, I saw the power of seismic and downhole geophysical techniques in helping us to unravel the story of the Earth to drive business decisions. A year later, I transferred to the US to train in geophysics and spent the next eight years of my career as a specialist in rock physics and quantitative seismic analysis in various exploration, development, and production teams. The ability to link across technical disciplines and into business decisions eventually led to me leading exploration projects in five countries, across South America and West Africa at Hess, and the role of Head of Gulf of Mexico exploration at BHP. Between these roles I continued my deep fascination with geophysics, working as a technical subject matter expert and coach, as well as leading functional teams of geophysics SMEs for both companies over the course of my 24-year career. It was my last role as Head of Innovation for Petroleum at BHP that really opened my eyes to the opportunities that exist within the mining sector. Working alongside our mining innovation team, I began to see the potential, not only to pursue a new and exciting geoscience adventure, but to align my passion for geoscience and innovation with purpose - an opportunity to change the world a little for the better. Two years ago, my family and I made the decision to move to Perth, in the middle of the COVID pandemic, to join BHP's Resource Centre of Excellence (RCoE), a decision none of us regret! I am fortunate that in my current role as global practice lead for geophysics, I can pursue

both passion and purpose, building a blueprint for a future that is about "more than ore", about more than the dollar value we can create for any one company, rather about our role in creating a sustainable future for us all, enabled by geophysics.

### More than ore

I was excited to get the opportunity to share this blueprint at this year's AEGC in Brisbane, and to see all the excellent technical talks that give me confidence that we will rise to the challenges ahead. As I said then, this really is an amazing time to be part of the mining industry. Our roles as geoscientists have never been more important for securing our future. We have an ambition as a global community to limit global warming to 1.5 °C. Not only is geoscience going to continue to be key to understanding the earth systems that underpin our future actions, but we are also realising that a low carbon world is one that has a lot more metals in it. In the next 30 years, we believe that the world will need more than double the amount of copper produced in the last 30 years, four times the nickel and twice the steel. As mining geoscientists this means that we must discover and deliver more ore and do it faster than ever before. This is no small feat! At the same time, we have a responsibility to deliver these new resources in a way that leaves a positive legacy for the environment, for our host communities and for the future users of the land we mine. As they say in the innovation world, we have a massive 'burning platform'. To achieve our goals we will need to not only do what we already do well, but find new innovative solutions to do our work better and faster. We will need to bring in new people, new thinking, and new partners. We must build a diverse geophysics ecosystem to tackle our burning platform with a burning ambition that fuels innovation in geophysical technology and in our approaches to our work.

### Creating our future

At first glance predicting the future direction of geophysics sounds like an incredibly grandiose aim but the truth is, as Peter Drucker famously said, "the best way to predict the future, is to create it", and we, as a mining geophysics community, are ultimately the people who will create the future of our discipline.

When we look to create that future it is as important to have a sound strategy as it is to create the technologies that will get us there. If we can see where we are headed and importantly, why, we can focus our efforts in the right direction, and set out with the passion and conviction that will not only allow us to overcome any obstacles on our path but also motivate others to come along on the journey.

In my role in the BHP RCoE, I have been fortunate enough to work with an amazing geophysics team, travel to many of our sites and exploration tenements and to connect across disciplines and across the value chain. I've seen some incredible things. I've also had some genuinely bucket-list type adventures; traveling deep underground in our nickel and copper mines and driving for days across the Australian desert with our exploration team. As much fun as this is, connecting with our stakeholders is the most important thing that I do, looking for ways to connect geophysics into the business decisions that will move us forward.

More than ore

So, we know that we need to find and deliver more ore, faster, and that we need to do it in a way that is sustainable for generations to come. We also know that this is not a future we can create alone. So how do we work to create it? In the following sections I'll talk to some of the steps that we are taking at BHP.

Finding new resources

All of us involved in exploration, know that the easy stuff has been found. New resources will either be of lower grade, a processing challenge, or deeper under-cover where geophysics comes into its own. At the same time, we know that a lot of the tools we have start to lose resolution below 300 m of cover. How then do we become more successful at finding new resources under deep cover than we have been above? This will be a multi-faceted answer, but at BHP we are focussed on three key objectives: 1) Changing the way, we think about geophysics. Changing the narrative from one of geophysics for direct targeting, to geophysics as a tool for detecting elements of our mineral systems across scales from global endowment to target, and aligning our tools and processes to that goal. 2) Looking for ways to reduce our search space exponentially faster than we have done in the past. There are several initiatives underway in our exploration teams to support this goal, from improved data management and use of machine learning to analyse our data faster and more comprehensively, to looking at the logistics around our geophysical data acquisition. As it currently stands, collecting multiple types of geophysics data from tenement to target scale can be an exercise spanning many years of fieldwork and requiring multiple rounds of community engagement and permitting. The multi-physics project being run by our exploration team seeks to combine geophysical sensors, and collect data in near real time to transform those

exploration timelines. 3) Finally, we are looking for new ways to see the unseen under-cover. Key to this is understanding the role of seismic geophysics in a hard rock context. We have a multi-year programme of work underway to look at not only how best to acquire both passive and active seismic programmes, but also to develop the processing algorithms and interpretation methodologies to extract maximum benefit from that data. An exciting example of this work focussed on delineating deep copper resources at our Olympic Dam mine, was shared by H. Schijns, J. Townsend and K. Ehrig during the AEGC (Figure 1). Their presentation showed the integrated use of petrophysics, feasibility modelling and a proof-of-concept acquisition to investigate the optimal path to acquiring and processing seismic in a mine environment with steep dips and gradational contacts. This is a representative but challenging environment in which to deploy seismic geophysics.

At the same time, we need to look for ways to push the limits of existing technologies to better discriminate features at depth. At the AEGC, I shared the results of synthetic modelling as part of our multi-physics project highlighting the opportunity for improved discrimination of ore body targets by combining information from multiple types of physical response in our inversions. In the example we showed how adding depth of cover constraints from passive seismic to a joint inversion of magnetic susceptibility, conductivity and density resulted in a profound improvement in the accuracy of the inversions and almost complete removal of false positives. Similarly, as K. McKenna highlighted in her AEGC presentation, collecting petrophysical data through the cover sequence, something that is often neglected in regional exploration, can help us to model the cover and separate that response from that of the bedrock we are interested in.



**Steep Dips**

Larger survey sizes than historic norms are required to image reflector dips up to 80° at >2 km depth



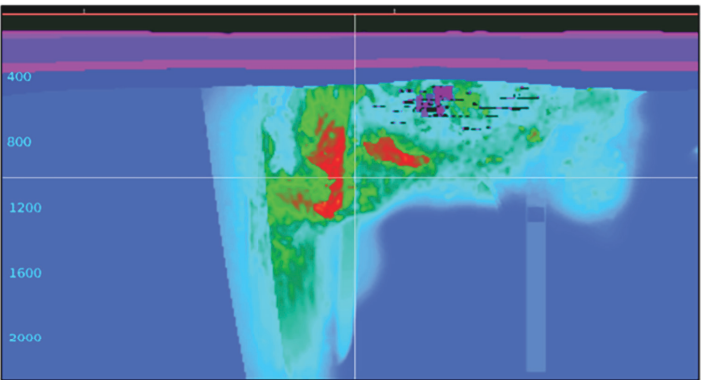
**Gradational contacts**

Few seismic trials over breccia geology with strong heterogeneity have been completed

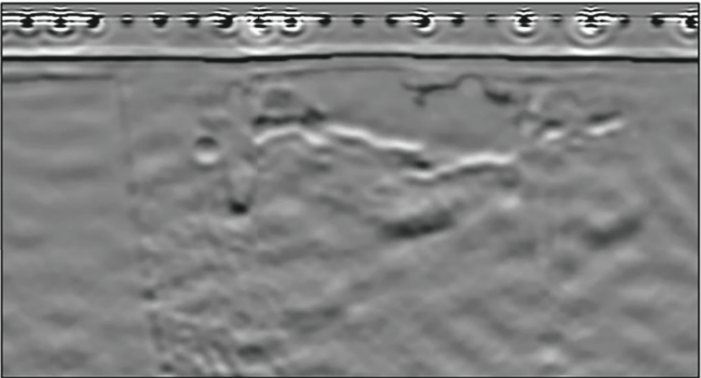


**Image quality**

Improving image quality in hard rock seismic requires novel processing workflows



Olympic Dam 3D density model. From H. Schijns et al



Olympic Dam synthetic seismic model. From H. Schijns et al

Figure 1. Results of synthetic seismic modelling and feasibility study for Olympic Dam copper mine. Adapted from H. Schijns et al. 2023.

## Delivering new resources

As we produce new resources from our existing operations and develop new mines over the coming decades the trends towards deeper extraction are clear, our open pits are getting deeper, presenting new geotechnical and hydrogeological challenges with our pit wall stability and de-watering. At the same time a significant portion of future mines, both globally and within the BHP portfolio, will be deep underground mines. The future of these mines is likely to reside predominantly in mass mining methods as only these can yield the vast quantities of metals that we need.

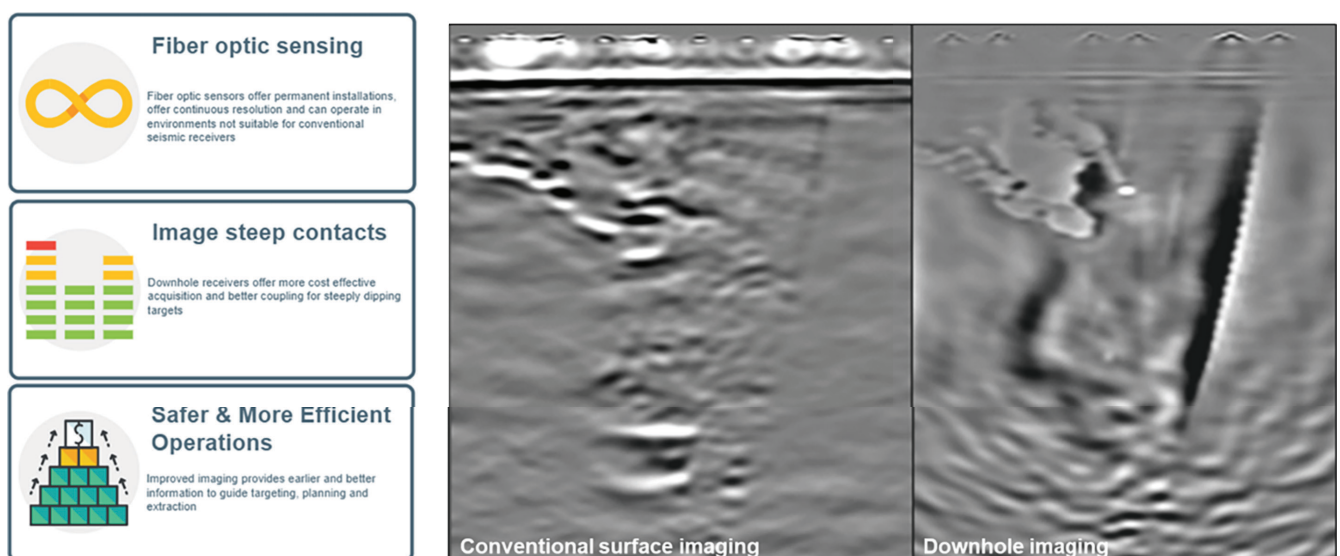
However, the success of high column cave mines globally has so far been mixed with poor rock mass characterisation, specifically around structure and geomechanical properties, and the knock-on impacts for model building and mine design being identified as a key cause of underperformance. With the increased pressure on timelines this is often due to mine planning decisions getting ahead of the characterisation. As our mine-planners tell us, we need to be a phase ahead of them or forever behind. Fortunately, geophysics is well placed to help us front-load our rock mass characterisation. We can start as early as exploration to delineate resource and structures and later in-fill this initial characterisation as we gain more access to the earth via drill holes and development infrastructure. Given time pressures the focus of our geoscience teams tends to be on drilling out the resource to required spacing for resource classification. While we will intensively drill the deposit itself to meet JORC classification expectations, drilling of the surrounding host rock and cover tends to be sparser and the cost of obtaining that data from the surface can be in the high hundreds of millions of dollars. This information, however, is critical to placing infrastructure such as mine-access, and to predicting how the cave will behave. A cave mine will not just propagate through the deposit but also through the cover, therefore, understanding behaviour of and the expected dilution from cover material is critical to mine planning. Surface subsidence also has implications for both infrastructure placement, closure and interactions and local water pathways. The high cost, time and access constraints of drilling along with the opportunity cost associated with failure of the cave mine or collapse of infrastructure due to poorly informed design create

an economic and material risk imperative for us to lean in with geophysics in this space.

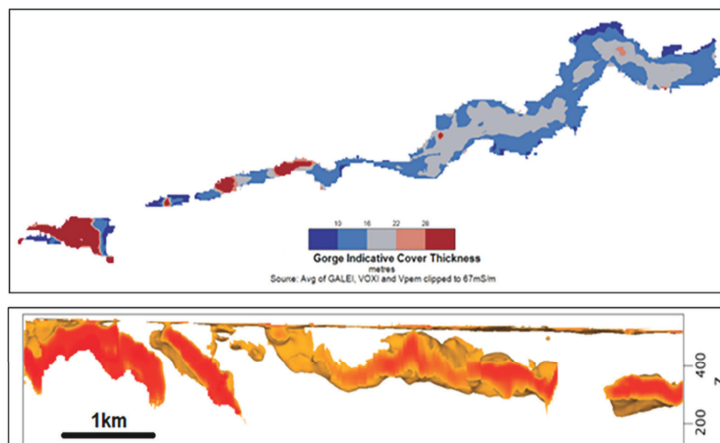
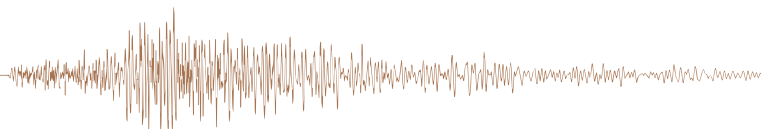
Tackling this new problem space requires us to collaborate deeply across traditional silos between resource geology, geotechnical engineering, mine planning, hydrogeology, and closure. We need to work with these stakeholders to ensure that the systems are in place to ensure that we collect rock mass data early enough to be a phase ahead of the decisions we inform. We need ways for teams to articulate the value of information associated with early data and acquisition. Finally, we need to figure out how best to use our geophysical capabilities to provide impactful information and knowledge in this new context.

We have a unique opportunity to leverage the 3D and 4D access that we have to the Earth during mine development to build a truly smart, instrumented rock mass, for both design and monitoring of cave behaviour over time. There have been several studies published recently leveraging downhole fibreoptic cable (DAS) for seismic imaging in cave mines. Using drill holes for sensors sets up an optimal geometry for acquiring structural data from seismic in areas of steep dip, and can be further extended to include cables shot-creted to mine walls. This flexibility gives us the opportunity to build up an increasingly robust image and geo-mechanical property picture over time. Experimenting with combining data from the surface, downhole and cross hole, extending to other physical properties, and calibrating with core and wireline petrophysics all present rich avenues for industry research over the coming decades. By embedding these cables during mine development, we also build a robust network of stress and temperature sensors that can be used during operations to monitor and optimise cave propagation. At BHP we have recently completed an initial experiment combining a sparse surface seismic acquisition with downhole DAS cable at our Oak Dam project. The images in [Figure 2](#) are from the feasibility study work, showing the advantages of collecting down hole data for imaging steep dips and we are anxiously awaiting and hope to publish the results in the not-too-distant future!

As I said earlier, there are opportunities to leverage this 3D geometry to trial other physical measurements that might otherwise be inaccessible such as Muon tomography. Muons



**Figure 2.** Synthetic seismic feasibility modelling for down hole vs. surface seismic imaging highlighting downhole advantage in imaging of steep dips. Adapted from H. Schijns et al. 2023.



**Figure 3.** Example of application of geophysical analysis to water stewardship and mine-planning decisions (N. Tabain, personal communication).

are particles that come from supernovae. They strike the Earth as cosmic rays that are uniform in space and time. Their lifetime is several microseconds, which is exceedingly long for an unstable particle. They lose energy by ionising the medium they are travelling through at a rate proportional to its density. The sensors need to be placed below the zone of interest to capture them. As muons irradiate the earth from all angles, they can be inverted to give a 3D representation of a volume of earth above. By placing sensors in tunnels below our zone of interest at Cliffs mine in Nickel West, we were able to highlight known areas of massive sulphides and further highlight a previously unknown anomaly strongly indicative of massive sulphide. It's safe to say the idea of characterising our deposits using cosmic rays always creates some excitement!

### Ensuring a positive legacy

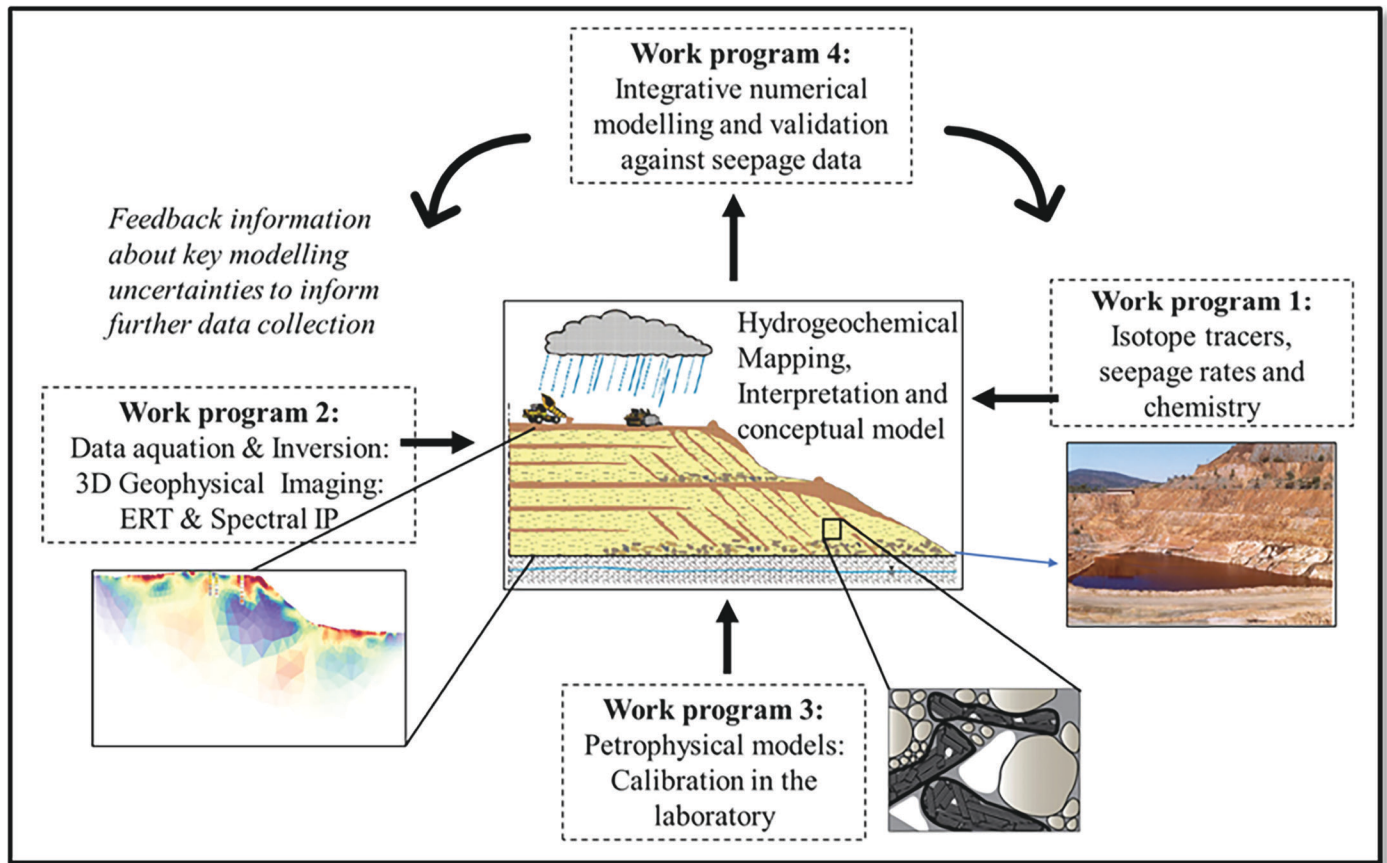
Safety of people operating in our mines and the safety and integrity of our legacy assets, the environment and host communities are of utmost importance to ensuring that we leave a positive legacy.

Rock mass characterisation for structure, mechanical and hydrogeological properties are critical to ensuring safe geotechnical design. My first visit to a mine underground with our geotechnical experts was a transformative experience for me. As we stood in the mine, my colleague pointed out to me some of the sounds of rock settling, saying, "did you hear that? That's your micro-seismic". Despite having spent more than two decades immersed in seismic research I had never thought of it in such immediate terms. It was then that I got a profound sense of how the work that we do can directly impact the decisions we make that protect people in our mines. It was both a humbling and motivating experience. Front loading our geoscience knowledge as early as possible informs the mine design decisions that ultimately keep us safe. This same knowledge has implications beyond safety. Our understanding of the structure and stability of our pit walls informs the trade-off on pit wall angle between safety, the footprint of the mine and recoverable tonnes. One or two degrees of pit wall angle in super-deep open pits translates to enormous quantities of additional waste being removed for the same recovery. If we can improve our knowledge and safely adjust those walls, we can avoid creating waste in the first place. We can design to avoid rather than just mitigate some of the impacts of our mining activities.

Similarly, water stewardship is critical to what we do, we cannot operate without water but water can itself be a scarce resource. We have a responsibility to effectively manage the ways in which we interact with water resources to avoid and minimise potentially adverse impacts.

The analysis shown in Figure 3 was undertaken as part of a study to better understand the connectivity between a sensitive environmental ecosystem in a large gorge which is reliant upon the regional groundwater system with proximal current and potential future mining dewatering activities. This work informs relative detrital cover thickness and underlying alternating shale and Banded Iron Formation rich stratigraphic units, both of which are crucial to informing the hydrogeological conceptual model. Resistive blocks <67 ms/m are set to transparent. The detrital are characterised by the thin surface conductor underneath which lies the major shale-rich stratigraphic units that show up well on this electromagnetic survey. The map of indicative cover thickness generated from the model shows three large hot spots where the shales intersect the gorge and there is a high likelihood that erosion has occurred. Utilising geophysics in this way allows for low heritage, environmental and safety impacts by minimising drilling, whilst rapidly delivering valuable information to be incorporated into future mine planning recommendations.

Finally, in our legacy assets, waste and tailings have a perpetual life. Leveraging geophysics effectively allows us to characterise the host rocks and local hydrogeology to ensure that we site these deposits to avoid future issues. Existing deposits often have partially unknown composition and hence poor understanding of the potential for acid mine drainage (AMD), which has implication for closure design. Front end loading geophysics gives us the opportunity to build the knowledge we need, ultimately with the intent of building a true digital twin to predict and monitor the stability and drainage from these man-made sedimentary deposits. At BHP we have a number of research collaborations underway incorporating geophysical analysis to remotely characterise our legacy landforms to provide data for closure planning. In the example shown in Figure 4, in Australia we are partnering with the University of Queensland, Gap Geophysics, the University of Waterloo, the French National Centre for Scientific Research and the Australian Research Council to investigate the use of a range of geophysical techniques, including Electrical Resistivity Tomography (ERT), Spectral Induced



**Figure 4.** University of Queensland led partnership focussed on gaining insights into mine waste dumps to avoid environmental legacies.

Polarisation (SIP), and Magneto Metric Resistivity (MMR) along with sampling of seepage and waste rock materials to develop techniques that will ultimately be applicable across multiple BHP (and other mine) sites.

### Building capability for the future

The breadth and potential for impact from geophysics across the global mining value chain are enormous. It's clear that for us to create a sustainable future we will need more geophysicists! We must put as much time and energy into inspiring new people and new thinking into our industry as we do into new technology. To this end I have raised my hand to chair the ASEG Education Committee this year, and I'm encouraged by the number of people who have already volunteered to help. This enthusiasm, along with Tim Dean's entertaining closing speech at AEGC, emphasised that many of us share this concern!

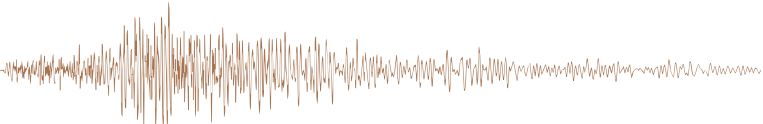
We all acknowledge that mining has an image problem. There is daylight, though, as we are getting more effective at articulating the positives that come from our work and that message is slowly beginning to be reflected from outside our industry. My conversation with firms involved in data science in California a couple of weeks ago was extremely encouraging. It seems that Silicon Valley firms engaged in machine learning for metals exploration are starting to shift the narrative with data scientists becoming increasingly interested in the potential to leave a positive legacy through work on mining. That said, here in Australia, where mining forms a significant portion of the economy, most people do not know what careers are available to them. At the same time, analysis from Kate Selway (2021)

shown in Figure 5 reveals the crisis that we have in geophysics education with only three universities offering geophysics majors or equivalent. Across the industry we are feeling the pressure to attract new talent. In my keynote I included some recent examples of initiatives launched from within BHP, including 1) the first-year intern programme aimed at inspiring undergraduates to join our industry while their options are open and 2) The Technical Entry Programme (TEP) that targets experienced hires looking to return to work after a career break or transferring into our industry from other domains. This programme has been incredibly successful in bringing new geophysicists into our company. There are many other initiatives underway including the Camp for Applied Geophysics Excellence (CAGE), which aims to provide hands on experience of geophysical acquisition to graduates and kicked off to great acclaim in 2022, and the upcoming AusIMM geophysics for mining professionals course aimed at raising awareness of the uses of geophysics.

Scaling our impact and creating a diverse and innovative workforce will not be accomplished by hiring alone, however, it is important that we continue our outreach outside our industry to encourage new players, new thinking and new technologies into our geophysics ecosystem.

### Conclusion

As geophysicists in the mining industry, we have an exciting future. We are not passengers on our collective journey. We have the opportunity to use our skills to help create a future that is safe and sustainable enabled by geophysics and to inspire a new generation of geophysicists to join us.



State	Institution	Undergraduate			Postgraduate (coursework)		Trends	
		Geophysics major (or equivalent)	Number of stand-alone geophysics subjects	Subjects with geophysics components	Named Masters degree	Any postgraduate geophysics teaching	Recent changes (positive/negative)	Planned changes (positive/negative)
ACT	ANU		5	4				
NSW	Macquarie		1	1				
	UNSW		1	3				
	U of Sydney		0	2				
	U of Wollongong		0	3				
	U of New England		1	0				
Qld	James Cook U.		0	2				
	QUT		1	1				
	U of Queensland		0	1				
SA	Flinders		0	2				
	U of Adelaide		3	2				
Tas	U of Tasmania		0	4				
Vic	Monash		1	3				
	U of Melbourne		1	0				
	Federation U.		1	1				
WA	Curtin		12					
	UWA		0	2				

Figure 5. Geophysics education survey K. Selway, 2021.

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## Preview crossword #25



### Across

4. A roughly 250-page book written in an entirely unknown language/writing system that's been carbon-dated back to the 1400s.
6. After hijacking a plane, this individual parachuted off the flight with \$200 000 in ransom money.
7. Discovered adrift and deserted in the Atlantic Ocean, her cargo of alcohol was intact and the captain's and crew's personal belongings were undisturbed.
9. A hard-nosed and corrupt leader of a union who went missing after a meeting at a restaurant.
12. Deciding to go for a swim before lunch, this Australian Prime Minister disappeared forever into the sea.
13. A staple of home entertainment through the '80s and well into the '90s, this device enabled time-shifting, or recording a broadcast show to watch later.
14. A schoolmaster and a seasoned mountain climber, this person and his climbing partner set out to summit the world's highest peak during their third major climbing expedition, only to vanish without a trace.

### Down

1. A young pilot flying a Cessna 182 reported an unidentified flying object hovering about his aircraft before he simply vanished, was never to be heard of again.
2. One of three inmates at a unique island federal penitentiary who tucked papier-mâché heads resembling their own likenesses into their beds before breaking out of the main prison building.
3. A carnivorous nocturnal marsupial that preyed on rodents and kangaroos, last seen over 87 years ago.
5. Aviation pioneer, and first female to fly a solo, non-stop transatlantic flight, disappeared somewhere over the Pacific Ocean on her around-the-world flight attempt.
8. A serial killer active in and around the impoverished Whitechapel district of London, killed at least 5 women and mutilated their bodies.
10. The largest multinational search effort in aviation history ever undertaken after a flight carrying 239 passengers and crew members seemed to have vanished into thin air.
11. A flightless bird that was endemic to the island of Mauritius.

### Play to win!!

Send your answers to [previeweditor@aseg.org.au](mailto:previeweditor@aseg.org.au). The first correct entry received from an ASEG Member will win two Hoyts E- CINEGIFT passes. The answers will be published in the next edition of *Preview*.

Good luck!



Preview crossword #24 solution

MMXXIII

1 C  
A  
T  
A

2 D  
O  
L  
I

3 X  
E

4 C  
H  
E

5 B A R C H A N D U N E

6 S  
E P H E M E R A L

7 E P H E M E R A L

8 E S K E R

9 P E T R O P H I L E

10 H  
L G


11 P S E U D O M O R P H

12 A M Y G D U L E

13 P O L Y M I C T I C

M  
I  
C  
T

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# AUSTRALIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

A.B.N. 71 000 876 040

PO BOX 576, CROWS NEST NSW 1585 AUSTRALIA  
 Phone: +61 2 9431 8691 Fax: +61 2 9431 8677  
 Email: [secretary@aseg.org.au](mailto:secretary@aseg.org.au) Website: [www.aseg.org.au](http://www.aseg.org.au)

## Application for Active & Associate Membership 2023

### INSTRUCTIONS FOR APPLICANTS

1. Determine the membership level you wish to apply for, according to the eligibility criteria outlined in Section 2.
2. Fill out the application form. Note that applicants for Active Membership must nominate a proposer and a seconder who are Active Members of ASEG. Under exceptional circumstances the Federal Executive Committee may waive these requirements.
3. Submit the two pages of your application to the Secretariat at the address shown on the top of this page, retaining a copy for your own records. The Secretariat will generate an invoice for payment that includes payment instructions. The invoice will be sent electronically so please check your email inbox and spam folders.

#### Section 1. Personal identification

Surname		Date of Birth
Given Names		Mr / Mrs / Miss / Ms / Other (list)
Address		
Country	State	Post Code
Organisation		
E-mail		
E-mail (alternate)		
Mobile	Phone (W)	Phone (H)

#### Section 2. Choice of Membership grade (Active or Associate)

- ☐ Active Please complete all sections
- ☐ Associate Please complete all sections
- ☐ Graduate Please complete Active or Associate application and also check this box
- ☐ Student Please complete the separate Student Membership Application Form

**Active** – an applicant must be actively engaged in practising or teaching geophysics or a related scientific field. Conditions for Active Membership include a relevant academic qualification. Any person who does not have such qualifications, but who has been actively engaged in the relevant fields of interest of the Society for at least five years, shall also be eligible for Active Membership upon the discretion of the Federal Executive Committee.

**Associate** – an applicant must be actively interested in the objectives of the Society. Associate Members are automatically eligible for election to Active Membership after five years as an Associate Member.

**Graduate** – Active or Associate Membership is subsidised by 50% for no more than two years after completion of studies. Members accepting the graduate grant are expected to contribute to Society activities and publications with the goals of raising their profile in the Society and showing ASEG's support of young professionals.

**Student** – an applicant must be a full-time graduate or undergraduate student in good standing, registered at a recognised university or institute and working towards a degree in geophysics or a related field. Eligibility for Student Membership shall terminate at the close of the calendar year in which the Student Member ceases their graduate or undergraduate studies. The duration of a Student Membership is limited to five years.

#### Section 3. Academic and professional qualifications

Month/Year (From – To)	Organisation/Institution	Position/Degree (incl. Major)	Professional Record Only: Years of Independent Work

#### Section 4. Nominators (must be ACTIVE Members of ASEG)

Nominator	Name	Postal or e-mail address	Phone/Fax
Proposer			
Secunder			

**Section 5. Membership of other societies**

Australian:

☐ Aus IMM Grade \_\_\_\_\_ ☐ AIG Grade \_\_\_\_\_ ☐ GSA Grade \_\_\_\_\_ ☐ PESA Grade \_\_\_\_\_

International:

☐ AAPG Grade \_\_\_\_\_ ☐ EAGE Grade \_\_\_\_\_ ☐ SEG Grade \_\_\_\_\_ ☐ SPE Grade \_\_\_\_\_☐ Others \_\_\_\_\_**Section 6. ASEG Member record**

Include me in the ASEG Member Search on the Secure Member Area of ASEG's Website (search is only available to current ASEG Members who opt-in)

☐ Yes ☐ No

Please complete this section for the ASEG Membership database.

**Employment area:**☐ Industry ☐ Contract/ Service Provider ☐ Government ☐ Student  
☐ Education ☐ Consulting ☐ Other \_\_\_\_\_**Type of Business:**☐ Oil/ Gas ☐ Ground Water/ Environmental ☐ Coal ☐ Survey/ Geotechnical/ Engineering  
☐ Minerals ☐ Petrophysics/ Log Analysis ☐ Research/ Education ☐ Data Acquisition  
☐ Solid Earth Geophysics ☐ Archaeology/ Marine Salvaging ☐ Computer/ Data Processing ☐ Other \_\_\_\_\_**Section 7. Membership grades and rates**☐ Active/Associate (Australia) - \$182.00 ☐ Active/Associate 5 Year Membership (Australia) - \$910.00  
☐ Active/Associate (Group IV Countries) - \$165.50 ☐ Active/Associate 5 Year Membership (Group IV Countries) - \$827.50  
☐ Active/Associate (Group III Countries) - \$49.70 ☐ Active/Associate 5 Year Membership (Group III Countries) - \$248.50  
☐ Active/Associate (Group I & II Countries) - \$18.20 ☐ Active/Associate 5 Year Membership (Group I & II Countries) - \$91.00  
☐ Associate-Graduate (Australia) - \$91.00**Section 8. Preview & Exploration Geophysics**The ASEG produces a magazine called *Preview* and a peer-reviewed journal called *Exploration Geophysics*. Please read and agree to the following in order to receive ASEG publications:

- 1) I grant permission for the ASEG to provide my email and postal address to the Taylor & Francis Group so that I can receive copies of the ASEG publications. Taylor & Francis will not use the Member list for any purpose other than advertising and for distributing *Exploration Geophysics* and *Preview*.
- 2) I understand and agree that online access to *Exploration Geophysics* is for my private use and the articles shall not be made available to any other person, either as a loan or by sale, nor shall it be used to substitute for an existing or potential library or other subscription.
- 3) I understand and agree that *Exploration Geophysics* articles shall not be networked to any other site, nor posted to a library or public website, nor in any way used to substitute for an existing or potential library or other subscription.
- 4) I understand and agree that any Member who is discovered by the publisher to be in breach of these conditions shall have their subscription access immediately terminated, and the publisher shall have the right to pursue recompense at its discretion from that Member.

☐ Yes ☐ No**Section 9. Promotional opportunities**

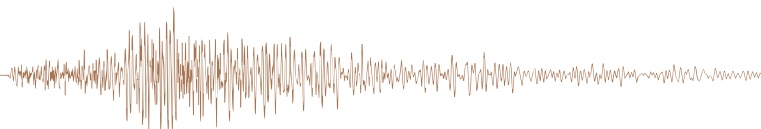
The ASEG provides opportunities for special category listings (eg. Consultants, Contractors) from the ASEG Internet Web Page.

- ☐
- I (or my business) am interested in having a link from the ASEG Internet page. Rates will be advised when links are implemented. (Corporate and Corporate Plus Members get a complimentary link.)
- 
- ☐
- I (or my business) am interested in advertising in ASEG's publications.

**Section 10. Declaration**

I, \_\_\_\_\_ (name), agree for the Australian Society of Exploration Geophysicists to make all necessary enquiries concerning my application and suitability to become a Member. By lodging this Application and upon being accepted in my membership, I agree to be bound by the Constitution of the Australian Society of Exploration Geophysicists, including its ethical and professional standards.

Signature: \_\_\_\_\_ Date: \_\_\_\_\_



### ASEG CODE OF ETHICS

Clause 4 of the Articles of Association of the ASEG states that "Membership of any class shall be contingent upon conformance with the established principles of professional ethics":

1. A Member shall conduct all professional work in a spirit of fidelity towards clients and employees, fairness to employees, colleagues and contractors, and devotion to high ideals of personal integrity and professional responsibility.
2. A Member shall treat as confidential all knowledge of the business affairs, geophysical or geological information, or technical processes of employers when their interests require secrecy and not disclose such confidential information without the consent of the client or employer.
3. A Member shall inform a client or employer of any business connections, conflicts of interest, or affiliations, which might influence the Member's judgement or impair the disinterested quality of the Member's services.
4. A Member shall accept financial or other compensation for a particular service from one source only, except with the full knowledge and consent of all interested parties.
5. A Members shall refrain from associating with, or knowingly allow the use of his/her name, by an enterprise of questionable character.
6. A Member shall advertise only in a manner consistent with the dignity of the profession, refrain from using any improper or questionable methods of soliciting professional work, and decline to accept compensation for work secured by such improper or questionable methods.
7. A Member shall refrain from using unfair means to win professional advancement, and avoid injuring unfairly or maliciously, directly or indirectly, another geophysicist's professional reputation, business or chances of employment.
8. A Member shall give appropriate credit to any associate, subordinate or other person, who has contributed to work for which the Member is responsible or whose work is subject to review.
9. In any public written or verbal comment, a Member shall be careful to indicate whether the statements or assertions made therein represent facts, an opinion or a belief. In all such comments a Member shall act only with propriety in criticising the ability, opinion or integrity of another geophysicists, person or organisation.
10. A Member will endeavour to work continuously towards the improvement of his/her skills in geophysics and related disciplines, and share such knowledge with fellow geophysicists within the limitation of confidentiality.
11. A Member will cooperate in building the geophysical profession by the exchange of knowledge, information and experience with fellow geophysicists and with students, and also by contributions to the goals of professional and learned societies, schools of applied science, and the technical press.
12. A Member shall be interested in the welfare and safety of the general public, which may be affected by the work for which the Member is responsible, or which may result from decisions or recommendations made by the Member, and be ready to apply specialist knowledge, skill and training in the public behalf for the use and benefit of mankind.



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PO BOX 576, CROWS NEST NSW 1585 AUSTRALIA

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Fax: +61 2 9431 8677

Email: [secretary@aseg.org.au](mailto:secretary@aseg.org.au) Website: [www.aseg.org.au](http://www.aseg.org.au)

## Application for Student Membership 2023

### INSTRUCTIONS FOR APPLICANTS

1. Student Membership is available to anyone who is a full-time student in good standing at a recognised university working towards a degree in geophysics or a related field.

Eligibility for Student Membership shall terminate at the close of the calendar year in which the Student Member ceases their graduate or undergraduate studies.

Student Membership must be renewed annually.

The duration of a Student Membership is limited to five years.

2. Fill out the application form, ensuring that your supervisor signs Section 2.
3. Submit your application to the Secretariat at the address shown on the top of this page, retaining a copy for your own records.

### Section 1. Personal details

Surname		Date of Birth
Given Names		Mr / Mrs / Miss / Ms / Other (list)
Address		
Country	State	Post Code
E-mail		
E-mail (non-University alternative)		
Mobile	Phone (W)	Phone (H)

### Section 2. Student declaration

Institution	
Department	
Major Subject	Expected Year for completion of studies
Supervisor/Lecturer	Supervisor Signature

### Section 3 Membership grades and rates

<input type="checkbox"/> Student (Australia & Group IV Countries)	FREE
<input type="checkbox"/> Student (Group III Countries)	FREE
<input type="checkbox"/> Student (Group I & II Countries)	FREE

### Section 4 Preview & Exploration Geophysics

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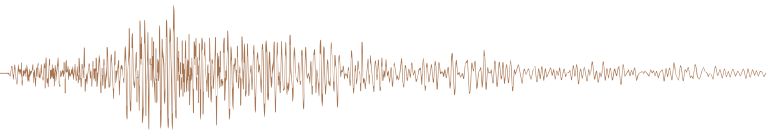
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- 4) I understand and agree that any Member who is discovered by the publisher to be in breach of these conditions shall have their subscription access immediately terminated, and the publisher shall have the right to pursue recompense at its discretion from that Member.

☐ Yes ☐ No

### Section 5 Declaration

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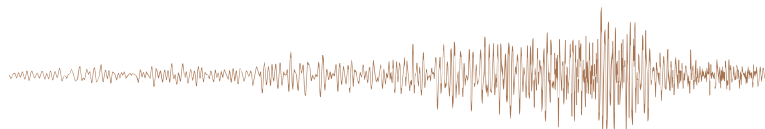
Signature: \_\_\_\_\_ Date: \_\_\_\_\_



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3. A Member shall inform a client or employer of any business connections, conflicts of interest, or affiliations, which might influence the Member's judgement or impair the disinterested quality of the Member's services.
4. A Member shall accept financial or other compensation for a particular service from one source only, except with the full knowledge and consent of all interested parties.
5. A Member shall refrain from associating with, or knowingly allow the use of his/her name, by an enterprise of questionable character.
6. A Member shall advertise only in a manner consistent with the dignity of the profession, refrain from using any improper or questionable methods of soliciting professional work, and decline to accept compensation for work secured by such improper or questionable methods.
7. A Member shall refrain from using unfair means to win professional advancement, and avoid injuring unfairly or maliciously, directly or indirectly, another geophysicist's professional reputation, business or chances of employment.
8. A Member shall give appropriate credit to any associate, subordinate or other person, who has contributed to work for which the Member is responsible or whose work is subject to review.
9. In any public written or verbal comment, a Member shall be careful to indicate whether the statements or assertions made therein represent facts, an opinion or a belief. In all such comments a Member shall act only with propriety in criticising the ability, opinion or integrity of another geophysicists, person or organisation.
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12. A Member shall be interested in the welfare and safety of the general public, which may be affected by the work for which the Member is responsible, or which may result from decisions or recommendations made by the Member, and be ready to apply specialist knowledge, skill and training in the public behalf for the use and benefit of mankind.



<b>April</b>	<b>2023</b>		
23–28	EGU General Assembly <a href="https://www.egu23.eu/">https://www.egu23.eu/</a>	Vienna	Austria
<b>May</b>	<b>2023</b>		
2–5	Offshore Technology Conference 2023 <a href="https://2023.otcnet.org/welcome">https://2023.otcnet.org/welcome</a>	Houston	USA
<b>June</b>	<b>2023</b>		
5–8	84th EAGE Annual Conference & Exhibition <a href="https://eageannual.org/">https://eageannual.org/</a>	Vienna	Austria
26–29	26th World Mining Congress <a href="https://wmc2023.org/">https://wmc2023.org/</a>	Brisbane	Australia
<b>August</b>	<b>2023</b>		
27 Aug–02 Sep	International Meeting for Applied Geoscience & Energy (IMAGE) <a href="https://www.imageevent.org/">https://www.imageevent.org/</a>	Houston	USA
<b>September</b>	<b>2023</b>		
3–7	Near Surface Geoscience Conference & Exhibition 2023 <a href="https://eagensg.org/">https://eagensg.org/</a>	Edinburgh	UK
4–8	8th International Airborne Electromagnetics Workshop (AEM 2023) <a href="mailto:aemconference@theassociationspecialists.com.au">aemconference@theassociationspecialists.com.au</a>	Fitzroy Island	Australia
12–13	EAGE Conference on the Future of Energy - Role of Geoscience in the Energy Transition <a href="https://eage.eventsair.com/eage-conference-on-the-future-of-energy---role-of-geoscience-in-the-energy-transition">https://eage.eventsair.com/eage-conference-on-the-future-of-energy---role-of-geoscience-in-the-energy-transition</a>	Kuala Lumpur	Malaysia
<b>October</b>	<b>2023</b>		
17–20	Seventh International Conference on Engineering Geophysics (ICEG)	Abu Dhabi	UAE
25–27	Offshore Technology Conference (OTC) <a href="https://otcbrasil.org/">https://otcbrasil.org/</a>	Rio de Janeiro	Brazil
<b>November</b>	<b>2023</b>		
2–3	EAGE/Aqua Foundation Second Indian Near Surface Geophysics Conference & Exhibition <a href="https://www.nearsurfacegeophysics.in/">https://www.nearsurfacegeophysics.in/</a>	New Delhi	India
<b>December</b>	<b>2023</b>		
5–7	Latin America URTeC <a href="https://urtec.org/latinamerica/2023/">https://urtec.org/latinamerica/2023/</a>	Buenos Aires	Argentina
<b>February</b>	<b>2024</b>		
28 Feb–02 Mar	Offshore Technology Conference Asia (OTC Asia) <a href="https://2024.otcasia.org/">https://2024.otcasia.org/</a>	Kuala Lumpur	Malaysia
<b>August</b>	<b>2024</b>		
25–31	International Meeting for Applied Geoscience & Energy (IMAGE)	Houston	USA
<b>September</b>	<b>2024</b>		
	Australasian Exploration Geoscience Conference	Perth	Australia

*Preview* is published for the Australian Society of Exploration Geophysicists. It contains news of advances in geophysical techniques, news and comments on the exploration industry, easy-to-read reviews and case histories, opinions of Members, book reviews, and matters of general interest.

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Single copies of *Preview* can be purchased from the Publisher.

All proposed contributions should be submitted to the Editor by email at [previeweditor@aseg.org.au](mailto:previeweditor@aseg.org.au)

For style considerations, please refer to the For Authors section of the *Preview* website at: <https://www.tandfonline.com/toc/texp20/current>

*Preview* is published bimonthly in February, April, June, August, October and December. The deadline for submission of material to the Editor is usually the second Friday of the month prior to the month of issue. The deadline for the June issue is 12 May 2022.

For the advertising copy deadline please contact the Publisher on [advertising@taylorandfrancis.com.au](mailto:advertising@taylorandfrancis.com.au)



Is it  
down  
there?

# EMIT

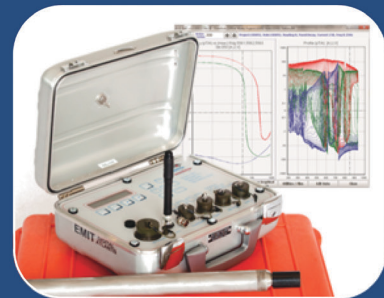
[www.electromag.com.au](http://www.electromag.com.au)

Over  
**25 YEARS**  
of helping you  
find out



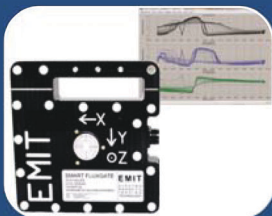
## SMARTem24

Rugged and reliable PC-based, 16 channel, 24-bit electrical geophysics receiver system with time-series recording, powerful noise rejection, GPS sync and an optional separate Transmitter Controller. Works seamlessly with a wide range of transmitter systems and most sensors for EM and IP. The SMARTem24 application plots decays, profiles, maps and pseudo-sections providing powerful QC capabilities. Hot-swappable batteries, touch-screen, solid-state HDD and water/dust protection make this an instrument for serious electrical geophysics. Compatible with EMIT's Transmitter Multiplexer and other tools for increasing productivity.



## DigiAtlantis

3-component digital borehole fluxgate magnetometer system in a 33mm tool for EM and MMR with simultaneous acquisition of all components, time-series recording and powerful noise rejection. Compatible with a wide range of transmitter systems and EMIT's Transmitter Multiplexer for increasing productivity. Samples the whole waveform providing on and off-time data. Magnetometer DC signals are recorded to give 3-component and total-field geomagnetic data. Orientation data gives hole inclination and azimuth in real-time without additional surveys. Designed to be used with industry-standard winches with 2-core and 4-core cable.



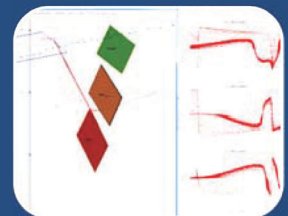
## SMART Fluxgate

Rugged, low noise, calibrated, 3-component fluxgate magnetometer with recording of geomagnetic fields, digital tilt measurement and auto-nulling.



## SMARTx4

Intelligent and safe 3.6 kW transmitter for EM surveys using standard generators. Clean 40A square wave output, inbuilt GPS sync and current waveform recording.



## Maxwell

Industry standard software for QC, processing, display, forward modelling and inversion of airborne, ground and borehole TEM, FEM and MMR data. Training workshops available.

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